TECHNICAL MANUAL
UNIT, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE

FOR

TRUCK, UTILITY: S250 SHELTER CARRIER, 4X4, M1113
(2320-01-412-0143) (EIC: B6B);

TRUCK, UTILITY: UP-ARMORED CARRIER, 4X4, M1114
(2320-01-413-3739) (EIC: B6C);

TRUCK, UTILITY: EXPANDED CAPACITY, ARMAMENT CARRIER, M1151
(2320-01-518-7330) (EIC: BA5);

TRUCK, UTILITY: EXPANDED CAPACITY, ARMAMENT CARRIER,
IAP/ARMOR READY, M1151A1
(2320-01-540-2038) (EIC: BEG);

TRUCK, UTILITY: EXPANDED CAPACITY, ENHANCED, M1152
(2320-01-518-7332) (EIC: BA6);

TRUCK, UTILITY: EXPANDED CAPACITY, ENHANCED, IAP/ARMOR READY, M1152A1
(2320-01-540-2007) (EIC: BEH);

TRUCK, UTILITY: COMMAND AND CONTROL/
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(2320-01-540-1993) (EIC: BEK);

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(2320-01-540-2017) (EIC: BEJ);

TRUCK, UTILITY: EXPANDED CAPACITY,
TOW ITAS CARRIER, M1167
(2320-01-544-9638).

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HEADQUARTERS, DEPARTMENTS OF THE ARMY,
THE AIR FORCE, AND MARINE CORPS

DECEMBER 1997
PCN 184 110331 00
WARNING

EXHAUST GASES CAN KILL

Brain damage or death can result from heavy exposure. Precautions must be followed to ensure crew safety when the personnel heater, main, or auxiliary engine of any vehicle is operated for any purpose.

1. Do not operate your vehicle engine in enclosed areas.
2. Do not idle vehicle engine with vehicle windows closed.
3. Be alert at all times for exhaust odors.
4. Be alert for exhaust poisoning symptoms:
   - Headache
   - Dizziness
   - Sleepiness
   - Loss of muscular control
5. If you see another person with exhaust poisoning symptoms:
   - Remove person from area
   - Expose to open air
   - Keep person warm
   - Do not permit physical exercise
   - Administer artificial respiration, if necessary*
   - Notify a medic

*For artificial respiration, refer to FM 21-11.

6. BE AWARE, the field protective mask for Nuclear, Biological, or Chemical (NBC) protection will not protect you from carbon monoxide poisoning.

THE BEST DEFENSE AGAINST EXHAUST POISONING IS ADEQUATE VENTILATION.
WARNING SUMMARY

- Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

- Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

- Diesel fuel is highly flammable. Do not perform any procedure near fire, flames, or sparks. Severe injury or death will result.

- Do not touch hot exhaust system components with bare hands. Severe injury will result.

- Do not remove surge tank filler cap before releasing internal pressure when engine temperature is above 185°F (85°C). Steam or hot coolant under pressure will cause injury.

- Do not drain oil when engine is hot. Severe injury to personnel will result.

- Always wear eye protection when bleeding brakes. Failure to do this may cause injury if brake fluid comes in contact with eyes.

- Do not perform battery system checks or inspections while smoking or near fire, flames, or sparks. Batteries may explode, causing damage to vehicle, injury, or death to personnel.

- Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry or disconnected battery ground cable contacts battery terminal, a direct short will result, causing injury to personnel or damage to equipment.

- Use caution when testing thermostat. Hot water will cause burns.

- Negative battery cable must be disconnected before disconnecting any harness from protective control box or serious injury to personnel or damage to equipment will result.

- Keep hands and arms away from fan blade and drivebelts while engine is running or serious injury may result.

- Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing maintenance on batteries. Injury will result if acid contacts eyes or skin.

- When removing battery cable clamps, disconnect ground cable first. Ensure all switches are in OFF position before disconnecting ground cable. Do not allow tools to come in contact with vehicle when disconnecting cable clamps. A direct short can result, causing instant heating of tools, tool damage, battery damage, or battery explosion.

- Allow transmission/transfer case to cool before performing maintenance. Failure to do this may cause injury.

- Always apply parking brake and chock opposite wheel before removing wheel. Avoid removing wheel when vehicle is on sloping terrain. Injury to personnel or damage to equipment may result.

- Gloves must be worn whenever handling winch cable. Severe injury may result.

- Hydraulic jacks are used for raising and lowering, and are not used to support vehicle. Never work under vehicle unless wheels are blocked and it is properly supported. Injury or damage to equipment may result if vehicle suddenly shifts or moves.

- Remove only the inner group of nuts when removing a wheel from the vehicle. Removing the outer nuts which hold the rim together while the assembly is inflated could result in serious injury or death.

- In all disassembly of the wheel assembly operations, ensure the tire is totally deflated before removing wheel nuts. Failure to follow proper safety precautions could cause serious injury or death.

- Never inflate a wheel assembly with the wheel locknuts removed in an attempt to separate inner and outer rim halves. The assembly will separate under pressure, resulting in serious injury or death.
WARNING SUMMARY (Cont'd)

- Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which could cause individual fasteners to fail. Any of these situations could cause serious injury or death.

- Never use tubes in wheel assemblies. Use of a tube defeats built-in safety features, and could allow the wheel to come apart under pressure, resulting in serious injury or death.

- Use only replacement parts specified in TM 9-2320-387-24P. Wheels assembled with components which do not meet specifications could cause the assembly to separate under pressure, resulting in serious injury or death.

- Never inflate a wheel assembly without having checked wheel locknut torques that ensure that wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of cage during inflation; never directly in front. Keep hands out of the cage during inflation. Inflate assembly to recommended pressure using a clip-on air chuck. Do not exceed 30 psi (207 kPa) cold bias tire inflation pressure or 50 psi (344 kPa) cold radial tire inflation pressure. Failure to follow these instructions may result in serious injury or death.

- NBC contaminated filters must be handled and disposed of only by authorized and trained personnel. The unit commander or senior officer in charge of maintenance personnel must ensure that prescribed protective clothing (FM 3-4) is used, and prescribed safety measures and decontamination procedures (FM 3-5) are followed. The local unit SOP is responsible for final disposal of contaminated air filters. Failure to do this may cause severe injury to personnel.

- Seatbelts are to be replaced as a set. Failure to do this may cause injury to personnel or damage to equipment.

- The Department of Transportation requires 105 mm cannon ammunition to be in wooden boxes when transporting ammunition on public highways, by fixed wing aircraft, rail, or ship. Movement of cannon ammunition in fiber containers (inner pack) in the HMMWV ammunition rack is restricted to other than public highways.

- Air-conditioning system must be discharged prior to replacing components. Failure to do this may result in injury to personnel or damage to equipment.

- Ensure all slack from the three-point seatbelt or Improved Personal Restraint System is removed. The three-point seatbelt and Improved Personal Restraint System will lock only during sudden stops or impact. Injury and/or death to personnel may result if an accident occurs and seatbelts or lap and shoulder straps are not in use or adjusted properly.

- Protective eye equipment (goggles/shield) must be worn when removing snaprings or springs. Failure to comply may result in injury to personnel.

- Ensure automatic fire extinguishing system (AFES) anti-recoil device is installed in place of deflector valve. Failure to do so can result in discharge of liquid and powder agents can cause injury to personnel.

- Vehicle armor is extremely heavy and must be supported during removal and installation. Failure to do so may result in injury to personnel or damage to equipment.
ARMY TM 9-2320-387-24-1
AIR FORCE TO 36A12-1A-3052-2
MARINE CORPS TM 11033-IN VOL 1

CHANGE
NO. 6

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DEPARTMENTS OF THE ARMY,
THE AIR FORCE, AND MARINE CORPS
WASHINGTON, D.C., 30 JUNE 2009

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VOLUME 1 OF 2
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PETER J. SCHOOMAKER  
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Chief of Staff

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JOYCE E. MORROW  
Administrative Assistant to the  
Secretary of the Army  
0703802

By Order of the Secretary of the Air Force:

JOHN P. JUMPER  
General, United States Air Force  
Chief of Staff

Official:

GREGORY S. MARTIN  
General, United States Air Force  
Commander, Air Force Materiel Command

By Order of the Marine Corps:

S. I. SCHULER  
Colonel, USMC  
Program Manager Motor  
Transportation (PMM151)  
Marine Corps Systems Command

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To be distributed in accordance with the initial distribution number (IDN) 381020, requirements for  
TM 9-2320-387-24-1.  
PCN 184 110331 00
TM 9-2320-387-24-1, December 1997, is changed as follows:

1. Two new models have been added to the front cover. The new cover, located at the end of the change package, replaces the existing cover.

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By Order of the Secretary of the Army:

PETER J. SCHOOMAKER
General, United States Army
Chief of Staff

Official:

JOYCE E. MORROW
Administrative Assistant to the
Secretary of the Army
0602405

By Order of the Secretary of the Air Force:

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By Order of the Secretary of the Army:

ERIC K. SHINSEKI
General, United States Army
Chief of Staff

Official:

JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army
0119703

By Order of the Secretary of the Air Force:

RONALD R. FOGLEMAN
General, United States Air Force
Chief of Staff

Official:

HENRY VICCELLIO, JR.
General, United States Air Force
Commander, Air Force Materiel Command

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## LIST OF EFFECTIVE PAGES

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**VOLUME 2**

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UNIT, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE

FOR
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TRUCK, UTILITY: UP-ARMORED CARRIER, 4X4, M1114 (2320-01-413-3739) (EIC: B6C);
TRUCK, UTILITY: EXPANDED CAPACITY, ARMAMENT CARRIER, M1151 (2320-01-518-7330) (EIC: BA5);
TRUCK, UTILITY: EXPANDED CAPACITY, ARMAMENT CARRIER, IAP/ARMOR READY, M1151A1 (2320-01-540-2038) (EIC: BEG);
TRUCK, UTILITY: EXPANDED CAPACITY, ENHANCED, M1152 (2320-01-518-7332) (EIC: BA6);
TRUCK, UTILITY: EXPANDED CAPACITY, ENHANCED, IAP/ARMOR READY, M1152A1 (2320-01-540-2007) (EIC: BEH);
TRUCK, UTILITY: COMMAND AND CONTROL/GENERAL PURPOSE VEHICLE, M1165 (2320-01-540-1993) (EIC: BEK);
TRUCK, UTILITY: COMMAND AND CONTROL/GENERAL PURPOSE VEHICLE, IAP/ARMOR READY, M1165A1 (2320-01-540-2017) (EIC: BEJ);
TRUCK, UTILITY: EXPANDED CAPACITY, TOW ITAS CARRIER, M1167 (2320-01-544-9638).

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This manual contains a table of contents and alphabetical index for both volumes 1 and 2.
# HOW TO USE THIS MANUAL

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HOW TO USE THIS MANUAL

ABOUT YOUR MANUAL

a. Spend some time looking through this manual. You'll find that it has a new look, different than most of the TMs you've been using. New features added to improve the convenience of this manual and increase your efficiency are:

1. Accessing Information - These include physical entry features such as the bleed-to-edge indicators on the cover and edge of the manual. Extensive troubleshooting guides for specific systems lead directly to step-by-step directions for problem solving and maintenance tasks.

2. Illustrations - A variety of methods are used to make locating and fixing components much easier. Locator illustrations with keyed text, exploded views, and cut-away diagrams make the information in this manual easier to understand.

3. Keying Text With Illustrations - Instructions are located together with figures that illustrate the specific task you are working on. In most cases, the task steps and figures are located side-by-side, making part identification and procedure sequence easier to follow.

The TM is the fundamental means by which the Army communicates to soldiers the requirements and procedures necessary to perform equipment operations and maintenance. This manual describes in detail the Unit, Direct and General Support Maintenance authorized by the Maintenance Allocation Chart (MAC) (appendix B) and Source, Maintenance, and Recovery (SMR) codes (TM 9-2320-387-24P).

b. General Features. Your TM is the best source available for providing information and data critical to vehicle operation and maintenance:

Volume 1
- Safety summary (warning pages a, b, and c)
- General information, equipment descriptions, and data (chapter 1)
- Principles of operation (chapter 1, section III)
- Preventive Maintenance Checks and Services - PMCS (chapter 2, section III)
- General maintenance instructions (chapter 2, section IV)
- Electrical/mechanical systems troubleshooting (chapter 2, section V)
- Detailed maintenance procedures (chapters 3 through 9)

Volume 2
- Safety summary (warning pages a through d)
- Troubleshooting (chapter 14, section I)
- Detailed maintenance procedures (chapters 10 through 33)
- Maintenance Allocation Chart - MAC (appendix B)
- Expendable/durable supplies and materials list (appendix C)
- Illustrated list of manufactured items (appendix D)
- Torque limits (appendix E)
- Body repair materials (appendix F)
- Mandatory replacement parts (appendix G)
- Wiring diagrams and schematics (appendix H)

A typical example of how to use this manual is provided on the following pages.
USING YOUR MANUAL: AN EXAMPLE

a. TASK: The operator of an ECV vehicle has complained that his carrier uses too much engine oil. The vehicle has been assigned to you for repair.

b. TROUBLESHOOTING STEPS:

1. Look at the cover of this manual. You'll see chapter titles listed from top to bottom on the right-hand side.

2. Look at the right edge of the manual. On some of the pages you'll see black bars (bleed-to-edge indicators) that are aligned with the chapter bars on the cover. These are the locations of the chapters in the text.

3. Look for SERVICE AND TROUBLESHOOTING INSTRUCTIONS in the chapter list on the cover. This is where the troubleshooting information is located.

4. Turn to those pages with the edge indicator matching the black bar for service and troubleshooting instructions. Page numbers are also listed next to chapter titles.

5. Chapter 2 is divided into five sections:
   • Section I – Repair Parts, Special Tools, TMDE, and Support Equipment
   • Section II – Service Upon Receipt
   • Section III – PMCS
   • Section IV – General Maintenance Instructions
   • Section V – Electrical/Mechanical Systems Troubleshooting
6. Turn to section V, ELECTRICAL/MECHANICAL SYSTEMS TROUBLESHOOTING (page 2-33).

This troubleshooting section is system-oriented and is broken down into five top level tests and nineteen system level tests.

7. One of the first pages of this section is the ELECTRICAL/MECHANICAL SYSTEM TROUBLESHOOTING (turn to page 2-35).

8. Look down the list of symptoms until you find ENGINE LUBRICATION TESTS. In that paragraph you will find the diagnostic flow chart from which the vehicle operator can choose the test such as OIL LEAKS OR ENGINE PROBLEMS.

9. Turn to the test indicated.
10. On page 2-192, steps relating to resolving the problem of excessive oil loss are listed. Read the diagnostic flow chart until you find OIL LEAKS OR ENGINE PROBLEMS. The tests listed are shown in the example page to the right of this text.

11. In accordance with Test 1, you checked the oil level and filter for leaks. The oil level and filter appear normal and you move on to Test 2.

12. In Test 2, you begin a methodic check of the engine lubricating system. You discover a leak in the oil cooler assembly adjacent to one of the mounting brackets. One of the welds has cracked, allowing a class III leak from a small area of the cooling fins. The oil cooler assembly must be repaired or replaced.

13. At this point, the engine lubrication diagnostic flow chart would direct you to a specific detailed procedure to solve the problem. However, the engine lubricating system is complex and you must now refer to the table of contents to locate the proper task paragraph.

NOTE: Before attempting to repair or replace the oil cooler assembly, as a Unit mechanic, you must:

a. Determine the maintenance responsibility of repair or replacement of the component.

b. If the task is at your echelon of maintenance responsibility, you must identify the tools needed and the replacement parts required.

Refer to the Maintenance Allocation Chart – MAC (appendix B) to determine not only the maintenance responsibility of the item, but also to obtain an estimate of the time required to perform the task, tools needed, and any special notes/requirements necessary.

Refer to TM 9-2320-387-24P, Unit, Direct Support and General Support Maintenance Repair Parts and Special Tools List for requisition data concerning replacement parts for this task.
c. OIL COOLER ASSEMBLY REPLACEMENT: After reporting the results of your troubleshooting efforts to your supervisor, he decides that the most expedient means of returning the vehicle to service would be to replace the oil cooler assembly.

1. Turn to the TABLE OF CONTENTS and find the chapter dealing with the engine. You find it as CHAPTER 3, ENGINE SYSTEMS (UNIT) MAINTENANCE. Furthermore, you note that the chapter is divided into five sections. You are interested in Section I. Lubrication System Maintenance.

2. Turn to chapter 3, section I on page 3-1. Here you find the Lubrication System Maintenance Task Summary. Read down the list of tasks until you find the one that will correct your maintenance problem. For our example, you find it as task 3-8, Engine, Transmission, and Power Steering Oil Cooler Assembly Maintenance. Turn to page 3-12.
3. On page 3-12, you find paragraph 3-8 with the detailed procedure for replacing the oil cooler assembly.

d. DETAILED MAINTENANCE PROCEDURES: Detailed maintenance procedures include everything you must do to accomplish a basic maintenance task. Unless otherwise stated, general mechanic’s automotive tool kit will be used for maintenance of this vehicle.


2. The ten basic headings listed under INITIAL SETUP outline task conditions, materials, special tools, manpower requirements, and special conditions. The headings are:

- **Applicable Models:** Any models that require a particular maintenance task. If a maintenance task covers all models, then this heading will not be used.

- **Test Equipment:** Test equipment needed to complete a task. If test equipment is not required, this heading will not be used.

- **Tools:** These are common tools and general mechanic tool sets required to perform maintenance tasks. These common tools should be on hand to properly perform the task. Torque wrenches are required for many tasks; the proper torque wrench should be available to tighten mounting hardware.

- **Special Tools:** Those special tools needed to complete a maintenance task. If no special tools are needed, this heading will not be used.

If you don’t have one of these special tools, requisition it (before starting the task) using the data supplied in TM 9-2320-387-24P, the repair parts and special tools list for this level of maintenance. Special tools are located in section III.

- **Materials/Parts:** This heading lists only mandatory replacement materials or parts (gaskets, O-rings, sealant, etc.). To replace other unservicable parts, refer to TM 9-2320-387-24P for requisition data. If no mandatory replacement materials/parts are required, this heading will not be used.
• **Personnel Required:** The number of personnel needed to perform a task. If only one mechanic is needed, this heading will not be used.

**NOTE**

If you think that you need more help to adequately or safely complete a task, perhaps as the result of unusual conditions, etc., alert your supervisor and ask for help.

• **Manual References:** Those TMs needed to complete the task.

• **Equipment Condition:** Notes the conditions that must exist before starting the task. If none are required, this heading will not be used. For oil cooler assembly replacement, the left-hand engine splash shield should be removed before we can start the task. If not already done, follow the procedure for splash shield removal in para. 10-23 before proceeding with this task.

• **General Safety Instructions:** Summarizes all safety warnings for the maintenance task. If none are required, this heading will not be used.

• **Maintenance Level:** Identifies maintenance level required to perform task.

3. A step-by-step maintenance procedure follows the INITIAL SETUP and gives detailed instructions for the procedure. These instructions give the part’s general location and name and action performed. In the example Engine, Transmission, and Power Steering Oil Cooler Assembly Replacement, a. Removal, step 1 is “Disconnect two engine oil cooler supply and return lines (7) from engine oil cooler ports (9).” Note that the numbers in parentheses correspond to the part’s callout number in the accompanying illustration.

**NOTE**

Warnings, cautions, and notes provide supplemental information:

• **Warnings:** Indicate conditions, practices, or procedures which must be observed to avoid personnel injury, loss of life, or long-term health hazard.

• **Cautions:** Indicate condition, practices, or procedures which must be observed to avoid damage to equipment or destruction of equipment.

• **Notes:** Include essential information of special importance, interest, or aid in job performance, which should be remembered and would be otherwise difficult to find or incorporate into the text.

4. At the end of a procedure, FOLLOW-ON TASKS will list those additional tasks that must be performed to complete the procedure. The follow-on tasks for engine, transmission, and power steering oil cooler assembly replacement are:

   • Fill power steering fluid to proper level (TM 9-2320-387-10).
   • Fill transmission oil to proper level (TM 9-2320-387-10).
   • Fill engine oil to proper level (TM 9-2320-387-10).
   • Install headlight housing (para. 10-18).
   • Install left-hand splash shield (para. 10-23).
   • Start engine (TM 9-2320-387-10) and check for leaks.

   e. Refer to the example pages for para. 3-8, Engine, Transmission, and Power Steering Oil Cooler Assembly Maintenance as we review the following points:

1. **Modular Text:** Both pages of text and illustrations are to be used together. This manual was designed so the two pages would be visible at once, making part identification and procedure sequence easy to follow.

2. **Initial Setup:** Outlines task conditions.

3. **Illustrations:** An exploded diagram of the component shows part locations, attachments, and spatial relationships. Cutaway views (part of the vehicle is erased) show the location and orientation of screws and attachments.

f. Your manual is easy to use once you understand its design. We hope it will encourage you to use your TM more often as an aid to maintenance support.
CHAPTER 1
INTRODUCTION

Section I. GENERAL INFORMATION

1-1. SCOPE

a. This technical manual contains instructions for unit, direct, and general support maintenance of
the 4x4, 1-1/4 ton Expanded Capacity Vehicles (ECV).

b. Models included are:
   (1) M1113 S250 Shelter Carriers
   (2) M1114 Up-Armored Carriers
   (3) M1151 Armament Carriers
   (4) M1151A1 Armament Carriers, IAP/Armor Ready
   (5) M1152 Expanded Capacity Utility Trucks
   (6) M1152A1 Expanded Capacity Utility Trucks, IAP/Armor Ready
   (7) M1165 Command and Control/General Purpose Vehicles
   (8) M1165A1 Command and Control/General Purpose Vehicles, IAP/Armor Ready
   (9) M1167 Expanded Capacity TOW ITAS Carriers

1-2. MAINTENANCE FORMS, RECORDS, AND REPORTS

Department of the Army forms and procedures used for equipment maintenance will be those prescribed
by DA Pam 750-8, The Army Maintenance Management System (TAMMS) User’s Manual (Marine Corps)
refer to TM 4700-15/1 series.

1-3. DESTRUCTION OF ARMY EQUIPMENT TO PREVENT ENEMY USE

Refer to TM 750-244-6, Procedures for Destruction of Army Tank-automotive Equipment to Prevent
Enemy Use.

1-4. PREPARATION FOR SHIPMENT

Refer to TM 746-10, Marking, Packaging, and Shipment of Supplies and Equipment: General Packaging
Instructions for Field Use.

1-5. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR)

If your vehicle needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell
us what you don’t like about your equipment. Let us know why you don’t like the design or performance.
The preferred method for submitting QDRs is through the Army Electronic Product Support (AEPS)
website under the Electronic Deficiency Reporting System (EDRS). The web address is:
https://aeps.ria.army.mil. This is a secured site requiring a password that can be applied for on the front
page of the website. If the above method is not available to you, put it on an SF 368, Product Quality
Deficiency Report (PQDR), and mail it to us at: Department of the Army, U.S. Army Tank-automotive and
We’ll send you a reply. (Marine Corps) Submit QDR’s in accordance with MCO 4855-10.
The quarterly Equipment Improvement Report and Maintenance Digest, TB 43-0001-62 series, contains valuable field information on the equipment covered in this manual. The information in the TB 43-0001-62 series is compiled from some of the Equipment Improvement Reports that you prepared on the vehicles covered in this manual. Many of these articles result from comments, suggestions, and improvement recommendations that you submitted to the EIR program. The TB 43-0001-62 series contains information on equipment improvements, minor alterations, proposed Modification Work Orders (MWOs), warranties (if applicable), actions taken on some of your DA Form 2028s (Recommended Changes to Publications and Blank Forms), and advance information on proposed changes that may affect this manual. The information will help you in doing your job better and will help in keeping you advised of the latest changes to this manual. Also refer to DA Pam 25-30, Consolidated Index of Army Publications and Blank Forms, and appendix A, References, of this manual.

The equipment described herein contains metric components and requires metric common and special tools; therefore, metric units in addition to standard units will be used throughout this publication. In addition, a metric conversion table is located on the inside back cover of this publication.

The maintenance instructions contained herein make reference to removing and discarding piece parts such as: gaskets, lockwashers, cotter pins, O-rings, seals, etc.; these items should be considered mandatory replacement items and replaced with new parts during assembly/installation.

Section II. EQUIPMENT DESCRIPTION AND DATA

The 1-1/4 ton, 4x4, ECV vehicles are tactical vehicles designed for use over all types of roads, as well as cross-country terrain, in all weather conditions. The vehicles have four driving wheels, powered by a V-8 liquid-cooled turbocharged diesel engine. Four-wheel hydraulic service brakes and a mechanical parking brake are standard. All vehicles are equipped with a pintle hook for towing. Tiedowns and lifting eyes are provided for air, rail, or sea shipment.
1-10. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES (Cont’d)

S250 SHELTER CARRIER: M1113

PURPOSE: The M1113 shelter carrier provides the capability to secure and transport the S250 electrical equipment shelter. The optional winch permits recovery operations of similar vehicles. For payload, refer to para. 1-15.
1-10. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES (Cont’d)

UP-ARMORED CARRIER, W/SUPPLEMENTAL ARMOR: M1114

PURPOSE: The M1114 up-armored vehicle carrier provides mounting and firing of the MK19 automatic grenade launcher, M2, caliber .50 machine gun; M60, 7.62 mm machine gun; M240B, 7.62 mm machine gun; and M249, 5.56 mm Squad Assault Weapon (SAW); ring-mounted with a 360° arc of fire. The M1114 up-armored vehicle carrier provides added ballistic protection for armament components, crew, and ammunition. The optional rear winch permits recovery operations of similar vehicles. For payload, refer to para. 1-15.
EXPANDED CAPACITY, ARMAMENT CARRIER: M1151

PURPOSE: The M1151 expanded capacity armament carrier provides mounting and firing of the MK19 automatic grenade launcher; M2, caliber .50 machine gun; M60, 7.62 mm machine gun; M240B, 7.62 mm machine gun; and M249, 5.56 mm Squad Assault Weapon (SAW); ring-mounted with a 360° arc of fire, with armor protection for crew, weapon components, and ammunition. For higher payload capacity, the M1151 is equipped with a reinforced frame, crossmembers, lifting shackles, heavy-duty variable rate rear springs, shock absorbers, reinforced control arms, heavy-duty tires and rims, and a transfer case and differential with a modified gear ratio. For payload, refer to para. 1-15.
EXPANDED CAPACITY, ARMAMENT CARRIER IAP/ARMOR READY: M1151A1

PURPOSE: The M1151A1 expanded capacity, armament carrier IAP/armor ready provides mounting and firing of the MK19 automatic grenade launcher, M2, .50 caliber machine gun; M60, 7.62 mm machine gun; M240B, 7.62 mm machine gun; and M249, 5.56 mm Squad Assault Protection (SAW); ring-mounted with a 360° arc of fire, with armor protection for crew, weapons components. For higher payload capacity, the M1151A1 is equipped with a reinforced frame, crossmembers, lifting shackles, heavy-duty variable rate rear springs, shock absorbers, reinforced control arms, heavy-duty tires and rims, and a transfer case and differential with a modified gear ratio. For payload, refer to para. 1-15.
EXPANDED CAPACITY, ENHANCED: M1152

PURPOSE: The M1152 expanded capacity, enhanced truck is used to transport personnel. The M1152 provides the capability to secure and transport the S250 electrical equipment shelter. For higher payload capacity, the M1152 is equipped with a reinforced frame, crossmembers, lifting shackles, heavy-duty variable rate rear springs, shock absorbers, reinforced control arms, heavy-duty tires and rims, and a transfer case and differential with a modified gear ratio. The optional front winch permits recovery operations of similar vehicles. For payload, refer to para. 1-15. The increased payload capabilities accommodate the following kit configurations:

a. 105MM TOWED HOWITZER PRIME MOVER (L119 KIT) consists of:
   - Larger rear bumper and reinforced mounting
   - Body wiring harness trailer receptacle extension
   - Ammunition stowage rack and tiedown straps
   - Camouflage net stowage rack
   - Winch
   - Two-man crew area soft top
   - Troop area soft top
   - Cargo bulkhead

b. TOWED VULCAN SYSTEMS (TVS) MOVER consists of:
   - Two-man crew area soft top
   - Troop area soft top
   - Camouflage net stowage rack
   - Troop seat kit
   - Cargo bulkhead

c. S250 ELECTRICAL EQUIPMENT SHELTER consists of:
   - Shelter support
   - Shelter tailgate
   - 200 amp umbilical power cable
EXPANDED CAPACITY, ENHANCED, IAP/ARMOR READY: M1152A1

PURPOSE: The M1152A1 expanded capacity, enhanced, IAP/armor ready is used to transport personnel. The M1152A1 comes equipped with Integrated Armor protection (IAP) which provides added ballistic protection for armament components, crew, and ammunition. The M1152A1 vehicles are capable of transporting a two-man or four-man crew and eight passengers. The M1152A1 provides the capability to secure and transport the S250 electrical equipment shelter. For higher payload capacity, the M1152A1 is equipped with a reinforced frame, crossmembes, lifting shackles, heavy-duty variable rate rear springs, shock absorbers, reinforced control arms, heavy-duty tires and rims, and a transfer case and differential with a modified gear ratio. The optional front winch permits recovery operations of similar vehicles. For payload, refer to para. 1-15.
1-10. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES (Cont’d)

COMMAND AND CONTROL/GENERAL PURPOSE VEHICLE: M1165

PURPOSE: The M1165 command and control/general purpose vehicle is used to transport personnel. The M1165 vehicles are capable of transporting a two-man or four-man crew and eight passengers. For higher payload capacity, the M1165 is equipped with a reinforced frame, crossmembers, lifting shackles, heavy-duty variable rate rear springs, shock absorbers, reinforced control arms, heavy-duty tires and rims, and a transfer case and differential with a modified gear ratio. The optional front winch permits recovery operations of similar vehicles. For payload, refer to para. 1-15.
1-10. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES (Cont’d)

COMMAND AND CONTROL/GENERAL PURPOSE VEHICLE, IAP/ARMOR READY: M1165A1

PURPOSE: The M1165A1 command and control/general purpose vehicle is used to transport personnel. The M1165A1 comes equipped with Integrated Armor protection (IAP) which provides added ballistic protection for armament components, crew, and ammunition. The M1165A1 vehicles are capable of transporting a four-man crew. For higher payload capacity, the M1165A1 is equipped with a reinforced frame, crossmembers, lifting shackles, heavy-duty variable rate rear springs, shock absorbers, reinforced control arms, heavy-duty tires and rims, and a transfer case and differential with a modified gear ratio. The optional front winch permits recovery operations of similar vehicles. For payload, refer to para. 1-15.

M1165A1
EXPANDED CAPACITY VEHICLE, TOW IMPROVED TARGET ACQUISITION SYSTEM (ITAS): M1167

PURPOSE: The M1167 expanded capacity vehicle is equipped with an improved target acquisition system (ITAS) used to mount and operate the missile launcher system with armor ballistic protection for crew, missile stowage, secondary weapons mount for close range, and ammunition. These tactical vehicles are designed for use over all types of roads, as well as cross-country terrain, in all weather conditions. All vehicles are able to stow a minimum of six missiles mounted in the cargo area and are equipped with a pintle hook for towing, tiedowns, and lifting eyes for air, rail, or sea shipment. The optional front winch permits recovery operations of similar vehicles. For payload, refer to para. 1-15.
1-11. LOCATION AND DESCRIPTION OF MAJOR EXTERIOR COMPONENTS

The exterior components described below are common to all vehicles covered in this manual. Special differences are found in TM 9-2320-387-10 or Table 1-1, Differences Between Models, in this manual.

A  AIR CLEANER – Filters air before it enters intake manifold.

B  ENGINE – Provides power for the vehicle.

C  TRANSMISSION – Transmits engine power to transfer case at varying speeds.

D  FUEL TANK – Stores fuel.

E  GEARED HUB – Transfers turning action of halfshafts to wheels for vehicle motion.

F  PINTLE HOOK – Permits towing of vehicles or equipment.

G  REAR PROPELLER SHAFT – Transmits power from the transfer case to the rear differential.

H  TRANSFER CASE – Provides full-time four-wheel drive with three drive ranges.

I  FRONT PROPELLER SHAFT – Transmits power from the transfer case to the front differential.

J  MASTER CYLINDER AND HYDRO-BOOSTER – Provides hydraulic pressure and power assist for vehicle stopping power.

K  DIFFERENTIAL – Transfers turning action of the propeller shaft to the geared hubs through the halfshafts.

L  WINCH – 9,000 lb electrically powered or 10,500 lb hydraulically powered to provide recovery capability. Located in front of vehicle on all models except M1114 (if equipped) and rear of vehicle on M1114 models (if equipped).
1-12. LOCATION AND DESCRIPTION OF MAJOR INTERIOR COMPONENTS

The major interior components shown below are common to all vehicles covered in this manual. Components not covered here can be found in TM 9-2320-387-10 or the applicable maintenance chapters of this manual.

A DIRECTIONAL SIGNAL CONTROL – Activates turn signal lights.
B AIR RESTRICTION GAUGE – Indicates restrictions in the air cleaner.
C STEERING WHEEL – Manual control for turning vehicle.
D INSTRUMENT CLUSTER – Houses controls and indicators.
E DIAGNOSTIC CONNECTOR – Connection point for STE/ICE-R test set.
F TRANSMISSION SHIFT LEVER – Manual control for shifting transmission.
G TRANSFER CASE SHIFT LEVER – Manual control for shifting transfer case.
H PARKING BRAKE LEVER – Manual control for applying parking brake.
I ACCELERATOR PEDAL – Foot control for determining engine speed.
J BRAKE PEDAL – Foot control for stopping vehicle.
K MAIN LIGHT SWITCH – Controls operation of vehicle lights.
L ROTARY SWITCH – When positioned to START, the starter is engaged to crank the engine.

ALL MODELS EXCEPT M1114
1-12. LOCATION AND DESCRIPTION OF MAJOR INTERIOR COMPONENTS (Cont'd)

1. P (Park)
2. R (Reverse)
3. N (Neutral)
4. D (Overdrive)
5. D (Manual Third)
6. 2 (Manual Second)
7. 1 (Manual First)
The location and contents of caution, data, and warning plates are provided in this paragraph. If any of these plates are worn, broken, painted over, missing, or unreadable, they must be replaced. Information on data plate may vary with the model.
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont’d)

ALL MODELS EXCEPT M1114

TRUCK UTILITY: EXPANDED CAPACITY,
4X4; N/E, W/N (HIGHWAY), M1112

AT CURB WT
A. 37.6
B. 39.7

ATTACH SLINGS AT POINTS SL
AND TIEOFFS AT POINTS TO.

MFD. BY AM GENERAL
WEIGHT AND DIMENSIONAL DATA

CURB
GVR
GVW

FRONT AXLE 3400 LBS.
Rear Axle 2700 LBS.
TOTAL 6100 LBS.

MAX TOWED LOAD 4300 LBS.
VERTICAL PIVOT LOAD 430 LBS.
SHIPPING CAGE 704 CU. FT.
SHIPPING WEIGHT DRY 5960 LBS.
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

**CAUTION**
HIGH INTENSITY NOISE HEARING PROTECTION REQUIRED

**FRESH AIR INTAKE**
OPERATING LEVER LOCATED UNDER DUCT ON GRILLE
PULL TO OPEN

**TO ADJUST SEAT**
1. LIFT SLIDE SET BAR AND MOVE SEAT FORWARD OR REARWARD TO DESIRED LOCATION
2. LIFT ADJUSTER KNOB TO RAISE OR LOWER SEAT TO DESIRED HEIGHT

M1114 VEHICLES
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont’d)

### MAX. VEHICLE OPERATING SPEEDS

<table>
<thead>
<tr>
<th>Transfer Range Selection</th>
<th>&quot;L&quot;</th>
<th>&quot;H&quot;</th>
<th>&quot;HL&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;R&quot; Reverse</td>
<td>10 MPH</td>
<td>27 MPH</td>
<td>27 MPH</td>
</tr>
<tr>
<td>&quot;D&quot; Drive</td>
<td>21 MPH</td>
<td>55 MPH</td>
<td>55 MPH</td>
</tr>
<tr>
<td>&quot;2&quot; Second</td>
<td>14 MPH</td>
<td>38 MPH</td>
<td>38 MPH</td>
</tr>
<tr>
<td>&quot;I&quot; First</td>
<td>8 MPH</td>
<td>23 MPH</td>
<td>23 MPH</td>
</tr>
</tbody>
</table>

**Transfer Case In High "H" When Operating On Hard Surface**

**Fording**

Shallow Fording Depth

30 INCHES

---

**VEHICLE BREAK-IN SERVICE**

During the first 500 mi. (804 km) of operation:

* No Trailer Towing
### 1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

**TRUCK UTILITY: UP-ARMORED HEAVY VARIANT**
12100 GVW, 4X4 WE 1114

- **MFR**: O'GARA HESS & EISENHARDT

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFR'S. SERIAL NUMBER</td>
<td>10207/87T0015</td>
</tr>
<tr>
<td>REGISTRATION NUMBER</td>
<td></td>
</tr>
<tr>
<td>NATIONAL STOCK NUMBER</td>
<td>2320-01-413-3739</td>
</tr>
<tr>
<td>VEHICLE CURB WEIGHT</td>
<td>9800 LBS</td>
</tr>
<tr>
<td>PAYLOAD MAXIMUM</td>
<td>2300 LBS</td>
</tr>
<tr>
<td>GROSS WEIGHT MAXIMUM</td>
<td>12100 LBS</td>
</tr>
<tr>
<td>DATE OF DELIVERY</td>
<td></td>
</tr>
<tr>
<td>CONTRACT NUMBER</td>
<td>DAAE07-94CO4106</td>
</tr>
</tbody>
</table>

**U.S. PROPERTY**

- **M1114 VEHICLES**

---

**TRUCK UTILITY: EXPANDED CAPACITY**
4X4, W/E, HMMWV, XM 1113

- **MFR**: A.M.GENERAL

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFR'S. SERIAL NUMBER</td>
<td>19207/87T0014</td>
</tr>
<tr>
<td>REGISTRATION NUMBER</td>
<td></td>
</tr>
<tr>
<td>NATIONAL STOCK NUMBER</td>
<td>2320-01-412-0143</td>
</tr>
<tr>
<td>VEHICLE CURB WEIGHT</td>
<td>6100 LBS</td>
</tr>
<tr>
<td>PAYLOAD MAXIMUM</td>
<td>5400 LBS</td>
</tr>
<tr>
<td>GROSS WEIGHT MAXIMUM</td>
<td>11500 LBS</td>
</tr>
<tr>
<td>DATE OF DELIVERY</td>
<td></td>
</tr>
<tr>
<td>CONTRACT NUMBER</td>
<td>WA-X001-96-0045</td>
</tr>
</tbody>
</table>

**U.S. PROPERTY**

- **M1113 VEHICLES**

---

- **VENT**

---

- **DEEP FORD**
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

<table>
<thead>
<tr>
<th>MANUALS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MAINTENANCE MANUAL</td>
<td>TM 9-2320-387-24</td>
</tr>
<tr>
<td>OPERATORS MANUAL</td>
<td>TM 9-2320-387-10</td>
</tr>
<tr>
<td>PARTS LIST</td>
<td>TM 9-2320-387-24P</td>
</tr>
</tbody>
</table>

M1114 VEHICLES
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

M114 VEHICLES

ENG STOP RUN START

AIR

TEMP

FAN

MIN MAX

OFF HI LO
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont’d)

WARNING

DO NOT USE HAND THROTTLE AS AN AUTOMATIC VEHICLE SPEED OR CRUISE CONTROL. THE HAND THROTTLE WILL NOT DISENGAGE AUTOMATICALLY WHEN BRAKE IS APPLIED.

WARNING c

SEAT BELT HAS NON-LOCKING RETRACTORS. FOR PROPER USE, WEBBING MUST FIRST BE COMPLETELY EXTENDED FROM THE NON-LOCKING RETRACTORS. ALL EXCESS WEBBING MUST THEN BE ADJUSTED AT THE BUCKLE.
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont’d)

SLAVE RECEPTACLE INSIDE
MISSILE RACK CONFIGURATION

LAUNCH TUBE

FRONT

MISSILE TUBES SHALL BE LOADED AS SHOWN TO PREVENT DAMAGE TO EQUIPMENT

BOTTOM RAIL CONFIGURATION

NOSE

1

FRONT

2

NOSE

3

BACK

TOP VIEW

TOP RAIL CONFIGURATION

FRONT

NOSE

5

6

NOSE

4

BACK

TOP VIEW
1-14. DIFFERENCES BETWEEN MODELS

The differences between models are provided in this paragraph.

Table 1-1. Differences Between Models.

<table>
<thead>
<tr>
<th>Equipment/Function</th>
<th>Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M1113</td>
</tr>
<tr>
<td>Armament Mounting</td>
<td>X</td>
</tr>
<tr>
<td>S250 Shelter Configuration</td>
<td>X</td>
</tr>
<tr>
<td>Vehicle Winch (if equipped)</td>
<td>X</td>
</tr>
<tr>
<td>Basic Armor</td>
<td></td>
</tr>
<tr>
<td>Up-Armor</td>
<td>X</td>
</tr>
<tr>
<td>Howitzer Prime Mover</td>
<td></td>
</tr>
<tr>
<td>Integrated Armor Protection (IAP)</td>
<td></td>
</tr>
</tbody>
</table>
Vehicle performance data for the ECV vehicles is listed in Table 1-2. Information not covered can be found in TM-9-2320-387-10.

**Table 1-2. Tabulated Data.**

**NOTE**

Standard and metric measurements will be used in this table.  
A list of their abbreviations is provided below.

### TABULATED DATA ABBREVIATIONS

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>ABBREVIATION</th>
<th>MEASUREMENT</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampere</td>
<td>A</td>
<td>Liters Per Minute</td>
<td>L/m</td>
</tr>
<tr>
<td>Celsius</td>
<td>C</td>
<td>Maximum</td>
<td>max</td>
</tr>
<tr>
<td>Centimeter</td>
<td>cm</td>
<td>Maximum</td>
<td>max</td>
</tr>
<tr>
<td>Fahrenheit</td>
<td>F</td>
<td>Maximum</td>
<td>max</td>
</tr>
<tr>
<td>Gallon</td>
<td>gal</td>
<td>Millimeter</td>
<td>mm</td>
</tr>
<tr>
<td>Gallons Per Minute</td>
<td>gpm</td>
<td>Maximum</td>
<td>max</td>
</tr>
<tr>
<td>Horsepower</td>
<td>hp</td>
<td>Newton-Meter</td>
<td>N-m</td>
</tr>
<tr>
<td>Inch</td>
<td>in</td>
<td>Pint</td>
<td>pt</td>
</tr>
<tr>
<td>Kilogram</td>
<td>kg</td>
<td>Pound</td>
<td>lb</td>
</tr>
<tr>
<td>Kilometers Per Hour</td>
<td>kph</td>
<td>Pound-Feet</td>
<td>lb-ft</td>
</tr>
<tr>
<td>Kilometers Per Liter</td>
<td>km/L</td>
<td>Pounds Per Square Inch</td>
<td>psi</td>
</tr>
<tr>
<td>KiloPascal</td>
<td>kPa</td>
<td>Quart</td>
<td>qt</td>
</tr>
<tr>
<td>KiloWatt</td>
<td>kW</td>
<td>Revolutions Per Minute</td>
<td>rpm</td>
</tr>
<tr>
<td>Liters</td>
<td>L</td>
<td>Volt</td>
<td>V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>STANDARD</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PAYLOAD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1113</td>
<td>5,100 lb</td>
<td>2,313 kg</td>
</tr>
<tr>
<td>M1114</td>
<td>2,300 lb</td>
<td>1,043 kg</td>
</tr>
<tr>
<td>M1151</td>
<td>4,000 lb</td>
<td>1,814 kg</td>
</tr>
<tr>
<td>M1151A1</td>
<td>3,950 lb</td>
<td>1,792 kg</td>
</tr>
<tr>
<td>M1151A1 w/Perimeter B Kit</td>
<td>1,800 lb</td>
<td>816 kg</td>
</tr>
<tr>
<td>M1152</td>
<td>5,100 lb</td>
<td>2,313 kg</td>
</tr>
<tr>
<td>M1152A1</td>
<td>5,000 lb</td>
<td>2,268 kg</td>
</tr>
<tr>
<td>M1152A1 w/Perimeter B Kit</td>
<td>3,340 lb</td>
<td>1,515 kg</td>
</tr>
<tr>
<td>M1165</td>
<td>4,950 lb</td>
<td>2,245 kg</td>
</tr>
<tr>
<td>M1165A1</td>
<td>4,870 lb</td>
<td>2,209 kg</td>
</tr>
<tr>
<td>M1165A1 w/Perimeter B Kit</td>
<td>2,230 lb</td>
<td>1,012 kg</td>
</tr>
<tr>
<td>M1167</td>
<td>2,300 lb</td>
<td>1,043 kg</td>
</tr>
</tbody>
</table>

|                     |              |          |
| 2. CAPACITIES*      |              |          |
| Cooling System      | 27.25 qt     | 25.8 L   |
| Engine              |              |          |
| Crankcase Only      | 7 qt         | 6.6 L    |
| Crankcase and Filter| 8 qt         | 7.6 L    |
| Fuel Tank           | 25 gal.      | 94.6 L   |
| Differential (each) | 2 qt         | 1.9 L    |
| Transmission:       |              |          |
| Drain and Refill    | 7.7 qt       | 7.3 L    |
| W/Dry Converter     | 13.5 qt      | 12.8 L   |
| Transfer Case       | 3.35 qt      | 3.17 L   |
| Geared Hub          | 1 pt         | 0.47 L   |
| Steering Hydraulic System with Steering Cooler | (TM 9-2320-387-10) | |
| Brake Hydraulic System | 1.63 pt    | 0.77 L   |
| Brake Master Cylinder (Serial Numbers 2999999 and Below) | 1.12 pt | 0.53 L |
| Brake Master Cylinder (Serial Numbers 3000000 and Above) | 2.36 pt | 1.12 L |
| Windshield Washer Reservoir | 2.5 qt | 2.37 L |
| Geared Fan Drive    | 1.2 pt       | 0.57 L   |

*ALL HYDRAULIC SYSTEMS AND ALL FUEL CAPACITIES ARE CALCULATED APPROXIMATIONS
### ENGINE

<table>
<thead>
<tr>
<th>Standard</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>GM 6.5 L</td>
</tr>
<tr>
<td>Type</td>
<td>Diesel, Turbocharged Liquid-Cooled, V8</td>
</tr>
<tr>
<td>Brake Horsepower</td>
<td>190 hp @ 3,400 rpm 119.4 kW @ 3,400 rpm</td>
</tr>
<tr>
<td>Idle Speed</td>
<td>700 ± 25 rpm</td>
</tr>
<tr>
<td>Operating Speed</td>
<td>1,500-2,300 rpm</td>
</tr>
<tr>
<td>Oil Pressure @ Idle</td>
<td>20 psi</td>
</tr>
<tr>
<td>Oil Pressure @ Operating Speed</td>
<td>30-50 psi</td>
</tr>
</tbody>
</table>

### FUEL SYSTEM

- **Fuel Pump (Mechanical):**
  - Type: Cam-Driven Diaphragm
- **Fuel Filter:**
  - Type: Fuel/Water Separator
- **Air Cleaner:**
  - Type: Dry Element
- **Glowplug:**
  - Type: Fast Start

### COOLING SYSTEM

- **Surge Tank Cap Pressure:**
  - 15 psi 103 kPa
- **Thermostat:**
  - Starts to Open: 190°F 88°C
  - Fully Open: 212°F 100°C
- **Radiator:**
  - Type: Downflow
  - Fan: (Serial Numbers 299999 and Below)
    - Type: Ten Blade
    - Diameter: 19 in. 48.26 cm
  - Fan: (Serial Numbers 300000 and Above)
    - Type: Nine Blade
    - Diameter: 23 in. 58.0 cm

### ELECTRICAL SYSTEM

- **Alternator:**
  - Manufacturer: Neihoff
  - Model: 12447109
  - Output: 200 A @ 1,600 rpm (engine)
  - Rated Voltage: 24V/12V
- **Starter:**
  - Manufacturer: Prestolite
  - Model: MFY
  - Capacity: 9.5 hp
  - Voltage: 24 V
- **Batteries (2):**
  - Voltage: 12 V

### TRANSMISSION

- **Manufacturer:** Hydramatic
- **Model:** 4L80-E
- **Type:** 4-Speed, Automatic, Torque Converter Stall Ratio of 2.1 and Direct Drive w/Lock-Up Clutch in Fourth Gear
- **Gear Ratios:**
  - First: 2.48:1
  - Second: 1.48:1
  - Third: 1.00:1
  - Fourth: 0.75:1
  - Reverse: 2.08:1
- **Oil Type:** Dexron® VI
- **Oil Pressure:** 35-324 psi 241-2,234 kPa
### Table 1-2. Tabulated Data (Cont'd).

<table>
<thead>
<tr>
<th>Section</th>
<th>Standard</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8. TRANSFER CASE</strong> <em>(Serial Numbers 299999 and Below)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
<td>New Venture Gear</td>
<td></td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td>242 w/Intercooler</td>
<td></td>
</tr>
<tr>
<td><strong>Gear Ratios:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High and High Lock</td>
<td>1.0:1</td>
<td></td>
</tr>
<tr>
<td>Low Lock</td>
<td>2.72:1</td>
<td></td>
</tr>
<tr>
<td><strong>8.1. TRANSFER CASE</strong> <em>(Serial Numbers 300000 and Above)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
<td>Magna Powertrain</td>
<td></td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td>MP2226</td>
<td></td>
</tr>
<tr>
<td><strong>Gear Ratios:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High and High Lock</td>
<td>1.0:1</td>
<td></td>
</tr>
<tr>
<td>Low Lock</td>
<td>2.72:1</td>
<td></td>
</tr>
<tr>
<td><strong>9. DIFFERENTIAL</strong></td>
<td>AM General</td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Hypoid Gears</td>
<td></td>
</tr>
<tr>
<td><strong>Gear Ratio</strong></td>
<td>3.08:1</td>
<td></td>
</tr>
<tr>
<td><strong>10. GEARED HUB</strong></td>
<td>AM General</td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Spur Gears</td>
<td></td>
</tr>
<tr>
<td><strong>Gear Ratio</strong></td>
<td>1.92:1</td>
<td></td>
</tr>
<tr>
<td><strong>11. SERVICE BRAKE CALIPER (FRONT AND REAR)</strong> <em>(Serial Numbers 299999 and Below)</em></td>
<td>Kelsey-Hayes</td>
<td>66 mm</td>
</tr>
<tr>
<td><strong>Piston Diameter</strong></td>
<td>2.6 in.</td>
<td></td>
</tr>
<tr>
<td><strong>11.1. SERVICE BRAKE CALIPER (FRONT AND REAR)</strong> <em>(Serial Numbers 300000 and Above)</em></td>
<td>Wilwood</td>
<td>47.5 mm</td>
</tr>
<tr>
<td><strong>Piston Diameter</strong></td>
<td>1.870 in.</td>
<td></td>
</tr>
<tr>
<td><strong>12. SERVICE BRAKE ROTOR (FRONT AND REAR)</strong> <em>(Serial Numbers 299999 and Below)</em></td>
<td>Kelsey-Hayes</td>
<td>305 mm</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>12 in.</td>
<td>22 mm</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>0.866 in.</td>
<td></td>
</tr>
<tr>
<td><strong>12.1. SERVICE/PARKING BRAKE ROTOR (FRONT AND REAR)</strong> <em>(Serial Numbers 300000 and Above)</em></td>
<td>Wilwood</td>
<td>307 mm</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>12.08 in.</td>
<td>24 mm</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>0.945 in.</td>
<td></td>
</tr>
<tr>
<td><strong>13. PARKING BRAKE CALIPER</strong> <em>(Serial Numbers 300000 and Above)</em></td>
<td>Carlisle</td>
<td>24 mm</td>
</tr>
<tr>
<td><strong>Piston Diameter</strong></td>
<td>0.945 in.</td>
<td></td>
</tr>
<tr>
<td><strong>14. WHEELS AND TIRES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tire Size (Radial)</strong></td>
<td>37 in. x 12.5 in. x 16.5 in.</td>
<td>93.98 cm x 31.75 cm x 41.9 cm</td>
</tr>
<tr>
<td><strong>Wheels:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Offset Disc</td>
<td></td>
</tr>
<tr>
<td><strong>Runflat Insert:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Rubber</td>
<td></td>
</tr>
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</table>
Table 1-2. Tabulated Data (Cont'd).

<table>
<thead>
<tr>
<th>SERIAL NUMBERS</th>
<th>STEERING SYSTEM</th>
<th>STANDARD</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>246890 and Below</td>
<td>Steering Gear: Manufacturer: Delphi</td>
<td>13/16:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type: Variable Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ratio: 13/16:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power Steering Pump: Manufacturer: Delphi</td>
<td>1,450 psi</td>
<td>9,998 kPa</td>
</tr>
<tr>
<td></td>
<td>Model: 125</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output Pressure (max): 1,450 psi</td>
<td>9,998.4 kPa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacity (engine 1,500 rpm): 2.6 gpm</td>
<td>9.5 mm + 4.8 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flow Rate (max): 3.5 gpm</td>
<td>13.2 L/m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toe-In (Front/Rear @ Curb Weight): 0.375 in. + 0.1875 in.</td>
<td>11 mm ± 3.2 mm</td>
<td></td>
</tr>
<tr>
<td>Through 299999</td>
<td>Steering Gear: Manufacturer: Sheppard</td>
<td>13/16:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type: Variable Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ratio: 13/16:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power Steering Pump: Manufacturer: Delphi</td>
<td>1,450 psi</td>
<td>9,999.4 kPa</td>
</tr>
<tr>
<td></td>
<td>Model: 125</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output Pressure (max): 1,450 psi</td>
<td>9,999.4 kPa</td>
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<tr>
<td></td>
<td>Capacity (engine 1,500 rpm): 2.6 gpm</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Flow Rate (max): 3.5 gpm</td>
<td>13.2 L/m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toe-In (Front/Rear @ Curb Weight): 0.375 in. + 0.1875 in.</td>
<td>11 mm ± 3.2 mm</td>
<td></td>
</tr>
<tr>
<td>Above 300000</td>
<td>Steering Gear: Manufacturer: Sheppard</td>
<td>13/16:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type: Variable Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ratio: 13/16:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power Steering Pump: Manufacturer: PSS, Inc.</td>
<td>1,740 + 72.5 psi</td>
<td>11,997 ± 500 kPa</td>
</tr>
<tr>
<td></td>
<td>Model: 125</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output Pressure (max): 1,740 ± 72.5 psi</td>
<td>11,997 ± 500 kPa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacity (engine 1,500 rpm): 2.6 gpm</td>
<td>9.5 mm + 4.8 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flow Rate (max): 3.5 gpm</td>
<td>13.2 L/m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toe-In (Front/Rear @ Curb Weight): 0.375 in. + 0.1875 in.</td>
<td>11 mm ± 3.2 mm</td>
<td></td>
</tr>
</tbody>
</table>

16. FRAME
Manufacturer: AM General
Type: Box
No. of Crossmembers: Five

17. WINCH (optional)
Model: MIL-9000
Type: Electric Drive, Thermal Cutoff Switch
Capacity: 9,000 lb
Model: Mile Marker
Type: Hydraulic
Capacity: 10,500 lb

18. AIR-CONDITIONING COMPRESSOR
Manufacturer: Harrison
Model: 510
Field Coil: 24V
Section III. PRINCIPLES OF OPERATION

1-16. GENERAL

This section explains how components of the ECV series vehicles work together. The systems (functional groups) covered are listed in the Principles of Operation Reference Index, paragraph 1-17.

1-17. PRINCIPLES OF OPERATION REFERENCE INDEX

<table>
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<th>SYSTEM</th>
<th>PAGE NO.</th>
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<tr>
<td>1-19</td>
<td>Fuel System Operation</td>
<td>1-25</td>
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<tr>
<td>1-20</td>
<td>Cooling System Operation (Serial Numbers 299999 and Below)</td>
<td>1-26</td>
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<tr>
<td>1-20.1</td>
<td>Cooling System Operation (Serial Numbers 300000 and Above)</td>
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<td>1-21</td>
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<td>Generating System Operation (200 Ampere Alternator)</td>
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<td>1-23</td>
<td>Battery System Operation</td>
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<td>1-24</td>
<td>Windshield Wiper/Washer System Operation</td>
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<td>1-25</td>
<td>Service/Parking Brake System Operation</td>
<td>1-32</td>
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<tr>
<td>1-26</td>
<td>Service Brake System Operation</td>
<td>1-33</td>
</tr>
<tr>
<td>1-27</td>
<td>Steering Control System Operation (Serial Numbers 299999 and Below)</td>
<td>1-35</td>
</tr>
<tr>
<td>1-27.1</td>
<td>Steering Control System Operation (Serial Numbers 300000 and Above)</td>
<td>1-36.1</td>
</tr>
<tr>
<td>1-28</td>
<td>Suspension System Operation</td>
<td>1-37</td>
</tr>
<tr>
<td>1-29</td>
<td>Air-Conditioning System Operation (M1114)</td>
<td>1-38.1</td>
</tr>
<tr>
<td>1-29.1</td>
<td>Air-Conditioning System Operation (Two-Man)</td>
<td>1-38.2</td>
</tr>
<tr>
<td>1-29.2</td>
<td>Air-Conditioning System Operation (Four-Man)</td>
<td>1-38.4</td>
</tr>
<tr>
<td>1-30</td>
<td>200-Ampere Umbilical Power Cable</td>
<td>1-40</td>
</tr>
</tbody>
</table>
1-18. DRIVETRAIN OPERATION

The drivetrain is identical for both models covered in this manual. It converts horsepower into mechanical force to move the vehicle. Major components of the drivetrain are:

A. ENGINE – The 6.5 liter V-8 turbocharged engine develops approximately 190 horsepower at 3,400 rpm to power the vehicle. The engines are essentially the same on all models except those equipped with deep water fording kit installed, which adds a specially vented CDR valve. This difference does not affect engine performance.

B. TRANSMISSION – Adapts engine power to meet different driving conditions. The automatic transmission has four forward speeds, a reverse, a neutral, and a park. A neutral safety switch prevents the vehicle from being started with the transmission in any selector lever position except park and neutral.

C. TRANSFER CASE – Directs engine-to-transmission power to front and rear differentials simultaneously. This condition means the vehicle is always in four-wheel drive. The transfer case allows for selection of three drive ranges and a neutral position. A complete description of these driving ranges and the recommended driving conditions during which they are used can be found in TM 9-2320-387-10.

D. PROPELLER SHAFTS – Link transfer case to differentials. Universal joints, located at either end of the front and rear propeller shafts, permit inline driving power between the transfer case and differentials even though they are mounted at different angles.

E. DIFFERENTIALS – Transmit driving power, via halfshafts and geared hubs, to left and right wheels. The differential ensures power is applied to the wheel having traction, regardless of which wheel is slipping. This feature is called torque biasing.

F. HALFSHAFTS – Transmit power from differentials to geared hubs.

G. GEARED HUBS – Serve as the front wheel steering spindle and act as the final drive components to front and rear wheels.
1-19. FUEL SYSTEM OPERATION

The HMMWV diesel fuel system operation is identical for both models covered in this manual. The system cleans and supplies fuel for the engine. Major components of the fuel system are:

- **A** Fuel Pump – Draws fuel from fuel tank through the supply line and pumps it to the fuel filter.
- **B** Fuel Return Line – Carries unused fuel from the injection pump back to the fuel tank.
- **C** Fuel Supply Line – Carries fuel from fuel tank to the system.
- **D** Fuel Tank – Stores 25 gallons (95 liters) of diesel fuel.
- **E** Fuel Filler Cap – Located at right rear side of vehicle, the cap is removed to permit fuel tank servicing.
- **F** Fuel Injectors – Receive metered fuel from the injection pump and spray fuel into the combustion chambers.
- **G** Fuel Filter/Water Separator – Filters water and sediment from fuel before fuel enters the injection pump.
- **H** Injection Pump – Directs metered and pressurized fuel to the eight injector nozzles. It is mounted on top of the engine under the intake manifold.
1-20. COOLING SYSTEM OPERATION (SERIAL NUMBERS 299999 AND BELOW)

The cooling system removes excess heat from the engine, engine oil, transfer oil, and transmission oil. Major components of the cooling system are:

A **ENGINE TEMPERATURE SENDING UNIT** – Sends signal indicating coolant temperature to gauge on instrument cluster.

B **ENGINE TEMPERATURE SWITCH** – Sends signal to activate control valve system to operate fan when engine temperature exceeds 220°F (104°C) and deactivates when engine temperature drops below 190°F (88°C).

C **WATER CROSSOVER** – Collects coolant from cylinder heads and channels it to the thermostat housing where it is redirected through the cooling system.

D **THERMOSTAT** – Shuts off coolant return flow to radiator until temperature reaches 190°F (88°C). Coolant is then directed to the radiator through the radiator inlet hose.

E **RADIATOR** – Directs coolant through a series of fins and baffles so outside air can dissipate excess engine heat before the coolant is recirculated through the engine.

F **OIL COOLER** – Directs engine oil (lower half of cooler), power steering oil (lower half of cooler), and transmission oil (upper half of cooler) through a series of fins or baffles so outside air can remove heat from oil.

G **SURGE TANK** – Filling and expansion point for cooling system.

H **PERSONNEL HEATER** – Provides heat for personnel and interior of vehicle.
1-20. COOLING SYSTEM OPERATION (SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

**I** FAN – Pulls outside air through radiator to remove heat from coolant.

**J** HYDRAULIC CONTROL VALVE – Directs hydraulic fluid to provide required pressure to actuate fan clutch as required by engine temperature. Hydraulic pressure is supplied by power steering pump.

**K** TIME DELAY MODULE – Sends delayed signal to fan clutch solenoid for delay of fan actuation to provide needed horsepower for engine acceleration.

**L** FAN CLUTCH SOLENOID – Actuates hydraulic control valve as required by coolant temperature.

**M** WATER PUMP – Driven by serpentine belt, provides circulation of coolant through cooling system.

**N** FAN CLUTCH – Hydraulically actuated by pressure from hydraulic control valve to control operation of fan. Hydraulic pressure is supplied by power steering pump.

**O** DRAIN VALVE – Draining point for radiator and cooling system.

**P** RADIATOR SHROUD – Permits a greater concentration of air to be pulled through the radiator.
1-20.1. COOLING SYSTEM OPERATION (SERIAL NUMBERS 300000 AND ABOVE)

The cooling system removes excess heat from the engine, engine oil, transfer case oil, and transmission oil. Major components of the cooling system are:

A. **TRANSFER CASE** – Directs engine coolant through a series of fins or baffles so coolant can remove heat from transfer case oil.

B. **ENGINE TEMPERATURE SENDING UNIT** – Sends signal indicating coolant temperature to gauge on instrument cluster.

C. **WATER CROSSOVER** – Collects coolant from cylinder heads and channels it to the thermostat housing where it is redirected through the cooling system.

D. **THERMOSTAT** – Shuts off coolant return flow to radiator until temperature reaches 190°F (88°C). Coolant is then directed to the radiator through the radiator inlet hose.

E. **RADIATOR** – Directs coolant through a series of fins and baffles so outside air can dissipate excess engine heat before the coolant is recirculated through the engine.

F. **OIL COOLER** – Directs engine oil (lower half of cooler) and transmission oil (upper half of cooler) through a series of fins or baffles so outside air can remove heat from oil.

G. **SURGE TANK** – Filling and expansion point for cooling system.

H. **DIFFERENTIAL COOLER** – Directs engine coolant through a series of fins or baffles so coolant can remove heat from differential oil.
1-20.1. COOLING SYSTEM OPERATION (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

- **WATER PUMP** – Driven by serpentine belt, provides circulation of coolant through cooling system.
- **DRAINVALVE** – Draining point for radiator and cooling system.
- **GEARED FAN DRIVE** – Transmits engine power and torque to drive the radiator cooling fan and clutch.
- **FAN** – Pulls outside air through radiator to remove heat from coolant.
- **TWO-PIECE RADIATOR SHROUD** – Permits a greater concentration of air to be pulled through the radiator.

![Diagram of cooling system components](image-url)
1-21. STARTING SYSTEM OPERATION

The starting system is identical for both vehicles covered in this manual, and consists of the following components and circuits:

A **ROTARY SWITCH** – When in START position, provides battery power through neutral start switch to the starter solenoid circuit 14.

B **NEUTRAL STARTER SWITCH** – When transmission shift lever is in P (Park) or N (neutral) position, this switch closes allowing battery power to reach the starter solenoid.

C **PROTECTIVE CONTROL BOX** – Acts as a link between body harness and engine harness.

D **STARTER SOLENOID** – A magnetic relay that transmits 24-volt battery power to the starter motor.

E **STARTER MOTOR** – Cranks the engine for starting, and is supplied 24-volt battery power through circuit 6A.
1-22. GENERATING SYSTEM OPERATION

The 200-ampere generating system maintains battery charge and provides electrical power to operate vehicle circuits. Major components of the generating system are:

A. **BATTERY GAUGE** – Indicates electrical system voltage. It is connected to the electrical system through circuit 567.

B. **ALTERNATOR (200-AMPERE)** – Is rated at 28 volts at 200 amperes, and 14 volts at 50 amperes with external regulator. The alternator assists and recharges the vehicle batteries during operation.

C. **CIRCUIT 568** – Senses vehicle voltage, and activates the field current in the alternator circuit to alternator.

D. **PROTECTIVE CONTROL BOX** – Protects the vehicle electric system in the event battery polarity is reversed. Provides load dump, glow plug operation, and interfacing of engine body harnesses.

E. **CIRCUIT 2** – Sends AC signal, indicating alternator shaft rpm, to frequency switch in protective control box to prevent operation of starter solenoid when engine is running.

F. **BATTERIES** – Two 12-volt batteries are connected in a series to provide 24 volts to start vehicle and assist alternator during operation.

G. **POSITIVE CABLE 6** – Provides 28-volt alternator output to maintain charge across two batteries.

H. **POSITIVE CABLE 68A** – Provides 16-volt alternator output to maintain charge across the lower battery.

I. **CIRCUIT 3** – Connects to negative stud on alternator with engine ground strap to provide a ground circuit to alternator.
The battery system is identical for both vehicles covered in this manual and consists of the following circuits and components:

- **CIRCUIT 6A** - Connects the batteries to the starter and to the protective control box through circuit 81A.
- **BATTERIES** - Two 6TN batteries are connected to provide 24 volts DC for the electrical starting system.
- **SLAVE RECEPTACLE** - Links an external power source directly to the slaved vehicle's batteries to assist in cranking the engine when the vehicle's batteries are not sufficiently charged.
- **SHUNT** - Used when measuring current draw from batteries utilizing STE/ICE-R.
- **PROTECTIVE CONTROL BOX (PCB)** - Protects the vehicle electrical system if the battery system polarity is reversed. Provides frequency lockout, load dump, glow plug operation, and interfacing of engine body harnesses.
- **ROTOR SWITCH** - When in START position, actuates starter solenoid through circuits 11A and 74A. When in RUN position, closes circuit 29A to activate instrument cluster gauges through circuit 27.
- **CIRCUIT 7A** - Connects the starter negative terminal to engine ground while circuit 7E connects shunt to engine ground.
- **STARTER SOLENOID** - Actuates starter motor gear to crank vehicle engine.
1-24. WINDSHIELD WIPER/WASHER SYSTEM OPERATION

The following miscellaneous components and circuits are not covered in any of the other electrical systems:

A. WINDSHIELD WIPER MOTOR – When knob is turned to LOW or HIGH position, circuit 27 carries battery power to wiper motor to activate windshield wipers.

B. CIRCUIT 57 – Provides a ground circuit for wiper motor.

C. WINDSHIELD WASHER MOTOR – When knob on wiper motor is pushed, the washer motor is activated through circuit 71 to spray water onto windshield.
1-25. SERVICE/PARKING BRAKE SYSTEM OPERATION

The parking brake system is a mechanically-actuated system that provides a means of keeping the vehicle still once it stops. It also assists in emergency stopping if there is a complete service brake system failure. Major components of the parking brake system are:

A. PARKING BRAKE ROTORS – Attached to output flanges on rear differential, rotors prevent output flanges from turning when parking brake is applied.

B. BRAKE PADS – Apply friction to rotors when hand lever is applied.

C. PARKING BRAKE CALIPERS – Force brake pads against rotors when hand lever is applied.

D. PARKING BRAKE CABLES – Connect parking brake hand lever to equalizer bar.

E. EQUALIZER BAR – Evenly distributes braking pressure to the rear brake rotors.

F. PARKING BRAKE ROD – Connects parking brake hand lever to equalizer bar.

G. PARKING BRAKE HAND LEVER – Permits operator to engage the parking brake.

H. PARKING BRAKE HAND LEVER ADJUSTING CAP – Permits operator to make minor tension adjustment of parking brake.
1-26. SERVICE BRAKE SYSTEM OPERATION

The service brake system is identical for both models covered in this manual. It is an inboard-mounted, four-wheel, disc brake, hydraulically-assisted system. Major components of the braking system are:

A  BRAKE LINKAGE – Directs brake pedal pressure to hydro-booster.

B  HYDRO-BOOSTER – Converts hydraulic power from the steering pump to mechanical power to the master cylinder, providing power assist during braking.

C  MASTER CYLINDER/RESERVOIR – Stores brake fluid, and converts mechanical pedal pressure to hydraulic pressure.

D  PROPORTIONING VALVE – Provides balanced front-to-rear braking and activates brake warning lamp in case of brake system malfunction.

E  ACCUMULATOR – Stores hydraulic pressure for additional power-assisted braking in case of loss of pressure in steering system.

F  BRAKE PEDAL – Provides operator control for stopping vehicle.

G  BRAKE PRESSURE LIMITER – Limits front brake line pressure to prevent brake lockup.
1-26. SERVICE BRAKE SYSTEM OPERATION (Cont’d)

A HYDRAULIC BRAKE LINES – Direct brake fluid under pressure to all four brake calipers from master cylinder.

B BRAKE CALIPER – Converts hydraulic pressure to mechanical force to compress brake pads against brake rotors.

C BRAKE ROTOR – Attached to output flange on front and rear differentials. Rotor prevents output flange from turning when brakes are applied.

D BRAKE PADS – Apply friction to brake rotor when brake pedal is depressed.
The steering system is identical for both models covered in this manual. Major components of the steering system are:

A HYDRAULIC CONTROL VALVE – Directs hydraulic fluid to provide required pressure to actuate and deactuate fan clutch as required by engine temperature. Hydraulic pressure is supplied by power steering pump.

B HYDRO-BOOSTER – Converts hydraulic power from the steering pump to mechanical power to the master cylinder, providing power assist during braking.

C POWER STEERING COOLER – Is part of oil cooler which directs power steering fluid through a series of fins or baffles so outside air can dissipate excess heat before the fluid is recirculated through the steering system.

D SERPENTINE BELT – Transmits mechanical driving power from crankshaft drive pulley to steering pump pulley which drives the steering pump.

E OIL RESERVOIR AND STEERING PUMP – Combined in one unit, the reservoir serves as an oil filling point and the pump supplies the oil under pressure throughout the steering system.

F FAN CLUTCH – Hydraulically actuated and deactuated by the hydraulic control valve. The fan is actuated when hydraulic pressure is released, and deactuated when hydraulic pressure is applied. Hydraulic pressure is supplied by the power steering pump.
1-27. STEERING CONTROL SYSTEM OPERATION (SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

A STEERING WHEEL – Serves as manual steering control for the operator.

B STEERING COLUMN – Transmits turning effort from steering wheel to intermediate steering shaft.

C INTERMEDIATE STEERING SHAFT – Permits angle of torque from steering column to input shaft of power steering gear.

D STEERING GEAR – Converts hydraulic power from steering pump to mechanical power at pitman arm.

E PITMAN ARM – Transfers steering torque from power steering gear to center link.

F TIE ROD ASSEMBLY – Transmits movement from center link to geared hub.

G GEARED HUB – Serves as the pivot point and link for the front wheels via the tie rod assembly.

H CENTER LINK – Transmits movement from pitman arm to tie rods.

I IDLER ARM – Supports right side of center link.
1-27.1. STEERING CONTROL SYSTEM OPERATION (SERIAL NUMBERS 300000 AND ABOVE)

Major components of the steering system are:

A. **OIL RESERVOIR** – The oil reservoir serves as an oil filling point.

B. **HYDRO-BOOSTER** – Converts hydraulic power from the steering pump to mechanical power to
   the master cylinder, providing power assist during braking.

C. **STEERING GEAR** – Converts hydraulic power from steering pump to mechanical power at
   pitman arm.

D. **POWER STEERING COOLER** – Directs power steering fluid through a series of fins or baffles so
   outside air can dissipate excess heat before the fluid is recirculated through the steering system.

E. **SERPENTINE BELT** – Transmits mechanical driving power from crankshaft drive pulley to
   steering pump pulley which drives the steering pump.

F. **STEERING PUMP** – Supplies the oil under pressure throughout the steering system.
1-27.1. STEERING CONTROL SYSTEM OPERATION (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

A **STEERING WHEEL** – Serves as manual steering control for the operator.

B **STEERING COLUMN** – Transmits turning effort from steering wheel to intermediate steering shaft.

C **INTERMEDIATE STEERING SHAFT** – Permits angle of torque from steering column to input shaft of power steering gear.

D **STEERING GEAR** – Converts hydraulic power from steering pump to mechanical power at pitman arm.

E **PITMAN ARM** – Transfers steering torque from power steering gear to center link.

F **TIE ROD ASSEMBLY** – Transmits movement from center link to geared hub.

G **GEARED HUB** – Serves as the pivot point and link for the front wheels via the tie rod assembly.

H **CENTER LINK** – Transmits movement from pitman arm to tie rods.

I **IDLER ARM** – Supports right side of center link.
1-28. SUSPENSION SYSTEM OPERATION

The suspension system is identical for both models covered in this manual. It is an independent coil spring-type system. Major components of the suspension system are:

A BALL JOINTS – Connect geared hub to control arms, and allows change of angle between geared hub and control arms during suspension movement.

B UPPER CONTROL ARM – Connects geared hub to frame rail.

C STABILIZER BAR (FRONT ONLY) – Prevents vehicle sway when cornering.

D GEARED HUB – Serves as a mounting point for wheel and tire assembly and provides 1.92:1 gear reduction to increase torque to wheel and tire assembly.

E LOWER CONTROL ARM – Connects geared hub to frame rail.

F SHOCK ABSORBER – Dampens suspension movement and limits amount of suspension travel.

G COIL SPRING – Supports weight of vehicle and allows suspension travel to vary depending on terrain and vehicle loading.
A RADIUS Rod (REAR ONLY) – Connects geared hub to frame to maintain rear end alignment.
The M114 air-conditioning system consists of the following major components:

A. **DISCHARGE LINE** – High-pressure gas is carried through the discharge line from the compressor to the condenser.

B. **COMPRESSOR** – Inside the compressor, low-pressure gas refrigerant is compressed into a high-pressure gas that is pushed into the condenser by the compressor.

C. **SUCTION LINE** – Refrigerant, in low-pressure gas form, is drawn from the evaporator by the suction action of the compressor.

D. **EXPANSION VALVE** – High-pressure liquid refrigerant enters a nonadjustable expansion valve where the refrigerant is formed into a liquid spray.

E. **EVAPORATOR** – Refrigerant enters evaporator as a liquid spray. It absorbs heat from the air in the crew compartment and vaporizes into a low-pressure gas.

F. **LIQUID LINE** – High-pressure liquid refrigerant is carried back to the evaporator by the liquid line to repeat the evaporation/condensation cycle.

G. **CONDENSER** – Refrigerant enters the condenser as a high-pressure gas. When condensed, it gives up its heat to the outside air and becomes a high-pressure liquid.
The Two-Man air-conditioning system consists of the following major components:

A **COMPRESSOR** – Inside the compressor, low-pressure gas refrigerant is compressed into a high-pressure gas that is pushed into the condenser by the compressor.

B **DISCHARGE LINE** – High-pressure gas is carried through the discharge line from the compressor to the condensers.

C **RECEIVER-DRYER** – The primary function of the receiver-dryer is to separate gas and liquid. The secondary purpose is to remove moisture and filter out dirt.

D **CONDENSER** – Refrigerant enters the condenser as a high-pressure gas. When condensed, it gives up its heat to the outside air and becomes a high-pressure liquid.

E **LIQUID LINE** – High-pressure liquid refrigerant is carried back to the evaporator by the liquid line to repeat the evaporation/condensation cycle.

F **THERMAL EXPANSION VALVE** – This type of valve senses both temperature and pressure. High-pressure liquid refrigerant enters expansion valve where the refrigerant is formed into a liquid spray.

G **EVAPORATOR** – Refrigerant enters evaporator as a liquid spray. It absorbs heat from the air in the crew compartment and vaporizes into a low-pressure gas.

H **SUCTION LINE** – Refrigerant, in low-pressure gas form, is drawn from the evaporator by the suction action of the compressor.
1-29.1. AIR-CONDITIONING SYSTEM OPERATION (TWO-MAN) (Cont’d)
1-29.2. AIR-CONDITIONING SYSTEM OPERATION (FOUR-MAN)

The Four-Man air-conditioning system consists of the following major components:

A. **COMPRESSOR** – Inside the compressor, low-pressure gas refrigerant is compressed into a high-pressure gas that is pushed into the condenser by the compressor.

B. **DISCHARGE LINE** – High-pressure gas is carried through the discharge line from the compressor to the condensers.

C. **RECEIVER-DRYER** – The primary function of the receiver-dryer is to separate gas and liquid. The secondary purpose is to remove moisture and filter out dirt.

D. **CONDENSERS** – Refrigerant enters the condenser as a high-pressure gas. When condensed, it gives up its heat to the outside air and becomes a high-pressure liquid.

E. **LIQUID LINE** – High-pressure liquid refrigerant is carried back to the evaporator by the liquid line to repeat the evaporation/condensation cycle.

F. **THERMAL EXPANSION VALVE** – This type of valve senses both temperature and pressure. High-pressure liquid refrigerant enters expansion valve where the refrigerant is formed into a liquid spray.

G. **EVAPORATORS** – Refrigerant enters evaporator as a liquid spray. It absorbs heat from the air in the crew compartment and vaporizes into a low-pressure gas.

H. **SUCTION LINE** – Refrigerant, in low-pressure gas form, is drawn from the evaporator by the suction action of the compressor.
1-30. 200-AMPERE DUAL VOLTAGE UMBILICAL POWER CABLE

The 200-ampere dual voltage umbilical power cable covered in this manual applies to the M113, M1152, and M1152A1 and consists of the following major component:

A POWER CABLE – located behind the companion seat, provides power for shelter equipment.
CHAPTER 2
SERVICE AND TROUBLESHOOTING (UNIT) INSTRUCTIONS

Section I. REPAIR PARTS, SPECIAL TOOLS, TEST, MEASUREMENT, DIAGNOSTIC EQUIPMENT (TMDE), AND SUPPORT EQUIPMENT

2-1. COMMON TOOLS AND EQUIPMENT

For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE) applicable to your unit.

2-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

Special Tools, Test, Measurement, and Diagnostic Equipment (TMDE), and Support Equipment used to maintain the vehicles covered in this manual can be found in TM 9-2320-387-24P. Calibrate all measuring and test equipment used to determine equipment conformance in accordance with TB 43-1800.

2-3. FABRICATED TOOLS

Fabricated tools needed to maintain the equipment in this manual can be found in appendix D. These tools are not available for issue, but must be fabricated and applied by unit, direct, and general support personnel only.

2-4. REPAIR PARTS

Repair parts are listed and illustrated in TM 9-2320-387-24P.

Section II. SERVICE UPON RECEIPT

2-5. GENERAL

a. Upon receipt of a new, used, or reconditioned vehicle, you must determine if the vehicle has been properly prepared for service. The following steps should be followed:
   (1) Inspect all assemblies, subassemblies, and accessories to ensure they are in proper working order.
   (2) Secure, clean, lubricate, or adjust as needed.
   (3) Check all basic issue items (TM 9-2320-387-10) to ensure every item is present, in good condition, and properly mounted or stowed.
   (4) Follow general procedures for all services and inspections given in TM 9-2320-387-10.

b. The operator will assist when performing service upon receipt inspections.

c. See TM 9-2320-387-10 when checking equipment for proper operation.

d. Refer to TM 9-2320-387-10 for information concerning break-in procedures.
2-6. GENERAL INSPECTION AND SERVICING INSTRUCTIONS

The following steps should be taken while performing general inspection and services:

**WARNING**

Protective eye equipment (goggles/shield) must be worn when removing snaprings or springs. Failure to comply may result in injury to personnel.

**NOTE**

Cooler fin and engine protective covers can be used to prevent damage to the vehicle components during maintenance. Refer to appendix D, figures D-40 and D-41 for fabrication instructions.

1. Use TM 9-2320-387-10 as well as other sections of this manual when servicing and inspecting equipment.

**WARNING**

Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

2. Clean all exterior surfaces coated with rust-preventive compounds. Use drycleaning solvent (appendix C, item 26).

3. Clean fittings before lubrication. Clean parts with drycleaning solvent (SD), type II, or equivalent. Dry before lubricating. Relubricate all items found contaminated after fording.

4. Inspect electrical connectors for corrosion and/or damage (i.e., bent pins). Clean and repair damage. Apply sealing compound (appendix C, item 60) before reconnecting plugs.

5. Read Processing and Deprocessing Record of Shipping, Storage, and Issue of Vehicles and Spare Engines, tag (DD Form 1397) and follow all precautions listed. This tag should be attached to steering wheel, steering column, or rotary switch.

2-7. SPECIFIC INSPECTION AND SERVICING INSTRUCTIONS

The following steps should be taken while performing specific inspections and services:

1. Do the semiannual preventive maintenance checks and services listed in section III in this chapter.

2. Lubricate the vehicle. Do not lubricate gear cases and engine unless processing tag states that the oil is unsuitable for 500 mi (805 km) operation. If oil is suitable, just check level.

3. Schedule semiannual service on DD Form 314 (Preventive Maintenance Schedule and Record Card).

4. If vehicle is delivered with a dry, charged battery, activate it according to TM 9-6140-200-14.

5. Check vehicle coolant level and determine if solution is proper for climate (refer to TB 750-651 for preparation of antifreeze solutions).

6. Remove towing brackets from their stowed position behind the bumper and install them in their proper location [para. 9-2].
Section III. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

2-8. GENERAL

NOTE

The army has an agreement with the door manufacturer to issue free patch kits to repair armor doors that exhibit cracks originating from the window area (M1114 doors only). If you find cracks that extend 1.25 in. (31.75 mm) from either side or 6.25 in. (158.75 mm) below the window opening, contact TACOM, Light Truck Group, AMSTA-LC-CHLA, Warren, MI 48397-5000 at DSN 786-4389 or Commercial 586-574-3806, or E-mail uparmoredhmmwv@tacom.army.mil for guidance on obtaining a kit.

The best way to maintain vehicles covered by this manual is to inspect them on a regular basis so minor faults can be discovered and corrected before they result in serious damage, failure, or injury. All intervals are based on normal operation. Hard time intervals may be shortened if lubricants are contaminated or if you are operating the equipment under adverse conditions, including longer-than-usual operating hours. Hard-time intervals may be extended during periods of low activity, though adequate preservation precautions must be taken. This section contains systematic instructions of inspection, adjustment, lubrication, and correction of vehicle components to avoid costly repairs or major breakdowns. This is Preventive Maintenance Checks and Services (PMCS).

2-9. INTERVALS

a. Unit maintenance, assisted by operator/crew, will perform checks and services contained in table 2-1 at the following intervals:

(1) Semiannually. Every 6 months or 3,000 miles (4,828 km), whichever comes first.
(2) Annually. Every 12 months or 6,000 miles (9,656 km), whichever comes first.
(3) Biennially. Every 24 months or 12,000 miles (19,310 km), whichever comes first.

b. Refer to following steps when performing lubrication checks and services:

(1) Intervals. Lubrication services coincide with the vehicle's semiannual preventive maintenance service. For this purpose, a 10% tolerance (variation) in specified lubrication point mileage is permissible. Those vehicles not accumulating 1,000 mi (1,609 km) in a 6-month period will be lubricated at the time of semiannual preventive maintenance service.

(2) For Operation of Equipment in Protracted Cold Temperatures Below -15°F (-26°C). Remove lubricants prescribed in lubrication table for temperatures above -15°F (-26°C). Relubricate with lubricants specified in lubrication table for temperatures below -15°F (-26°C). If OEA lubricant is required, see the temperature ranges prescribed in the lubrication table. OEA lubricant is to be used in place of OE/HDO 10 lubricant for all temperature ranges where OE/HDO 10 is specified in the lubrication table.

c. Perform all semiannual inspections in addition to annual inspections at the time of the annual inspection. Perform all annual and semiannual inspections in addition to biennial inspections at the time of the biennial inspection.

2-10. REPORTING REPAIRS

All vehicle shortcomings will be reported on DA form 2404 (DA Pam 750-8), Equipment Inspection and Maintenance Worksheet, immediately after the PMCS, and before taking corrective action. All vehicle deficiencies will be reported in the equipment record.
2-11. GENERAL SERVICE AND INSPECTION PROCEDURES

a. While performing specific PMCS procedures, ensure items are correctly assembled, secure, not worn, serviceable, not leaking, and adequately lubricated as defined below:

(1) An item is CORRECTLY ASSEMBLED when it is in proper position and all parts are present.
(2) When wires, nuts, washers, hoses, or attaching hardware cannot be moved by hand, they are SECURE.
(3) An item is WORN if there is too much play between joining parts or when marking data, warning, and caution plates are not readable.
(4) An item is UNSERVICEABLE if it is worn beyond repair and is likely to fail before the next scheduled inspection.
(5) LEAKS. TM 9-2320-387-10 contains definitions of class I, II, and III leaks and their effect on vehicle operation.
(6) If an item meets the specified lubrication requirements, then it is ADEQUATELY LUBRICATED.

b. Where the instruction tighten appears in a procedure, you must tighten with a wrench to the given torque value even when the item appears to be secure.

**WARNING**

Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

c. Where the instruction clean appears in a procedure, you must use drycleaning solvent (appendix C, item 26) to clean grease or oil from metal parts. After the item is cleaned, rinsed, and dried, apply a light grade of oil to unprotected surfaces to prevent rusting.

d. Clean rubber and plastic materials with soap and water. Refer to TM 9-2320-387-10 for general vehicle cleaning instructions.

2-12. SPECIFIC PMCS PROCEDURES

a. The preventive maintenance for which you are responsible is provided in table 2-1. The checks and services listed are arranged in logical order, requiring minimal time and effort on your part.

b. The following columns read across on the PMCS schedule:

(1) **Item Number.** Provides logical order of PMCS performance and is used as a source number for DA Form 2404, on which your PMCS results will be recorded.

(2) **Interval.** Shows the interval next to each item number to indicate when that check is to be performed. The interval will be repeated when consecutive item numbers are to be inspected during the same interval. Interval columns include:

(a) Semiannual (six month) checks;
(b) Annual (yearly) checks; and
(c) Biennial (every two years) checks.

(3) **Item To Be Inspected.** Lists the system, common name, or location of the item to be inspected.

(4) **Procedures.** Provides instructions for servicing, inspection, lubrication, replacement, or adjustment and, in some cases, having item repaired at a higher level.

**NOTE**

Always do your preventive maintenance checks and services in the order prepared. Once it gets to be a habit, you will be able to spot anything wrong in a hurry.

(5) **Not Fully Mission Capable If.** If vehicle meets criteria in this column, vehicle is Not Mission Capable (NMC).
# Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV.

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>PRIOR TO ROAD TEST</strong></td>
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<td></td>
<td>Ensure operator/crew has performed PMCS listed in TM 9-2320-387-10.</td>
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<td></td>
<td><strong>ROAD TEST</strong></td>
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<td></td>
<td>Maintenance personnel will be with vehicle operator to assist in perform-</td>
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<td>ing PMCS checks and verify pre-service checks.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Semi-annually</td>
<td>Pre-Service Checks</td>
<td>a. Notice if starter engages smoothly and turns the engine at normal cranking speed.</td>
<td>a. Starter inoperative or makes excessive grinding sound.</td>
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<td></td>
<td></td>
<td></td>
<td>b. Listen for unusual noise at idle, at operating speed, and under acceleration. Be alert for excessive vibration and the smell of oil, fuel, and exhaust.</td>
<td>b. Engine knocks, rattles, or smokes excessively.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>c. Check for transmission response to shifting and for smoothness of operation in all gear ranges. Be alert for unusual noises and difficulty in shifting in any speed range.</td>
<td>c. Transmission shifts improperly, does not shift, or makes excessive noises.</td>
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<td><strong>NOTE</strong></td>
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<td>If desired transfer case gear range cannot be selected, turn engine off, shift transmission to neutral or park, select transfer case range, and restart engine.</td>
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<td></td>
<td>d. Check for transfer response to shifting and for smoothness of operation in all gear ranges. Be alert for unusual noises and difficulty in shifting in any gear range.</td>
<td>d. Transfer jumps out of gear or makes excessive noises.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>e. Test for response to accelerator feed. Observe for sticking pedal.</td>
<td>e. Pedal sticking or binding.</td>
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<td>f. With vehicle speed at approximately 5 mph (8 kph), turn steering wheel to left, then right, to detect hard steering, steering backlash, or shimmy. Vehicle should respond instantly. With vehicle moving on straight, level terrain, lightly hold steering wheel to check for pull and wandering.</td>
<td>f. Steering binds, grabs, wanders, or has excessive free play.</td>
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<td></td>
<td>g. Apply brake pedal with steady force. Vehicle should slow and stop without pulling to one side or jerking. Release brake pedal. The brakes should release immediately and without difficulty.</td>
<td>g. Brakes chatter, pull to one side, or inoperative. Brakes will not release.</td>
</tr>
</tbody>
</table>
### Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td><strong>h.</strong> Bring vehicle to full stop. Engage parking brake while transmission is still in (overdrive). Vehicle should remain stationary.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Semi-annually</td>
<td>Pre-Service Checks</td>
<td><strong>i.</strong> Observe vehicle response to road shock. Side sway or continuous bouncing indicates a malfunction.</td>
<td><strong>h.</strong> Parking brake doesn’t hold vehicle stationary.</td>
</tr>
<tr>
<td>2</td>
<td>Semi-annually</td>
<td>Body</td>
<td><strong>a.</strong> Make sure the vehicle has been cleaned of mud, gravel, etc., from the underbody, outside, and crew compartment area.</td>
<td><strong>b.</strong> Thoroughly wash all underbody sheet metal panels and corners.</td>
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<td></td>
<td></td>
<td></td>
<td><strong>b.</strong> Make sure the vehicle has been cleaned of mud, gravel, etc., from the underbody, outside, and crew compartment area.</td>
<td><strong>c.</strong> Any body damage that would hinder vehicle operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>c.</strong> Inspect for loose rivets, cracks, loose or missing bolts, and general body damage.</td>
<td><strong>d.</strong> Inspect armor doors (all vehicles except M1114) for cracks. If cracks are found, notify your supervisor.</td>
</tr>
<tr>
<td>2.1</td>
<td>Semi-annually</td>
<td>Armor (M1114)</td>
<td><strong>a.</strong> Inspect for gaps between armor components that could degrade armor system protection capabilities.</td>
<td><strong>NOTE</strong> Gaps between vehicle armor panels that could allow penetration of a projectile or shrapnel could degrade armor system protection capabilities.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td><strong>b.</strong> Inspect armor doors for cracks. If cracks are found, see note in para. 2-8 and notify your supervisor.</td>
<td><strong>NOTE</strong> Any gap between armor components that could allow penetration of a projectile or shrapnel.</td>
</tr>
</tbody>
</table>
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
</table>
| 3       | Semi-annually   | Fuel System           | a. Inspect fuel filter/water separator assembly for dents and cracks that could cause leaks.  
|         |                 |                       | b. Inspect fuel injection pump, nozzle lines, and fittings for leaks and damage.  
|         |                 |                       | c. Inspect rear fuel injector nozzle rubber cap for presence and condition.  
|         |                 |                       | d. Inspect all fuel lines for loose connections, splits, cracks, and bends that could leak.  
|         |                 |                       | e. Disconnect the leads from each glow plug [para. 3-39] and check for continuity between glow plug terminal and ground. Continuity should be present.  
|         |                 |                       | f. Deleted  
|         |                 |                       | g. Deleted  
| 4       | Semi-annually   | Engine Accessory Drivebelt | Check for missing, broken, cracked, or frayed serpentine drivebelt.  
|         |                 |                       | d. Any class III leak.  
|         |                 |                       | e. Continuity is not present.  

![Fuel/Water Separator Diagram]  
Serpentine drivebelt is missing or broken. Belt fiber has more than one crack 1/8 in. (3.2 mm) in depth, or 50% of belt thickness, or has frays more than 2 in. (5 cm) long.
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Semi-annually</td>
<td>Protective Control Box</td>
<td>a. Inspect four bolts for security of mounting.</td>
<td>a. Mounting not secure, four bolts loose.</td>
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<td></td>
<td></td>
<td></td>
<td>b. Ensure cannon plugs are securely connected to box.</td>
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</tbody>
</table>
| 6       | Semi-annually | Cooling System           | **WARNING**

If vehicle has been operating, use extreme care to avoid being burned when removing cooling system radiator cap. Use heavy rags or gloves to protect hands. Turn radiator cap only one-half turn counterclockwise and allow pressure to be released before fully removing cap.

**CAUTION**

- Type 1, ethylene glycol (green), and Type 2, propylene glycol (purple), should never be mixed due to their difference in toxic properties. Failure to comply may result in damage to equipment.
- Using antifreeze without mixing it with water can cause high operating temperatures, blockage of cooling system passages, and damage to water pump seals.
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
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</tr>
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<tbody>
<tr>
<td>6</td>
<td>Semi-annually</td>
<td>Cooling System (Cont’d)</td>
<td><strong>NOTE</strong></td>
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<td></td>
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<td>• Coolant level is correct when coolant recovery tank is at the full mark (TM 9-2320-387-10).</td>
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<td>• Type 1 antifreeze is an ethylene glycol based coolant, green in color. Type 1 can be added to factory-filled pink coolant. When it becomes necessary to flush factory coolant, Type 1, ethylene glycol, will be used. When mixing Type 1 antifreeze with water, distilled water is recommended. Tap water should only be used in emergency situations.</td>
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<td></td>
<td><strong>a.</strong> Check coolant condition. Test coolant to see if draining is necessary (TB 750-651).</td>
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<td></td>
<td><strong>b.</strong> Inspect surge tank, radiator shroud, power steering cooler, oil cooler, all hoses, quick disconnects, and fittings for security of mounting, leaks, and deterioration. Inspect and clean as necessary the radiator and oil cooler cores.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Semi-annually</td>
<td>Air-Intake System</td>
<td><strong>WARNING</strong></td>
<td></td>
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<td></td>
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<td>If NBC exposure is suspected, all air filter media should be handled by personnel wearing protective equipment. Consult your unit NBC officer or NBC NCO for appropriate handling or disposal instructions.</td>
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<tr>
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<td></td>
<td><strong>a.</strong> Inspect and clean air cleaner element and housing (para. 3-13).</td>
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<td><strong>b.</strong> Check CDR valve oil saturation. Disconnect CDR valve oil fill tube hose from CDR valve and inspect. Some oil accumulation in the CDR valve is acceptable.</td>
<td></td>
</tr>
</tbody>
</table>
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
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<tbody>
<tr>
<td>7</td>
<td>Semi-annually</td>
<td>Air-Intake System (Cont’d)</td>
<td><strong>CAUTION</strong>&lt;br&gt;Do not clean CDR valve with solvent. This will damage the diaphragm inside the CDR valve. Wiping with a rag is the only authorized method of cleaning.&lt;br&gt;&lt;br&gt;<strong>c.</strong> Remove and wipe off the CDR valve and hoses with a rag.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Semi-annually</td>
<td>200-Amp Alternator</td>
<td><strong>a.</strong> Inspect alternator and voltage regulator for condition, proper installation, and security of mounting. &lt;br&gt;<strong>b.</strong> Inspect electrical wiring for broken strands; frayed, cracked, or worn insulation; and loose connections. &lt;br&gt;<strong>c.</strong> Check pulley for damage. &lt;br&gt;<strong>d.</strong> Deleted</td>
<td><strong>a.</strong> Mounting bolts missing or alternator damaged. &lt;br&gt;<strong>b.</strong> Wiring frayed, broken, or loose connections &lt;br&gt;<strong>c.</strong> Pulley damaged or pulley nut is loose.</td>
</tr>
<tr>
<td>9</td>
<td>Semi-annually</td>
<td>Accelerator Linkage</td>
<td><strong>Deleted</strong>&lt;br&gt;Inspect for bends, excessive play, cracks, and damage that could cause failure.</td>
<td><strong>Linkage damaged, bent, or cracked.</strong></td>
</tr>
<tr>
<td>10</td>
<td>Semi-annually</td>
<td>Suspension and Steering System</td>
<td><strong>a.</strong> Deleted &lt;br&gt;<strong>b.</strong> Deleted &lt;br&gt;<strong>c.</strong> Deleted</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Semi-annually</td>
<td>Suspension and Steering System (Cont’d)</td>
<td><strong>NOTE</strong> Do not lubricate shock absorber bushings, radius rod bushings, stabilizer bar bushing, or suspension arm pivot bushing.</td>
<td>d. Control arm bent, bushing worn, or obvious damage that would hinder operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d. Inspect control arms, control arm bushings, springs, shock absorbers, and bracket for damage.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>e. Inspect steering column U-joints, tie rods or radius rods, pitman arm, center link, and idler arm for breaks, cracks, and wear.</td>
<td>e. U-joints, tie rods, pitman arm, or idler arm are worn or cracked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>f. Tighten steering gear mounting bolts to 60 lb-ft (81 N·m). With vehicle started and transmission in PARK, turn steering wheel right and left and observe steering gear for movement.</td>
<td>f. Any mounting bolt missing or unserviceable or movement in steering gear.</td>
</tr>
</tbody>
</table>

**Diagram:**
- Control arm
- Bracket
- Shock absorber
- Ball joint
- Springs
- Center link
- Idler arm
- Pitman arm
- Tie rod
- Ball joint
- Control arm bushing

**Note:** Do not lubricate shock absorber bushings, radius rod bushings, stabilizer bar bushing, or suspension arm pivot bushing.
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Semi-annually</td>
<td>Suspension and Steering System (Cont’d)</td>
<td>g. Inspect power steering pump, power steering gear, hydraulic control valve, hoses, lines, and fittings for leaks or damage.</td>
<td>g. Any class III leak. Any component damaged.</td>
</tr>
<tr>
<td>11</td>
<td>Semi-annually</td>
<td>Brake System</td>
<td>a. Inspect master cylinder, hydro-booster, proportioning valve, pressure limiter, lines, and fittings for leaks and damage.</td>
<td>a. Any leak. Plugged, broken, or damaged lines and fittings.</td>
</tr>
</tbody>
</table>

**CAUTION**
- Use MIL-B-46176, Brake Fluid Silicone (BFS) for filling master brake cylinder. Failure to use BFS may cause damage to brake cylinder.
- Thoroughly clean exterior of master cylinder cover before removing cover. Dirt, water, or grease will contaminate brake fluid, causing brake system damage.
- Do not use screwdriver to remove cover. Damage to bail wire may result (S/N 299999 and below).
- To prevent excessive fluid spillage, ensure that rubber diaphragm is completely seated before installing cover to master cylinder.

**NOTE**
- Remove cover from brake master cylinder by moving bail wire using thumb pressure only (S/N 299999 and below).
- Remove cover from brake master cylinder by turning cover counter clockwise (S/N 300000 and above).
- Perform step b. for S/N 299999 and below and step b.1 for S/N 300000 and above.

**b.** Check master cylinder brake fluid level. Level should be 1/8 in. (3.2 mm) from top of master cylinder reservoir. Fill with BFS as necessary.

**b.1.** Check master cylinder brake fluid level. Level should be 1/8 in. (3.2 mm) from “mid” line of master cylinder reservoir. Fill with BFS as necessary.
### Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Semi-annually</td>
<td>Brake System (Cont’d)</td>
<td>c. Inspect service brake pads and service brake rotors for wear [para. 7-3] or [para. 7-3.1].</td>
<td>c. Service brake pads less than 1/8-in. (3.2 mm) (S/N 299999 and below), or less than 3/16-in. (4.8 mm) (S/N 300000 and above). Service brake rotors less than 13/16-in. (20.7 mm) (S/N 299999 and below), or less than 29/32-in. (22.9 mm) (S/N 300000 and above).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c.1. Inspect brake calipers for fluid leaks [para. 7-4] or [para. 7-4.1].</td>
<td>c.1. Any leaks.</td>
</tr>
</tbody>
</table>

**Diagrams:**
- **S/N 299999 AND BELOW**
  - **S/N 300000 AND ABOVE**

**Procedures:**
- d. Inspect rear dual service/parking brake pads and rotors for wear [para. 7-12] or [para. 7-12.1].
- d. Parking brake pads less than 1/8-in. (3.2 mm). Service brake rotors less than 13/16 in. (20.7 mm) (S/N 299999 and below) or less than 29/32-in. (22.9 mm) (S/N 300000 and above).
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Semi-annually</td>
<td>Brake System (Cont’d)</td>
<td>e. Inspect parking brake cable, cable clip, lever, spring, and pushrod/guide pin for binding and loose components.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>f. Inspect left and right parking/service brake assembly mounted between rear axle halfshafts and rear differential. Lubricate parking brake lever with grease (Appendix C, Item 32). Parking/service brake assembly needs no lubrication.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>g. Inspect rear parking brake cables for damage and/or chaffing in the area of the control arm. If cables are damaged, replace cables (paras. 7-16 and 7-17).</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Semi-annually</td>
<td>Engine and Transmission Mounts</td>
<td>a. Inspect engine mounts and insulators for cracks, loose, worn, or damaged condition.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Check for loose or missing engine mount capscrews and locknuts. If engine mount capscrews or locknuts are loose or missing, notify DS maintenance. (Refer to para. 15-3).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Deleted</td>
<td></td>
</tr>
</tbody>
</table>

TM 9-2320-387-24-1
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
</table>
| 13       | Semi-annually  | Starter              | **CAUTION**  
 a. Deleted  
b. Inspect cables and studs for loose nuts and damage. | b. Stud nut loose. |
| 14       | Semi-annually  | Transmission         | a. Inspect vent lines and connectors for security, cracks, and deterioration.  
b. Inspect transmission shift linkage for bends, excessive play, cracks, and damage that could cause failure. | a. Vent line cracked, plugged, or missing.  
b. Shift linkage is unserviceable. |
| 15       | Semi-annually  | Transfer Case        | a. Inspect transfer case vent lines and connectors for security, cracks, and deterioration.  
b. Inspect transfer case shift linkage for bends, excessive play, cracks, and damage that could cause failure.  
c. Deleted  
d. Deleted | a. Vent line cracked, plugged, or missing.  
b. Shift linkage is unserviceable. |
| 16       | Semi-annually  | Driveline Components | a. Inspect geared hub vent lines and connectors for security, cracks, and deterioration.  
b. Inspect geared hub for leaking seals and damage.  
c. Deleted  
d. Deleted  
e. Inspect differential vent lines and connectors for security, cracks, and deterioration.  
f. Inspect differentials for leaking seals and cracks.  
g. Inspect U-joints for damage, free play, and missing or unserviceable lubrication fittings. | a. Hub vent lines cracked, plugged, or missing.  
b. Class III leaks or damage.  
e. Differential vent line has hole, plugged, or cracked.  
f. Class III leak.  
g. U-joint is damaged, unserviceable, or missing lubrication fitting. |
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Semi-annually</td>
<td>Driveline Components (Cont’d)</td>
<td>Fill each axle differential with 2 qt (1.9 L) of GO.</td>
<td>b. Lube level not within 1/4 in. (6.4 mm) of fill plug opening when cold or to plug level when hot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>h.</strong> Change differential lubricant every 3,000 mi (4,830 km), when required by maintenance repair action or when contaminated by water or foreign material. Remove fill plug. Level should be within 1/4 in. (6.4 mm) of fill plug opening when lubricant is cold, or to plug level when hot. Install fill plug, and tighten to 15-25 lb-ft (20-33 N•m).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>i.</strong> Deleted</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Semi-annually</td>
<td>Exhaust Components</td>
<td>Inspect for cracked and loose pipes, muffler, and hangers. Check for exhaust leaks.</td>
<td>Cracked, loose, or holes in pipes or muffler. Exhaust leak.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>a.</strong> Inspect frame side rails for cracks, breaks, bends, wear, deterioration, and missing or loose fasteners.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Semi-annually</td>
<td>Frame, Support Braces and Cross-members</td>
<td>Inspect support braces and crossmembers for cracks, breaks, bends, deterioration, and loose or missing fasteners.</td>
<td>b. Any loose or missing fasteners. Cracks, bends, or breaks in crossmembers or support braces.</td>
</tr>
</tbody>
</table>
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont'd).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Semi-annually</td>
<td>Tires</td>
<td><strong>WARNING</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Changing tire pressures or wheel alignment out of the recommended specification may adversely affect the vehicle's handling characteristics. Loss of vehicle control may result, causing serious injury or death to personnel and damage to equipment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>NOTE</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vehicle must be up on jack stands for the following checks.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>a.</strong> Check tread depth of tires with tire gauge. If tread depth is less than 1/16 in. (1.59 mm), replace tire. Radial tires will take approximately 1,300 miles (2,092 km) to wear 1/32 in. (0.79 mm). If mission will require the vehicle to travel this distance within a month, replace tire if it measures 3/32 in. (2.38 mm).**</td>
<td>a. Tread depth is less than 1/16 in. (1.59 mm).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>b.</strong> Inspect tires for uneven wear and balance [para. 8-8]. The vehicle's wheel alignment is optimally designed for GVW operation. Operating the vehicle without a load can cause excessive wear on the outer edge of the tread pattern. If this pattern develops, turn tires around on the rims [para. 8-4 or para. 8-4.1].</td>
<td>b. Tires exhibit excessive or uneven wear or balance.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>c.</strong> Deleted</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>d.</strong> Deleted</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>e.</strong> Deleted</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>NOTE</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>If vehicle is new and has been driven less than 3,000 mi (4,800 km), it is not necessary to align wheels unless abnormal handling is reported.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>f.</strong> Check alignment of front and rear wheels [paras. 8-9 and 8-10].</td>
<td>f. Front or rear wheels are out of alignment.</td>
</tr>
<tr>
<td>ITEM NO.</td>
<td>INTERVAL</td>
<td>ITEM TO BE INSPECTED</td>
<td>PROCEDURES</td>
<td>NOT FULLY MISSION CAPABLE IF:</td>
</tr>
<tr>
<td>---------</td>
<td>------------------</td>
<td>-----------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>20</td>
<td>Semi-annually</td>
<td>Engine</td>
<td>a. Inspect engine for leaks or damage that could cause engine failure.</td>
<td>a. Class III leaks. Damage evident that would cause engine failure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Change oil and filter every 3,000 mi (4,800 km) or semiannually, whichever occurs first [para. 3-5]. Inspect drainplug for metal particles.</td>
<td>b. Metal particles are found on drainplug.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>NOTE</strong></td>
<td>Replace oil filter each time crankcase is drained. Fill crankcase with 8 qt (7.6 L) of engine oil. Crankcase capacity is 7 qt (6.6 L) and oil filter capacity is 1 qt (0.95 L).</td>
</tr>
</tbody>
</table>

<p>| 20.1    | Semi-annually    | Geared Fan Drive (Serial Numbers 300000 and Above Only) | <strong>WARNING</strong> If vehicle has been operating, use extreme care to avoid being burned when removing geared fan drive fill plug. Use rags or heavy gloves to protect hands. | a. Ensure fluid is even with bottom of fill plug hole.                                     |</p>
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
</table>
| 20.1    | Semi-annually  | Geared Fan Drive (Serial Numbers 300000 and Above Only) (Cont'd)                     | • The coupler shaft has a CV joint at the GFD end and one at the engine crankshaft end.  
  • Each CV joint has two grease fittings. Only one grease fitting needs to be lubricated. Second fitting is used to give an optional location depending on the position of the shaft when engine is stopped.  
  b. Lubricate coupler shaft CV joints.                                                                 | \[NOTE\] The coupler shaft has a CV joint at the GFD end and one at the engine crankshaft end.  
  • Each CV joint has two grease fittings. Only one grease fitting needs to be lubricated. Second fitting is used to give an optional location depending on the position of the shaft when engine is stopped.  
  b. Lubricate coupler shaft CV joints. |
| 21      | Semi-annually  | Batteries                                                                            | **WARNING**  
  • Do not perform battery system checks or inspections while smoking or near fire, flames, or sparks. Batteries may explode causing damage to vehicle, and injury or death to personnel.  
  • Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry or disconnected battery ground cable contacts battery terminal, a direct short will result, causing injury to personnel or damage to equipment.  
  **NOTE**  
  Refer to TM 9-6140-200-14 for more specific details on battery maintenance.  
  a. Inspect battery box for corrosion and debris.  
  b. Clean slave receptacle and coat with corrosion-resistant compound (appendix C, item 61).  
  **NOTE**  
  Add 4 points (.004) to specific gravity reading for every 10°F above 80°F.  
  c. Check and record specific gravity of each cell.  
  d. Inspect battery cables for frays, splits, or looseness.  
  a. Corrosion has made holes in metal battery box.  
  b. Terminals corroded.  
  c. Cell is below 1.225 specific gravity.  
  d. Cables frayed, split, or loose. |
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.1</td>
<td>Semi-annually</td>
<td>Doors</td>
<td>Special Purpose Bodies</td>
<td>Doors do not seal against body.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inspect door latches/strikes for proper adjustment (para. 11-9).</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Semi-annually</td>
<td>Cargo Shell Door</td>
<td>Check adjustment of cargo shell door (para. 11-15).</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Semi-annually</td>
<td>Deleted</td>
<td>Deleted</td>
<td>a. Brushes are missing or curled upward more than 1/4 inch (6.34 mm).</td>
</tr>
<tr>
<td>23.1</td>
<td>Semi-annually</td>
<td>Weapon Station Turret</td>
<td>a. Ensure brushes are present and are not curled upward.</td>
<td>b. Turret brake is misaligned or mounting bracket welds cracked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Inspect turret brake for cracked mounting bracket welds and for correct adjustment (para. 11-55).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Inspect for damage or bending of stop ring notches at 0 degrees, 90 degrees, 180 degrees, and 270 degrees stop positions.</td>
<td>c. Stop rings notches will not stop at required position.</td>
</tr>
<tr>
<td>24</td>
<td>Semi-annually</td>
<td>Vehicular Heater Components</td>
<td>Special Purpose Kits</td>
<td>a. Any class III leak, loose connections, splits, cracks, and bends.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Inspect arctic heater fuel line for loose connections, splits, cracks, and bends.</td>
<td>b. Any class III leaks. Hoses cracked or dry-rotted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Inspect coolant hoses for leaks and deterioration.</td>
<td>c. Wires frayed, split, or loose.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Inspect electrical wires for frays, splits, or looseness.</td>
<td>d. Any exhaust extension leak.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d. Inspect intake and exhaust extensions for proper installation, cracked and loose pipes.</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE**

If annual/biennial service is being performed, then final road test will be completed after last annual/biennial task is complete.
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Inspect vent tube mounting hardware for proper installation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Inspect intake and exhaust extensions for proper installation and leaks.</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Semi-annually</td>
<td>Final Road Test</td>
<td>Check vehicle for proper operation and performance.</td>
<td>Vehicle fails to operate properly.</td>
</tr>
<tr>
<td>26</td>
<td>Annually (6,000)</td>
<td>Fuel System</td>
<td>Replace filter element every 6,000 mi (9,600 km) or annually, whichever occurs first. Replace water separator element if unserviceable (para. 3-34).</td>
<td>c. Any exhaust extension leaks.</td>
</tr>
<tr>
<td>27</td>
<td>Annually (6,000)</td>
<td>Air-Intake System</td>
<td>Test CDR valve (para. 3-9).</td>
<td>CDR fails water manometer vacuum test.</td>
</tr>
<tr>
<td>28</td>
<td>Annually (6,000)</td>
<td>Electrical Wiring</td>
<td>Inspect all wiring and wiring harnesses for frays, splits, missing insulation, or poor condition.</td>
<td>Broken, frayed, split wires or harness.</td>
</tr>
<tr>
<td>28.1</td>
<td>Annually (6,000)</td>
<td>Fuel System</td>
<td>a. Check each glow plug for looseness and damage. Tighten each plug to 8-12 lb-ft (11-16 N•m).</td>
<td>a. Glow plugs are loose or damaged.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Check fuel tank for propeller shaft rub marks and damage. Ensure straps are properly installed in fuel tank slots. Tighten strap locknuts to 23-27 lb-in. (2.6-3 N•m).</td>
<td>b. Any class III fuel leak or tank strap improperly installed or loose.</td>
</tr>
<tr>
<td>28.2</td>
<td>Annually (6,000)</td>
<td>200-Amp Alternator</td>
<td>Check alternator mounting bolts for security of mounting. Tighten bolts to 40 lb-ft (54 N•m).</td>
<td>Any alternator mounting bolt is loose.</td>
</tr>
</tbody>
</table>
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.3</td>
<td>Annually (6,000)</td>
<td>Suspension and Steering System</td>
<td><strong>NOTE</strong> If access to lower ball joint locknut is a problem, remove geared hub from control arm para. 6-9.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Remove wheel and tire assembly para. 8-3. Check front and rear lower ball joint mounting. Tighten lower ball joint to lower control arm locknuts to 60 lb-ft (81 N·m). Tighten ball joint slotted nut to 73 lb-ft (99 N·m) and ensure cotter pin is present.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Check front and rear upper ball joint mounting. Tighten upper ball joint to upper control arm locknuts to 37 lb-ft (50 N·m). Tighten upper control arm-to-bracket locknuts to 260 lb-ft (353 N·m). Tighten ball joint slotted nut to 73 lb-ft (99 N·m) and ensure cotter pin is present.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>NOTE</strong> Do not overlubricate ball joints; one or two shots is adequate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Lubricate front and rear upper and lower ball joints with GAA.</td>
</tr>
<tr>
<td>28.4</td>
<td>Annually (6,000)</td>
<td>Engine and Transmission Mounts</td>
<td>Using 3/4-in. torque adapter (appendix B, item 134), tighten two capscrews securing transmission mount to adapter to 65-70 lb-ft (88-95 N·m). Tighten two locknuts securing transmission mount to crossmember to 28 lb-ft (38 N·m).</td>
</tr>
</tbody>
</table>

**NOTE** Transmission mount loose, cracked, or damaged.
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.5</td>
<td>Annually (6,000)</td>
<td>Starter</td>
<td><strong>CAUTION</strong> Disconnect negative cable. Inspect starter for mounting security. Tighten mounting bolts to 40 lb-ft (54 N•m).</td>
<td>Mounting bolt missing or will not torque.</td>
</tr>
</tbody>
</table>
| 28.6     | Annually (6,000) | Transfer Case         | **CAUTION** Use Dexron® VI for filling transfer case. Failure to use Dexron® VI may cause damage to transfer case.  
  
a. Check transfer case fluid level every 3,000 mi (4,800 km) or semiannually, whichever occurs first. Remove fill plug and gasket. Level should be within 1/2 in. (12.7 mm) of fill plug opening when vehicle is on level ground. Install fill plug and gasket, and tighten to 35 lb-ft (47 N•m).  
  
  **NOTE** Do not overtorque line nuts.  
  
b. Inspect oil cooler lines for leaks. Check for loose oil cooler line nuts. If loose, hold oil cooler line stationary and, using a pound-inch torque wrench, tighten line nuts to 192-216 lb-in. (22-24 N•m).  
  
b. Any class III oil leak. |
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.7</td>
<td>Annually</td>
<td>Driveline Components</td>
<td><strong>a.</strong> Adjust spindle bearing (all except vehicles S/N 300000 and above) [para. 6-12].</td>
<td>a. Bearing damaged.</td>
</tr>
<tr>
<td></td>
<td>(6,000)</td>
<td></td>
<td><strong>b.</strong> Tighten front prop shaft mounting capscrews to 13-18 lb-ft (18-24 N•m) and center support capscrews to 60 lb-ft (81 N•m). Tighten rear prop shaft capscrews to 13-18 lb-ft (18-24 N•m) and tighten front U-bolt nuts to 21 lb-ft (29 N•m).</td>
<td>b. Loose, missing, or broken capscrews.</td>
</tr>
</tbody>
</table>

**U-JOINT LUBRICATION FITTING**

**FRONT PROPELLER SHAFT UNIVERSAL AND SLIP JOINTS**

**REAR PROPELLER SHAFT UNIVERSAL AND SLIP JOINTS**

**c.** Tighten halfshaft mounting bolts to 48 lb-ft (65 N•m).

**c.** Loose, missing, or broken bolts.
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont'd).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.8</td>
<td>Annually (6,000)</td>
<td>Tires</td>
<td><strong>WARNING</strong> Changing tire pressures or wheel alignment out of the recommended specification may adversely affect the vehicle's handling characteristics. Loss of vehicle control may result, causing serious injury or death to personnel and damage to equipment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>NOTE</strong> Vehicle must be up on jack stands for the following check.</td>
<td>Any loose, missing, or broken wheel stud and locknuts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Rotate tires as diagram shows.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>ROTATION DIAGRAM</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><img src="image" alt="Rotation Diagram" /></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Tighten wheel lug nuts to 90-110 lb-ft (122-149 N·m) in tightening sequence shown.</td>
<td>b. Any broken studs, loose or missing lug nuts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>TIGHTENING SEQUENCE</strong></td>
<td></td>
</tr>
</tbody>
</table>
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.9</td>
<td>Annually (6,000)</td>
<td>Rear Cargo Door</td>
<td>Check for loose, missing, or broken wheel studs and locknuts.</td>
<td>Any loose, missing, or broken wheel stud and locknuts.</td>
</tr>
</tbody>
</table>

**CAUTION**
Prior to checking torque, the tire assembly must be deflated.

1. Release air pressure from tire [para. 8-4](para. 8-4) or [para. 8-4.1](para. 8-4.1).

**WARNING**
If vehicle is new and has been driven less than 3,000 mi (4,800 km), it is not necessary to align wheels unless abnormal handling is reported.

- Always use an OSHA approved tire inflation cage for inflation purposes.
- Stand on one side of the cage during inflation; never directly in front. Keep hands out of cage during inflation.
- Inflate assembly to recommended pressure using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold-inflation pressure. Failure to follow these instructions may result in serious injury or death.
- Never inflate a wheel assembly without having checked wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

**CAUTION**
Tighten locknuts gradually to avoid bent and broken studs, or damage to wheel components will result.

2. Tighten locknuts to 85 lb-ft (115 N·m) in sequence shown; repeat torque sequence at 125 lb-ft (170 N·m) (S/N 299999 and below) and at 110 lb-ft (149 N·m) (S/N 300000 and above).

3. Inflate tire to recommended tire pressure (TM 9-2320-387-10).

**TIGHTENING SEQUENCE**

S/N 299999 AND BELOW

S/N 300000 AND ABOVE
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.10</td>
<td>Annually (6,000)</td>
<td>Rear Cargo Door</td>
<td>Check rear cargo door for proper operation. Rotate gas springs (para. 11-23) 180° every six months and move left spring to right side and right spring to left side.</td>
<td></td>
</tr>
</tbody>
</table>
| 29       | Biennially | Transmission | **CAUTION**

Use Dexron® VI for filling transmission. Failure to do so may cause damage to transmission.

**NOTE**

Replace transmission oil filter each time transmission is drained. Fill transmission with 7.7 qt (7.3 L) of Dexron® VI.

Change fluid every 12,000 mi (19,300 km) or biennially, whichever occurs first (para. 5-2). Inspect transmission drainplug for metal particles. |
| 30       | Biennially | Transfer Case | **CAUTION**

- If water or metal particles are detected during transfer case draining, notify DS maintenance before refilling transfer case.
- Use Dexron® VI for filling transfer case. Failure to do so may cause damage to transfer case.

**NOTE**

Fill transfer case with 3.35 qt (3.17 L) of Dexron® VI. |

| DIPSTICK | |
|----------|
Table 2-1. Unit Level Preventive Maintenance Checks and Services HMMWV (Cont’d).

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>INTERVAL</th>
<th>ITEM TO BE INSPECTED</th>
<th>PROCEDURES</th>
<th>NOT FULLY MISSION CAPABLE IF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Biennially</td>
<td>Transfer Case (Cont’d)</td>
<td>Change fluid every 12,000 mi (19,300 km) or biennially, whichever occurs first. Inspect drainplug for metal particles. Install drainplug and tighten to 35 lb-ft (47 N·m). Install fill plug and gasket, and tighten to 35 lb-ft (47 N·m).</td>
<td>Metal particles are found.</td>
</tr>
<tr>
<td>31</td>
<td>Biennially</td>
<td>Power Steering Oil Filter</td>
<td>Replace power steering fluid and filter every 12,000 mi (19,300 km) or biennially, whichever occurs first.</td>
<td>Metal particles are found or fluid contaminated.</td>
</tr>
</tbody>
</table>
## SEMI ANNUAL (3,000 MILE) PMCS PARTS LIST

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>PART NUMBER</th>
<th>NSN</th>
<th>NOMENCLATURE</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>MS51943-31</td>
<td>5310-00-061-4650</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>MS21245-L10</td>
<td>5310-00-449-2381</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>MS35756-8</td>
<td>5315-00-616-5526</td>
<td>Woodruff Key</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>MS24665-355</td>
<td>5315-00-012-0123</td>
<td>Cotter Pin</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>MS51943-43</td>
<td>5310-00-061-4651</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>MS51943-35</td>
<td>5310-00-935-9021</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>MS51943-39</td>
<td>5310-00-488-3889</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>MS51967-18</td>
<td>5310-00-763-8919</td>
<td>Locknut</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>MS35338-45</td>
<td>5310-00-407-9566</td>
<td>Lockwasher</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>PF1218</td>
<td>4330-01-398-8484</td>
<td>Engine Oil Filter</td>
<td>1</td>
</tr>
<tr>
<td>11.</td>
<td>5593033</td>
<td>5310-01-252-2999</td>
<td>Nut and Lockwasher Assy</td>
<td>4</td>
</tr>
</tbody>
</table>

## ANNUAL (6,000 MILE) PMCS PARTS LIST

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>PART NUMBER</th>
<th>NSN</th>
<th>NOMENCLATURE</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>MS51943-31</td>
<td>5310-00-061-4650</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>MS21245-L10</td>
<td>5310-00-449-2381</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>MS35756-8</td>
<td>5315-00-616-5526</td>
<td>Woodruff Key</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>MS24665-355</td>
<td>5315-00-012-0123</td>
<td>Cotter Pin</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>MS51943-43</td>
<td>5310-00-061-4651</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>MS51943-35</td>
<td>5310-00-935-9021</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>MS51943-39</td>
<td>5310-00-488-3889</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>MS51967-18</td>
<td>5310-00-763-8919</td>
<td>Locknut</td>
<td>2</td>
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<tr>
<td>9.</td>
<td>MS35338-45</td>
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<tr>
<td>10.</td>
<td>PF1218</td>
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<td>Engine Oil Filter</td>
<td>1</td>
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<tr>
<td>11.</td>
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<td>Nut and Lockwasher Assy</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>SA910044</td>
<td>4330-01-190-3579</td>
<td>Fuel/Water Filter Element Kit</td>
<td>1</td>
</tr>
<tr>
<td>ITEM NO.</td>
<td>PART NUMBER</td>
<td>NSN</td>
<td>NOMENCLATURE</td>
<td>QTY</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>-----------------</td>
<td>----------------------</td>
<td>-----</td>
</tr>
<tr>
<td>1.</td>
<td>MS51943-31</td>
<td>5310-00-061-4650</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>MS21245-L10</td>
<td>5310-00-449-2381</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>MS35756-8</td>
<td>5315-00-616-5526</td>
<td>Woodruff Key</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>MS24665-355</td>
<td>5315-00-012-0123</td>
<td>Cotter Pin</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>MS51943-43</td>
<td>5310-00-061-4651</td>
<td>Locknut</td>
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</tr>
<tr>
<td>6.</td>
<td>MS51943-35</td>
<td>5310-00-935-9021</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>MS51943-39</td>
<td>5310-00-488-3889</td>
<td>Locknut</td>
<td>4</td>
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<tr>
<td>8.</td>
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<td>Locknut</td>
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<tr>
<td>9.</td>
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<td>Lockwasher</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>PF1218</td>
<td>2940-00-082-6034</td>
<td>Engine Oil Filter</td>
<td>1</td>
</tr>
<tr>
<td>11.</td>
<td>5593033</td>
<td>5310-01-252-2999</td>
<td>Nut and Lockwasher Assy</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>SA910044</td>
<td>4330-01-190-3579</td>
<td>Fuel/Water Filter Element Kit</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>12354864</td>
<td>4330-01-438-3813</td>
<td>Fluid Transmission Parts Kit</td>
<td>1</td>
</tr>
<tr>
<td>14.</td>
<td>5716372</td>
<td>4330-01-506-2918</td>
<td>Power Steering Oil Filter</td>
<td>1</td>
</tr>
</tbody>
</table>
LUBRICATION TABLE

<table>
<thead>
<tr>
<th>USAGE</th>
<th>FLUID/LUBRICANT</th>
<th>CAPACITIES</th>
<th>EXPECTED TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Oil (MIL-L-2104) (MIL-L-46167)</td>
<td>OE/HDO 30*</td>
<td>Crankcase: w/o filter 7 qt (6.6 L) w/filter 8 qt (7.6 L) Dry System 10 qt (9.5 L) (inc. oil cooler)</td>
<td>Above +15°F (-9°C) +40° to -15°F (+4° to -26°C) +40° to -65°F (+4° to -54°C)</td>
</tr>
<tr>
<td>Engine Oil (MIL-L-2104) (MIL-L-46167)</td>
<td>OE/HDO 10***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine Oil (MIL-L-2104) (MIL-L-46167)</td>
<td>OEA -30**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine Coolant</td>
<td>Ethylene Glycol and Water 1/2 Ethylene Glycol/1/2 Water 1/2 Ethylene Glycol/1/2 Water 3/5 Ethylene Glycol/2/5 Water</td>
<td>Radiator: 5 qt (4.7 L) Complete System: 26 qt (24.6 L)</td>
<td>+15°F (-9°C) and above +40° to -15°F (+4° to -26°C) +40° to -65°F (+4° to -54°C)</td>
</tr>
<tr>
<td>Brake System (Serial Numbers 299999 and Below)</td>
<td>Fluid Silicone BFS</td>
<td>Master Cylinder: 1.12 pt (0.53 L) Complete Systems 1.63 pt (0.78 L)</td>
<td>All Temperatures 1.12 pt (0.53 L) Complete System:</td>
</tr>
<tr>
<td>Brake System (Serial Numbers 300000 and Above)</td>
<td>Fluid Silicone BFS</td>
<td>Master Cylinder: 2.36 pt (1.12 L) Complete Systems 3.09 pt (1.46 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Transmission</td>
<td>Dexron® VI OEA</td>
<td>Dry: 13.5 qt (12.8 L) Drain &amp; Refill 7.7 qt (7.3 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Transfer Case</td>
<td>Dexron® VI</td>
<td>3.35 qt (3.17 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Steering System</td>
<td>Dexron® VI</td>
<td>1 qt (0.95 L) w/ cooler 1.25 qt (1.18 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Geared Hub (4)</td>
<td>Multipurpose Gear GO 80/90</td>
<td>1 pt ea (0.47 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Geared Fan Drive</td>
<td>GO 80/90 GO 75</td>
<td>N/A</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Axles (2)</td>
<td>Multipurpose Gear GO 80/90</td>
<td>2 qt ea (1.9 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Ball Joints, Tie Rod Ends, Pitman Arm, Idler Arm, Propeller Shafts, etc.</td>
<td>GAA</td>
<td>As Required</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Hinges, Cables, and Linkages</td>
<td>OE/HDO</td>
<td>As Required</td>
<td>All Temperatures</td>
</tr>
</tbody>
</table>

*OE/HDO 15/40 (Grade 15W-40) lubricant may be used when expected temperatures are above +5°F (-15°C).
**If OEA -30 lubricant is required to meet the temperature ranges listed in the table, then the OEA -30 lubricant is to be used in place of OE/HDO 10 lubricant for all temperature ranges.
***If operating conditions are severe or abnormal, service chassis lubrication points at 1,000 mi. (1,600 km).
Section IV. GENERAL MAINTENANCE INSTRUCTIONS

2-13. GENERAL MAINTENANCE INSTRUCTIONS TASK SUMMARY

<table>
<thead>
<tr>
<th>TASK PARA.</th>
<th>PROCEDURES</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-14.</td>
<td>Cleaning</td>
<td>2-30</td>
</tr>
<tr>
<td>2-15.</td>
<td>Inspection</td>
<td>2-31</td>
</tr>
<tr>
<td>2-16.</td>
<td>Repair</td>
<td>2-32</td>
</tr>
<tr>
<td>2-17.</td>
<td>Assembly</td>
<td>2-33</td>
</tr>
</tbody>
</table>

2-14. CLEANING

a. General Instructions. Cleaning procedures will be the same for the majority of parts and components which make up the vehicle subassemblies. General cleaning procedures are detailed in steps b through h.

b. The Importance of Cleaning. Great care and effort are required in all cleaning operations. The presence of dirt and foreign material is a constant threat to satisfactory vehicle operation and maintenance. The following will apply to all cleaning operations:

1. Hands must be kept free of any accumulation of grease which can collect dust and grit.
2. Clean all parts before inspection, after repair, and before assembly.
3. After cleaning, all parts must be covered or wrapped in plastic or paper to protect them from dust and/or dirt.

c. Disassembled Parts Cleaning. Place all disassembled parts in wire baskets for cleaning.

1. Dry and cover all cleaned parts.
2. Place on or in racks and hold for inspection or repair.
3. All parts subject to rusting must be lightly oiled and wrapped.
4. Keep all related parts and components together. Do not mix parts.

d. Castings.

1. Deleted.
2. Use a stiff brush to remove sludge and gum deposits.

WARNING

Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

3. Use compressed air to blow out all tapped capscrew holes and dry castings after cleaning.
2-14. CLEANING (Cont’d)

e. Oil Passages. Particular attention must be given to all oil passages in castings and machined parts. Oil passages must be clean and free of any obstructions.
   (1) Clean passages with wire probes to break up any sludge or gum deposits.
   (2) Deleted.
   (3) Dry passages with compressed air.

   **CAUTION**
   Do not allow solvents to come in contact with seals, cables, or flexible hoses. These cleaners cause leather, rubber, and synthetic materials to dry out, rot, and lose pliability, making them unserviceable.

f. Nonmetallic Parts. Clean hoses and other nonmetallic parts with soap and water.

g. Bearings.

   **WARNING**
   Do not use compressed air to dry bearings. Spinning a dry bearing with compressed air may cause injury to personnel or damage to equipment.
   (1) Bearings require special cleaning. After removing surface oil and gum deposits, place bearings in hot oil, 140°F (60°C), to loosen congealed oil and grease. Wipe bearings dry with a lint-free cloth; do not use compressed air.
   (2) See TM 9-214 for information and care of bearings.

h. Electrical Components

   (1) Clean electrical components with clean cloth dampened with drycleaning solvent. Care must be taken not to damage protective insulation.

   **WARNING**
   Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).
   (2) Use compressed air to dry electrical components.

2-15. INSPECTION

a. General Instructions. Procedures for inspections will be the same for many parts and components which make up the vehicle subassemblies. General procedures are detailed in steps b through k. Dimensional standards for parts have been fixed at extremely close tolerances, so use specification tables. Use specified inspection equipment for inspection where cracks and other damage cannot be spotted visually. Exercise extreme care in all phases of inspection. Repair or replace all unserviceable components (para. 2-16).

b. Castings.

   (1) Inspect all ferrous and nonferrous castings for cracks. See MIL-STD-6866, Inspection, Penetrant Methods. Particularly check areas around studs, pipe plugs, threaded inserts, and sharp corners. Replace cracked castings.
   (2) Inspect machined surfaces for nicks, burrs, and raised metal. Mark damaged areas for repair or replacement.
   (3) Inspect all pipe plugs, pipe plug openings, capscrews, and capscrew openings for damage and stripped threads. Replace if damaged or threads are stripped.
   (4) Check all gasket mating surfaces, flanges on housings, and supports for warpage with a straight-edge or surface plate. Inspect mating flanges for discolorations which may indicate leakage. Replace if warped.
   (5) Check all castings for conformance to applicable repair standards.
2-15. INSPECTION (Cont’d)

c. **Bearings.** Check all bearings for conformance to applicable repair standards. Refer to TM 9-214.
d. **Bushings and Bushing-Type Bearings.**
   (1) Check all bushings and bushing-type bearings for secure fit, evidence of heating, wear, burrs, nicks, and out-of-round condition.
   (2) Check for dirt in lubrication holes or grooves. Holes and grooves must be clean and free from damage.
e. **Machined Parts.**
   (1) Check machined parts for cracks, distortion, and damage.
   (2) Check all surfaces for nicks, burrs, and raised metal.
f. **Studs, Bolts, Capscrews, and Nuts.** Replace if bent, loose, stretched, or threads are damaged.
g. **Gears.**

   **NOTE**
   When gear teeth wear limits are not established, good judgment is required to determine if gear replacement is necessary.
   (1) Inspect all gears for cracks and missing teeth. Replace if cracked or teeth are missing.
   (2) Inspect gear teeth for wear, sharp fins, burrs, and galled or pitted surfaces.
   (3) Inspect splines for wear, burrs, and galled or pitted surfaces.
   (4) Check keyway slots for wear and/or damage.
h. **Oil Seals.** Oil seals are mandatory replacement items.
i. **Casting Plugs.** Inspect for leakage. Replace plugs when leakage is present.
j. **Springs.** Inspect for damaged, distorted, and collapsed coils.
k. **Snaprings, Retaining Rings, and Washers.** Many of these parts are mandatory replacement items. Inspect all others for obvious damage.

2-16. REPAIR

a. **General Instructions.** Repair of most parts and components is limited to general procedures outlined in applicable maintenance instructions and the following detailed procedures b through g.

   **CAUTION**
   Repaired items must be thoroughly cleaned to remove metal chips and abrasives to prevent them from entering working parts of vehicle components.

b. **Castings.**
   (1) All cracked castings will be replaced.
   (2) Only minor repairs to machined surfaces, flanges, and gasket mating surfaces are permitted. Remove minor nicks, burrs, and/or scratches by:
      (a) Using fine mill file.
      (b) Using abrasive cloth dipped in cleaning solvent.
      (c) Lapping across a surface plate.
      (d) Remachining of machined surfaces to repair damage, warpage, or uneven surfaces is not permitted. Replace castings.
   (3) Repair damaged threaded pipe plug and/or cap screw holes with a thread tap, or repair oversize holes with threaded inserts.
2-16. REPAIR (Cont’d)

d. Studs. Replace all bent and stretched studs. Repair minor thread damage with a thread restorer file. Replace studs having stripped or damaged threads as outlined below:
   (1) Remove using a stud remover. Back studs out slowly to avoid heat buildup and seizure which can cause stud to break off.
   (2) If studs break off too short to use a stud remover, use extractor to remove.
   (3) Replacement studs have a special coating and must have a small amount of antiseize compound (appendix C, item 16) applied on threads before stud is installed. Install replacement stud slowly to prevent heat buildup and snapping off.
e. Gears.
   (1) Remove gears using pullers, as required.
   (2) Use the same methods described in procedure b, step 2 for castings to remove minor nicks, burrs, or scratches on gear teeth.
   (3) If keyways are worn or enlarged, replace gear.
f. Bushings and Bushing-Type Bearings. When bushings and bushing-type bearings seize to a shaft and spin in the bore, the associated part must also be inspected and replaced, as required.
g. Oil Seals.
   (1) Remove oil seals being careful not to damage casting or adapter bore.
   (2) Always install new seal in bore using proper seal-replacing tool.

2-17. ASSEMBLY

a. Cleanliness is essential in all component assembly operations. Dirt and dust, even in minute quantities, are abrasive. Parts must be cleaned as specified, and kept clean. Wrap or cover parts and components when assembly procedures are not immediately completed.
b. Coat all bearings and contact surfaces with operating oil (differential oil for differential parts, transmission oil for transmission parts, etc.) to ensure lubrication of parts during initial operation after repair.

Section V. ELECTRICAL/Mechanical SYSTEMS TROUBLESHOOTING

2-18. GENERAL

a. This section provides information to diagnose and correct malfunctions of the electrical/mechanical system.
b. Principles of operation showing system operation can be found in chapter. It should be used as a reference when performing electrical/mechanical troubleshooting.
c. Each malfunction symptom given for an individual component or system is followed by step(s) you should take to determine the cause and corrective action you must take to remedy the problem.
d. Before taking any action to correct a possible malfunction, the following rules should be followed:
   (1) Question operator to obtain any information that might help determine the cause of the problem.
   (2) Never overlook the chance that the problem could be of simple origin. The problem could be corrected with minor adjustment.
   (3) Use all senses to observe and locate troubles.
2-18. GENERAL (Cont’d)

(4) Use test instruments or gauges to help determine and isolate problem.

(5) Always isolate the system where the malfunction occurs and then locate the defective component.

(6) Use standard automotive theories and principles when troubleshooting the vehicles covered in this manual.

c. The STE/ICE-R is an integral part of these troubleshooting procedures. It should be used whenever possible, although other options are given when available. The Vehicle Identification Number (VIN) assigned to the ECV vehicles is 21 (14 is the temporary VIN). On page 2-557, you will find information on STE/ICE-R description and operation. Use this information to become familiar with STE/ICE-R operation and the equipment contained in the test set. On page 2-537, you will find STE/ICE-R setup and internal checks. These must be performed prior to performing tests.
## 2-19. ELECTRICAL/MECHANICAL SYSTEMS TROUBLESHOOTING

### ELECTRICAL/MECHANICAL TROUBLESHOOTING

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NOTE TO THE RECIPIENT OF THIS MANUAL

There are 20 foldouts that are supplied with this manual. Take the foldouts and place them after the last page of diagnostics at the end of the paragraph. The foldout will then be with diagnostics for that system. Use the cross-reference information listed below to guide you in the placement of the foldouts.

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2-20. HOW TO USE THIS TROUBLESHOOTING GUIDE
### 2-20. HOW TO USE THIS TROUBLESHOOTING GUIDE (CONT'D)

**THERE ARE 5 TOP LEVEL TESTS.**  
USE THESE FOR GENERAL SYMPTOMS  
(HARD TO START, RUNS ROUGH, ETC).

**THERE ARE 18 SYSTEM LEVEL TESTS.**  
THESE ARE USED BY THE TOP  
LEVEL TESTS BUT YOU CAN GO  
STRAIGHT TO THEM IF YOU KNOW  
WHAT YOU'RE DOING.

**TROUBLESHOOTING PAGES.**  
THE LAYOUT IS SHOWN ON THE NEXT PAGE.  
THEY ARE SET UP SO THAT YOU DON'T READ  
ANY MORE THAN YOU HAVE TO. AFTER YOU  
HAVE FOUND THE FAULT, CORRECT IT AND  
MAKE SURE THE SYSTEM IS WORKING  
PROPERLY. CONTINUE IF THERE ARE  
ADDITIONAL PROBLEMS.

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2-20. HOW TO USE THIS TROUBLESHOOTING GUIDE (CONT'D)

PAGE LAYOUT
All diagnostic logic and flowcharts are on the left-hand page, with supporting information, help, test, instructions, and vehicle operation on the right.

Question number, so you know where you are and where to go when entering or leaving a test chain.

Notes, warnings, and cautions about a particular question.

Instructions for how to perform a test or make a measurement, usually in a box.

Question to be answered.

Known info and possible problems with the system.

Reason for question: This is to help by telling you why it's being asked. This is especially helpful when something's 'just a little bit bad' and you're not sure if it passed or failed.

Test options: Multiple choice of methods you can use to obtain the answer to the question.

HOW TO TROUBLESHOOT

PICK THE TESTS:
Select either a top level or a system level test.

DIAGNOSTIC PROCEDURE:
Just answer the questions on the left-hand page and follow the YES or NO path. Helpful information about the question is also on the right-hand page. If you aren't sure about a question or procedure, look on the right page for notes, instructions, and help.
2-20. HOW TO USE THIS TROUBLESHOOTING GUIDE (CONT'D)

**PAGE LAYOUT**

Diagnostic logic is on the left-hand page.

Related and helpful information is on the right-hand page.

**DIAGNOSTIC PROCEDURE**

Just answer the questions on the left-hand page. Follow the YES or NO path to the next step. Everything else on both pages is information to support the question. As a rule, the most important information (warnings, cautions, etc.) is closest to the question; less important information is farther away.

Is the symbol for a WARNING statement. If you see this symbol above a question, look on the right-hand page for the text of the message. The WARNING message on the right-hand page will also have the symbol above it.

Is the symbol for a CAUTION statement. If you see this symbol above a question, look on the right-hand page for the text of the message. The CAUTION message on the right-hand page will also have the symbol above it.
2-20. HOW TO USE THIS TROUBLESHOOTING GUIDE (CONT'D)

INFORMATION ABOUT THE QUESTION

TEST OPTIONS:
This box lists at least one way of getting the answer to the question. When there is more than one way to get the answer, the different options will be given. Usually the easiest or best option is first.

REASON FOR QUESTION:
If you know why the question is being asked, it should be easier to understand the diagnostic logic and easier to answer the question. This is especially helpful when a measurement is just a little bad. Knowing why the question is being asked should help you decide if the answer should be YES or NO.

INFORMATION ABOUT THE DIAGNOSTIC LOGIC

KNOWN INFO:
This box indicates what is known about the vehicle's condition. As you follow a test chain, parts will be listed here after they have checked ok. Sometimes this box will indicate a fault that you know exists, such as a shorted or open circuit, or a component that doesn't work. DO NOT USE THIS BOX TO PICK A JUMP-IN POINT. ALWAYS RUN A COMPLETE CHAIN WHEN INSTRUCTED TO DO SO.

POSSIBLE PROBLEMS:
This box is the opposite of KNOWN INFO. Possible causes of the problem are listed here until tested and shown to be ok.
2-20. HOW TO USE THIS TROUBLESHOOTING GUIDE (CONT'D)

INFORMATION ABOUT THE QUESTION

All warnings and cautions are given next to (or as close as possible to) the arrow pointing to the particular question. Look for the symbol that is in the box for the question in order to locate the particular note. Helpful notes, test procedures, or other information related to the question are provided here. These notes are provided as supporting information only; you don't usually need them to answer the question. The more skilled you become, the less you'll have to read these.

Any cross references to other manuals will be located in this area.

NOTES, WARNINGS, AND CAUTIONS ARE IN BOLDFACE TYPE.

Additional information, notes, and/or suggestions are in normal type so as not to draw too much attention.

TEST PROCEDURES

These are special notes about how to make measurements with the test equipment. Occasionally, if space is limited on a page, the easiest procedure will be listed with a page reference for the other procedures if you would rather use them. The procedures presume a basic working knowledge of the equipment to be used, but references are included for the less experienced operator.

TYPE OF MEASUREMENT

TYPE OF EQUIPMENT

Procedure for performing the measurement using the type of equipment listed above.

PICTURES

The pictures are supposed to make it easier to find what you're looking for, such as a pin in a connector or a particular wire or component.

PICTURES ARE PROVIDED WHEREVER POSSIBLE.
PCB - Protective Control Box, located on the firewall above the brake pedal.

STE/ICE-R - Simplified Test Equipment for Internal Combustion Engines - Reprogrammable, a testing system used for performing tests and measurements on the vehicle. In addition to acting as a conventional digital multimeter to measure voltage, current, and resistance, it is also capable of measuring pressure, speed, compression unbalance, engine power, and some specialized battery and starter evaluations. It is powered from the vehicle batteries. The complete system includes a vehicle test meter (VTM), a transducer kit (TK), cables, transit case, and technical publications.

DCA - Diagnostic Connector Assembly, an electrical harness on the vehicle which allows the STE/ICE-R to be powered and to make measurements of key vehicle signals from a single connection. In addition to many basic electrical signals such as starter voltage and current, it includes engine speed and fuel supply pressure. The STE/ICE-R can make TK measurements at the same time that it is connected to the DCA.

VTM - Vehicle Test Meter, a box which performs the measurement and analysis functions of the STE/ICE-R systems.

TK (and TK mode) - Transducer Kit, a collection of transducers, adapters, and fittings which permit the STE/ICE-R to be used as a general purpose measurement system for any application. This allows the STE/ICE-R to be used anywhere that you want to measure voltage, current, resistance, pressure, or speed. TK mode of operation is what you are doing when you use this kit (as opposed to DCA mode where you are using the vehicle's built-in sensors to make measurements).

Compression unbalance - A STE/ICE-R test that gives an indication of any engine cylinders that have lower compression than the average. It does this by monitoring the battery voltage during cranking. As each cylinder goes into compression, the extra load on the starter shows up as a drop in voltage. This works well for finding one or more cylinders that have a compression problem, but don't forget that it doesn't give the average compression. If all cylinders are low by the same amount, this test doesn't find it.

Troubleshooting - The process of making measurements and observing the operation of the vehicle to find out if anything is wrong with it and then to locate any problem that exists.

Diagnostics - Troubleshooting by following an exact procedure.

Test Chain - A series of tests to be followed in a particular order or sequence. It is referred to as a "chain" of tests because they are all connected one after another like the links of a chain.

System - A collection of devices which are all related to each other because they depend on each other to do some function or job. For instance, the function of the fuel system is to inject fuel into the cylinders at the correct time in the correct amount and with the correct quality. The collection of devices that are required to do this include the fuel pump, fuel lines, lift pump, fuel filter, injection pump, and injectors.
2-21. GLOSSARY OF ABBREVIATIONS AND COMMONLY USED TERMS (CONT'D)

Functional flow schematic - A diagram which is much like a normal electrical circuit diagram, except that its purpose is to show the flow of information through the system (or the flow of a signal or the flow of some material such as the fuel). This kind of diagram shows how each component or device depends on the others. It is called functional flow because it shows the function (purpose of each component) and how the output of one component flows into the next. For troubleshooting, the functional flow schematic is better than the usual circuit diagram because it allows you to quickly see how the system works and what to expect when you make measurements on a system that has faults. You can't expect the output of a device to be good when it has a bad input.

2-22. ELECTRIC CIRCUIT DESCRIPTION

An electrical circuit is a collection of electrical devices which are connected in a loop from a positive voltage source (the battery positive) to a negative source (the battery negative). It must be continuous, with no breaks (no opening in the loop) so that electrical current can flow from the positive to the negative. You can think of it like the plumbing in your house. There must be a source of water under pressure or nothing will flow through the pipes. Water pressure is like the positive voltage of the battery. There may be branches (tees) in the pipes going to several different places, but if you don't connect the pipes, you don't get water. The same thing is true with the electrical circuit. If the wires aren't connected, no electricity will flow through them.

In the plumbing of a house, all of the water must go to the drain (you won't permit it to be spilled on the floor). With the vehicle electrical circuit, the drain is the negative terminal of the battery. With the water pipes, the water always flows from high pressure to low pressure (another way of saying that water always flows downhill). The electrical current is the same as the water flow - it always goes from positive to negative voltage. Voltage is to electricity what pressure is to water. Just like the pressure in the water pipe, the greater the voltage, the more electricity will flow through the wires. Unlike the water pipes that will spill the water if they break, you can't spill the electricity. The closest thing to this in an electrical circuit is when two wires touch that aren't supposed to and the current flows to some place that it shouldn't (this is called a short circuit or a short). Shorts often happen where the wire touches the vehicle body (the body is connected to the negative terminal of the battery). Since the current always flows through the easiest path to negative, it will bypass the rest of the circuit where it was supposed to go, and go through the short directly to the battery. Because this new path to the battery negative is shorter, the malfunction is called a short circuit or a short.

If you put a valve in a water pipe, you can control how much water flows by closing the valve. What you are doing is pinching off the pipe with the valve which restricts the flow. If you shut it off completely, you can stop all water from flowing. In the electrical circuit, a resistor acts like a valve. If you make the resistor extremely large, you can stop the current from flowing. The resistance is measured in ohms.
When there is no electrical connection, such as when a wire is disconnected, the resistance is infinite (too large to be measured). No current will flow through the wires, because the circuit is no longer continuously connected. This is referred to as an open circuit or simply an open. Remember that an electrical circuit is formed by continuous loops of devices connected together. When you are troubleshooting, you are often asked to check for continuity, which simply means that you need to find out if there is a continuous path from one place in the circuit to another. Since you are trying to see if the path is continuous, you must check wires and switches rather than any special or active devices. You will usually just measure the resistance between two points. If the resistance is zero (or the value of any resistance that is supposed to be there), then there is continuity. In the case of looking for a short, this may mean that you have found the short. If the resistance is off-scale on the meter (infinite resistance) then there is no connection and you have found an open. A continuity test is the same whether you are looking for an open or a short, the only difference being what resistance values you are looking for and where you make the measurements.

You are familiar with the typical light switch which allows you to turn a light on and off. A switch of any kind in an electrical circuit is simply a way of opening the loop so that no current will flow through it. Something to remember while troubleshooting is that everything on the positive side of the switch still has full battery voltage while everything from the switch on through the rest of the circuit is (or should be) connected to the battery negative terminal and you will measure zero volts. This is easy to remember if you think of the faucet on a sink. If you shut off the faucet, there is no water flowing into the sink, but the water in the pipe is still under pressure.

Sometimes a switch is turned on and off automatically. An example is a circuit breaker, which is a device that measures how much current is flowing through it. If the current goes too high (possibly damaging equipment or melting the wires), then it opens an internal switch to stop the current flow. A relay is another form of switch that is turned on and off under remote control using a signal in another wire. When a device which requires a very large amount of current (such as the starter motor) must be turned on and off, a power relay is used. The idea is to use a small switch to turn on a larger switch. Thus, you don't have very large wires going all over the vehicle or large switches on the instrument panel. In the case of the starter's power relay, it is also called a solenoid. A solenoid is any device that changes the electrical current into a forward and backward motion. It is something like an electrical motor except that instead of continuously going around in the same direction, it goes in or out. For the starter, the solenoid is used to push a very large switch into the ON position.

When testing a circuit, you will need to know how much current is flowing. Current is easily measured with the STE/ICE-R. A device called a shunt is connected to the negative terminal of the battery. A shunt is a very precise resistor designed so that for every 1,000 amps of current that flow through it, there is a drop of .1 volt from one side to the other (different shunts may have different values). By measuring the voltage across the shunt, you know how much current is flowing through the circuit. The shunt is placed on the negative side because it is safer (less chance of accidents which may short out the batteries). Since all of the current eventually goes through the negative battery terminal anyway, the shunt gives the same measurement as if it were connected to the positive terminal. You can think of the shunt as doing the same thing as the water meter in your house. As you turn devices such as lights on or off, you can use the shunt to measure how much current they are using.
This is a top level test for problems with an engine that doesn’t start, or starts but immediately stops, or is very hard to start. If the engine starts but doesn’t run well after starting, try the STARTABILITY tests first.

FOR THE ENGINE TO START, ALL OF THE BASIC SYSTEMS SHOWN BELOW MUST BE WORKING. THESE STARTABILITY TESTS WILL HELP YOU TO VERIFY THE CONDITION OF EACH OF THESE SYSTEMS.

A functional flow schematic is not applicable to this section. However, so that you may refer to sections as you need them, a quick index to the systems required for starting is given here.

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<tr>
<th>PARAGRAPH</th>
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<tr>
<td>COMPRESSION/MECHANICAL</td>
<td>2-147</td>
</tr>
</tbody>
</table>
STARTABILITY

1. DOES THE ENGINE CRANK NORMALLY? (STARTER ENGAGES, CRANKS ENGINE AT LEAST 100 RPM, STARTER DISENGAGES)

   1. LISTEN.
   2. STE/ICE-R TEST 10 (Page 2-450)

   REASON FOR QUESTION
   If the engine cranks normally, the battery and starter are good enough to start the engine.

   YES
   GO TO STARTER CIRCUIT, Page 2-247

   NO

2. RUN THE FUEL SYSTEM TESTS. RETURN HERE.

   FUEL SYSTEM TESTS
   (Page 2-99)

   REASON FOR TESTS
   If the fuel system doesn't work, the vehicle won't start.

3. RUN THE AIR INTAKE/EXHAUST TESTS. RETURN HERE.

   AIR INTAKE/EXHAUST TESTS
   (Page 2-141)

   REASON FOR TESTS
   The air intake/exhaust system tests are easy to run and can cause starting problems.
Make sure all of the vehicle's fluids are at the proper level.

You could still have battery or starter problems with a cranking speed over 100 rpm, but that shouldn't stop the engine from starting. Tests for the battery and starter can be run separately, if you want to run them.

<table>
<thead>
<tr>
<th>ENGINE RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEACE-R TEST 10</td>
</tr>
</tbody>
</table>

1. Start Test 10, Engine RPM
2. Crank or start the engine. Displayed reading is RPM. Cranking rpm should be approximately 100-200. Idle rpm should be 700-750.
RUN THE GLOW PLUGS CIRCUIT TESTS. RETURN HERE.

1. GLOW PLUGS TESTS
   (Page 2-289)

REASON FOR QUESTION
If the engine is hard to start it may be the glowplugs.

RUN COMPRESSION UNBALANCE.
IS THE COMPRESSION UNBALANCE OK?

TEST OPTIONS
STE/CE-R TEST 14
   (Page 2-493)

REASON FOR QUESTION
If cylinder compression is far enough out of balance, it could prevent the vehicle from starting. The lower the unbalance, the better.

NOTIFY DS MAINTENANCE

GO TO 6, PAGE 2-48.2
The colder the engine (and air temperature), the more you need the glow plugs for starting. There are some times when you don't need to run the glow plugs test. If the engine is warm and the problem is there on a hot day, then the problem is probably NOT the glow plugs or cold start advance, and these tests may be bypassed. If it's colder than 50°F, run the glow plugs test, because just a few bad glow plugs can make a minor starting problem much worse.

If the vehicle passes the ST/ECE-R compression unbalance test, it may still have a compression problem, but it would mean that every cylinder has low compression. This is possible, but not too likely. If you're confident that everything else is working properly, notify DS maintenance.

**COMPRESSIVE UNBALANCE**

**ST/ECE-R TEST 14**

1. Run tests 72, 73 and 74 to verify that the batteries are OK.

   **CAUTION**
   THE GLOW PLUGS CONTROLLER AND THE CONTROL VALVE ELECTRICAL CONNECTOR MUST BE DISCONNECTED PRIOR TO TUNING THIS TEST.

2. Disconnect wire 54A at injection pump to prevent starting.
3. Disconnect glow plugs controller and control valve electrical connector. (to keep waveform clean).
4. Start Test 14, compression unbalance.
5. Wait for the GO message. Crank the engine.
6. Release the rotary switch when the VTM displays OFF. A number less than 25% is passing.
PERFORM INJECTION PUMP TEST.
IS FUEL INJECTION PUMP FUNCTIONING PROPERLY?

TEST OPTIONS
Run Startability Test
Page 2-46

REASON FOR TEST
A broken or dirty fuel injection pump can prevent vehicle from starting.

KNOWN INFO
ENGINE NOT LOCKED
BATTERIES OK
STARTING SYSTEM OK
GLOW PLUGS OK
INTAKE/AIR/EXHAUST OK
COMPRESSION OK

POSSIBLE PROBLEMS
INJECTION PUMP

NOTIFY DS MAINTENANCE (CHAPTER 16)
During high temperature and humidity, early model vehicles can experience difficulty starting while using JP-8 fuel. High temperatures can cause restrictive clearances in some older fuel injection head and rotor assemblies. The engine must be allowed to cool to allow adequate clearance of the pumping plungers to ensure adequate fuel delivery for starting. If this condition persists, run the startability tests. If vehicle passes all startability tests and troubleshooting procedures and still experiences difficulty in hot starting, identify the fuel injection pump and serial numbers.

All fuel injection pumps with P/N DB2831-5209 incorporated the improved head and rotor assembly, P/N 31506. If your serial number is less than shown in the Serial Number Break Column of the table below, the manufacturer recommends the fuel injection pump to be replaced, tagged as a “no hot restart” condition, and forward for rebuild. Notify direct support maintenance.

<table>
<thead>
<tr>
<th>Model Pump P/N (NSN)</th>
<th>Serial Number Break</th>
<th>Original P/N</th>
<th>New P/N (NSN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB2831-5079</td>
<td>776848</td>
<td>29124</td>
<td>31506</td>
</tr>
<tr>
<td>(2910-01-434-8597)</td>
<td>96 thru 98</td>
<td></td>
<td>(2910-01-414-5382)</td>
</tr>
<tr>
<td>DB2831-5485</td>
<td>776848</td>
<td>29124</td>
<td>31506</td>
</tr>
<tr>
<td>(2910-01-467-9085)</td>
<td>99 and Above</td>
<td></td>
<td>(2910-01-414-5382)</td>
</tr>
</tbody>
</table>
2-24. ENGINE RUNNING TESTS

This is a top level test for problems with an engine that starts but doesn't run well after starting. This includes an engine that starts but doesn't stay running for very long. If the engine doesn't start, or starts but immediately stops, or is very hard to start, try the STARTABILITY tests first.

A functional flow schematic is not applicable to this section. However, so that you may refer to sections as you need them, a quick index to the systems relating to engine running is given here.

<table>
<thead>
<tr>
<th>PARAGRAPH</th>
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<tr>
<td>FUEL SYSTEM</td>
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<td>2-141</td>
</tr>
<tr>
<td>COMPRESSION/MECHANICAL</td>
<td>2-147</td>
</tr>
</tbody>
</table>
ENGINE RUNNING

START

1

THIS SECTION IS FOR PROBLEMS SUCH AS ROUGH IDLE, ROUGH RUNNING, LACK OF POWER, UNUSUAL NOISE OR VIBRATIONS. IF THE VEHICLE WON'T START, RUN THE STARTABILITY TESTS.

2

DOES THE ENGINE RUN WITHOUT STALLING?

TEST OPTIONS

OBSERVE THE ENGINE AND VEHICLE OPERATION.

REASON FOR QUESTION
To detect and fix minor problems before looking for major problems.

 Known Info

<table>
<thead>
<tr>
<th>Known Info</th>
<th>Test Options</th>
<th>Reason for Question</th>
</tr>
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<tbody>
<tr>
<td>Engine Starts</td>
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<td>Possible Problems</td>
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<tr>
<td>Air Intake/Exhaust</td>
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<tr>
<td>Mechanical</td>
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<tr>
<td>Electrical</td>
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<tr>
<td>Glow Plugs</td>
<td></td>
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</tr>
<tr>
<td>Cooling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubrication</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

YES

NO

GO TO FUEL SYSTEM TESTS, Page 2-99

GO TO 3, Page 2-54
This is a check for all of those problems which can cause the engine to stop when it shouldn't. This includes fuel, air, and electrical problems. If the engine starts and then stops immediately, run the startability tests first.
ENGINE RUNNING

KNOWN INFO
ENGINE STARTS AND STAYS RUNNING
FUEL SYSTEM OK
AIR INTAKE/EXHAUST OK

POSSIBLE PROBLEMS
MECHANICAL
ELECTRICAL
GLOW PLUGS
COOLING
LUBRICATION

TEST OPTIONS

FROM 2, Page 2-52

DOES THE ENGINE SOUND NORMAL AND HAVE NORMAL VIBRATIONS AT ALL SPEEDS?

REASON FOR QUESTION
There could be problems which would make it unsafe to continue operating or could cause further damage.

TEST OPTIONS

OBSERVE THE ENGINE WHILE RUNNING THE VEHICLE AT VARIOUS SPEEDS.

IF NO FAULTS FOUND, GO TO COMPRESSION/MECHANICAL TESTS, Page 2-147.

GO TO 4, Page 2-56

YES

NO
Listen for noises from the engine that aren't usually there when the engine is running normally. Also be alert for unusual vibrations while the engine is idling and while you accelerate to a safe and reasonable speed.
ENGINE RUNNING

DIAGNOSTIC FLOWCHART

**KNOWN INFO**

Does the engine produce rated power?

**TEST OPTIONS**

1. STE/ICE-R TESTS 13, 12 (Pages 2-492, 2-491)
2. ACCELERATE ON A LEVEL SURFACE.

**REASON FOR QUESTION**
If the engine produces rated power now, then it is probably ok to use.

**YES**

**GO TO FUEL SYSTEM, Page 2-99**

**NO**

**IS THE EXHAUST COLORLESS?**

**TEST OPTIONS**

1. STE/ICE-R TEST 14 (Page 2-493)

**REASON FOR QUESTION**
Abnormal exhaust is a sign of a fuel, air, or mechanical problem.

**YES**

**GO TO FUEL SYSTEM, Page 2-99**

**NO**

**DOES THE ENGINE PASS COMPRESSION UNBALANCE?**

**TEST OPTIONS**

**REASON FOR QUESTION**
Bad compression can make other systems look bad. The lower the compression unbalance number, the better the engine.

**YES**

**NOTIFY DS MAINTENANCE (CHAPTER 14).**

**NO**

**GO TO 7, Page 2-58**
### Reference Information

If STE/ICE-R is not available, accelerate under full power to a safe and reasonable speed on a level surface. For STE/ICE-R test 12, a number higher than 6,700 is passing. For test 13, a number higher than 75 is passing.

It is normal for the engine to emit some black smoke when accelerating after idling for a while. Under most other conditions, exhaust smoke is usually from one of three sources:

- **Blue** smoke is usually oil.
- **Black** smoke is too much fuel or too little air (often caused by advanced injection timing).
- **White** smoke is usually water (often caused by retarded injection timing).

If the smoking is continuous or appears under a particular condition, the smoke probably indicates a problem and should be investigated.

If STE/ICE-R is not available, there is no easy way to test compression. In this case, go on to the next step but remember that compression may be a problem.

### Engine Running

#### Engine Power Test (Percent) STE/ICE-R Test 13

1. Set TEST SELECT switches to 13.
2. Press and release TEST button.
4. When CIP appears on display, press down sharply on engine accelerator and hold it to the floor. When VTM displays OFF, release accelerator.
5. A number will be displayed after the engine has returned to idle speed. This number is the test result in units of percent of nominal rated power.

#### Engine Power Test (RPM/Sec) STE/ICE-R Test 12

1. Set TEST SELECT switches to 12.
2. Press and release TEST button.
4. When CIP appears on display, press down sharply on engine accelerator and hold it to the floor. When VTM displays a number, release accelerator.
5. A number will be displayed after the engine has returned to idle speed. This number is the test result in units of rpm per second.

#### Compression Unbalance STE/ICE-R Test 14

1. Run tests 72, 73, and 74 to verify that the batteries are ok.
2. The glow plug controller and the control valve electrical connector must be disconnected prior to running this test.
3. Disconnect wire 54A at injection pump to prevent starting.
4. Disconnect glow plug controller and control valve electrical connector (to keep waveform clean).
5. Start Test 14, compression unbalance.
7. Release the rotary switch when the VTM displays OFF. A number less than 25% is passing.
ENGINE RUNNING

FROM 6, Page 2-56

TEST OPTIONS
1. CHECK TEMPERATURE GAUGE.
2. RUN ENGINE COOLING TESTS (Page 2-159).

REASON FOR QUESTION
A hot or cold engine may run rough and cause problems later (at very inconvenient times).

KNOWLEDGE INFO
ENGINE RUNS NO ABNORMAL NOISES OR VIBRATIONS EXHAUST OK COMPRESSION OK.

POSSIBLE PROBLEMS
FUEL SYSTEM COOLING SYSTEM ELECTRICAL SYSTEM

TEST OPTIONS
1. CHECK TEMPERATURE GAUGE.
2. RUN ENGINE COOLING TESTS (Page 2-159).

REASON FOR QUESTION
A hot or cold engine may run rough and cause problems later (at very inconvenient times).

KNOWLEDGE INFO
ENGINE RUNS NO ABNORMAL NOISES OR VIBRATIONS EXHAUST OK COMPRESSION OK ENGINE POWER OK.

POSSIBLE PROBLEMS
COOLING SYSTEM FUEL SYSTEM

TEST OPTIONS
1. CHECK TEMPERATURE GAUGE.
2. RUN ENGINE COOLING TESTS (Page 2-159).

REASON FOR QUESTION
A hot or cold engine may run rough and cause problems later (at very inconvenient times).

KNOWLEDGE INFO
MOST SYSTEMS SEEM TO BE RUNNING OK.

POSSIBLE PROBLEMS
DRIVETRAIN

TEST OPTIONS
1. RERUN THIS CHAIN.
2. DRIVETRAIN TESTS (Page 2-453).

REASON FOR QUESTION
We've checked just about everything that could cause an engine running problem.
Because the engine cooling tests can take a long time (mostly letting a cold engine warm up), you don't have to run them unless there is or may be a problem in the cooling system.
This paragraph is a top level test for problems with either the water cooling system or the oil cooling system. Just follow the path and answer the questions. Additional information and notes are given on the facing page when necessary. The cooling system consists of the oil and water radiators, the engine fan and its controller, the water pump, and the internal coolant passages in the engine.

**ENGINE COOLING**

- TP SENSOR
- 315
- CONTROL VALVE & TIME DELAY MODULE
- ENGINE FAN
- SURGE TANK
- WATER PUMP
- THERMOSTAT
- COOLANT
- FAN TEMPERATURE SWITCH
- ENGINE

**OIL COOLING**

- OIL COOLER
- TRANSMISSION FLUID
- ENGINE OIL
- TRANSMISSION
COOLING SYSTEM

TEST OPTIONS

REASON FOR QUESTION

The engine should not reach temperatures over 240°F (116°C).

KNOWN INFO

NONE

POSSIBLE PROBLEMS

TEMPERATURE GAUGE
TEMPERATURE SENDER
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS
SERPENTINE BELT
CONTROL VALVE

IS THE ENGINE TEMPERATURE GAUGE BELOW FULL SCALE AT ALL TIMES?

YES

GO TO A, Page 2-66

NO

GO TO 2

TEST OPTIONS

LOOK.

POSSIBLE PROBLEMS

TEMPERATURE GAUGE
TEMPERATURE SENDER
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS
SERPENTINE BELT
CONTROL VALVE

KNOWN INFO

TEMPERATURE GAUGE IS BELOW 240°F (116°C) AT ALL TIMES.

POSSIBLE PROBLEMS

TEMPERATURE GAUGE
TEMPERATURE SENDER
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS
SERPENTINE BELT
CONTROL VALVE

DOES THE TEMPERATURE GAUGE READ BELOW 120°F (49°C) WHEN THE ENGINE IS COLD AND THEN INDICATE HIGHER TEMPERATURES AS THE ENGINE WARM?

YES

GO TO INSTRUMENTS, Page 2-305

NO

GO TO 3

TEST OPTIONS

VISUAL

REASON FOR QUESTION

You want to know if the gauge is working properly.

POSSIBLE PROBLEMS

TEMPERATURE GAUGE
TEMPERATURE SENDER
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS
SERPENTINE BELT
CONTROL VALVE

KNOWN INFO

TEMPERATURE GAUGE SEEMS TO WORK OK

POSSIBLE PROBLEMS

TEMPERATURE GAUGE
TEMPERATURE SENDER
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS
SERPENTINE BELT
CONTROL VALVE

DOES THE ENGINE APPEAR TO BE PROPERLY COOLED WITH NO EVIDENCE OF OVERHEATING?

YES

GO TO INSTRUMENTS, Page 2-305

NO

GO TO ENGINE COOLING, Page 2-159 AND THEN INSTRUMENTS, Page 2-305

GO TO 4, Page 2-64
The question describes how the gauge should work. If you aren't sure if it's working properly, you may want to run the instruments test anyway.

Look for boiling coolant, a blown surge tank pressure cap, or leaking hoses to tell you if the engine is overheating.
COOLING SYSTEM

DIAGNOSTIC FLOWCHART

FROM 3, Page 2-62

TEST OPTIONS

LOOK.

REASON FOR QUESTION

The fan clutch should turn the fan on when the temperature is above 220°F (104°C).

4

DOES THE FAN TURN ON WHEN THE ENGINE TEMPERATURE GAUGE READS ABOVE 220°F (104°C)?

KNOWN INFO
TEMPERATURE GAUGE OK
TEMPERATURE SENDER OK

POSSIBLE PROBLEMS
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS
SERPENTINE BELT
FAN CLUTCH/TIMER

NO

GO TO ENGINE COOLING, Page 2-159

YES

5

INSPECT ALL HOSES: THE RADIATOR, THERMOSTAT HOUSING, AND THE OIL COOLER. IS THE VEHICLE FREE OF ANY EVIDENCE OF LEAKING FLUIDS?

KNOWN INFO
SERPENTINE BELT OK
FAN CLUTCH/TIMER OK
TEMPERATURE GAUGE AND SENDER OK

POSSIBLE PROBLEMS
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS

NO

SEE INFORMATION AT RIGHT.

YES

NO FAULTS.
220°F (104°C) is the approximate temperature at which the fan should turn itself on. The fan will turn on and off as the engine temperature varies.

If the leaking fluid is red, go to the transmission, para. 2-40, page 2-385. If the leaking fluid is yellow/green, go to engine cooling, para. 2-31, page 2-159. If the oil cooler is leaking, try to determine where the leak is coming from. The oil cooler in front of the radiator cools both engine oil and transmission fluid (top-half transmission fluid, bottom-half engine oil). If the leak is in the oil cooler, go to transmission or engine cooling. If the leak is elsewhere, go to lubrication system, para. 2-26, page 2-69.
COOLING SYSTEM

KNOWN INFO
TEMPERATURE GAUGE WENT ABOVE 250°F (120°C)

POSSIBLE PROBLEMS
ENGINE COOLING SYSTEM
TEMPERATURE GAUGE TEMPERATURE SENDER

DIAGNOSTIC FLOWCHART

A FROM 1, Page 2-62

TEST OPTIONS
LOOK.

REASON FOR QUESTION
If the coolant is not boiling, then the temperature measuring instruments are faulty.

IS THE COOLANT BOILING OR THE ENGINE OVERHEATING?

NO

GO TO INSTRUMENTS, Page 2-305

YES

GO TO ENGINE COOLING, Page 2-159
REFERENCE INFORMATION

WARNING

Use caution when inspecting hot engine parts to avoid burns. Never remove the pressure cap of a hot engine.

The coolant surge tank is clear so you can see what is happening.
This paragraph is a top level test for all of the lubrication systems in the vehicle. Just follow the path and answer the questions. Additional information and notes are given on the facing page when necessary.

The HMMWV includes a venting system that is also checked in this paragraph. The purpose of the vent system is to allow vapor to escape to the atmosphere under normal operation, and to prevent venting during deep-water fording operations. If the vents were left open, water would enter the engine and other systems and cause damage. The location of the vent lines is shown below. The location of the other parts in the lubrication system are shown in other lower level paragraph as required.

**NOTE**

Bold lines represent ventilation system.
LUBRICATION SYSTEM

1. RUN THE ENGINE LUBRICATION TESTS. WERE YOU ABLE TO CORRECT ALL OF THE FAULTS?

   TEST OPTIONS
   ENGINE LUBRICATION TESTS [PAGE 2-197].
   REASON FOR QUESTION
   The tests in para. 2-32 are easy to run and will test out the engine lubrication system.

   KNOWLEDGE
   NONE

   POSSIBLE PROBLEMS
   ENGINE LUBRICATION
   TRANSMISSION LUBRICATION
   CHASSIS LUBRICATION
   VENTING SYSTEM

   NOTIFY DS MAINTENANCE (CHAPTER 14).

2. CHECK THE TRANSMISSION FLUID. IS IT OK?

   TEST OPTIONS
   VISUAL - SEE NOTE AT RIGHT. IF YOU SUSPECT PROBLEMS WITH THE TRANSMISSION, YOU CAN RUN THE TESTS IN PARA. 2-40 [PAGE 2-385].
   REASON FOR QUESTION
   Transmission fluid level and appearance give a good indication of the system's condition.

   KNOWLEDGE
   ENGINE LUBRICATION OK

   POSSIBLE PROBLEMS
   TRANSMISSION LUBRICATION
   CHASSIS LUBRICATION
   VENTING SYSTEM

   SEE NOTE AT RIGHT.

3. CHECK ALL OF THE REMAINING VEHICLE LUBRICATION POINTS. ARE THEY ALL PROPERLY LUBRICATED AND IN GOOD REPAIR?

   TEST OPTIONS
   SEE TM 9-2320-387-10 FOR LOCATION AND LUBRICATION INSTRUCTIONS.
   REASON FOR QUESTION
   The chassis and drivetrain need to be properly lubricated in order to keep the vehicle in good repair.

   KNOWLEDGE
   ENGINE LUBRICATION OK
   TRANSMISSION LUBRICATION OK

   POSSIBLE PROBLEMS
   CHASSIS LUBRICATION
   VENTING SYSTEM

   LUBRICATE OR REPAIR AS NEEDED.

   YES

   NO

   GO TO 4.

   Page 2-72
The tests in para. 2-32 test the oil level, cleanliness, leaks in the system, and the CDR valve. Return here when you've fixed everything you can or if no faults were found.

Procedure for Checking Transmission Fluid

1. Start engine.
2. Hold down brake pedal and move transmission shift lever through all ranges including reverse.
3. Engage parking brake and place shift lever in neutral. Check fluid level on dipstick.
4. Proper level is between FULL and ADD marks on dipstick.

**NOTE**
Check fluid for a burnt smell, grit, discoloration, air bubbles, or a milky appearance.

- Burnt smell, discoloration, or grit indicates worn or damaged internal components. Notify DS maintenance (chapter 14).
- Bubbles indicate an overfilled system or air leaks in the system. Drain the fluid and refill to proper level (para. 5-2).
- Milky appearance is due to water in the system. Drain the fluid from the entire transmission and transmission cooling system and install a new filter (para. 5-2).
- Check fill tube for indications of fluid being blown out. If fluid is being blown out, check vent line for obstructions, and refill transmission to proper level (para. 5-2).

Among the items are the driveshafts, suspension, differentials, and geared hubs.
LUBRICATION SYSTEM

KNOWN INFO
ENGINE LUBRICATION OK
TRANSMISSION LUBE OK
CHASSIS AND DRIVELINE
LUBE OK

POSSIBLE PROBLEMS
VENT SYSTEM

CHECK ALL OF THE VENT LINES IN THE VEHICLE. ARE THEY ALL OK?

REPAIR AS NEEDED.

YES

TEST OPTIONS
SEE THE FOLDOUT PAGE IN THIS PARAGRAPH FOR LOCATIONS OF THE VENT LINES.

REASON FOR QUESTION
Make sure that the vent system is intact. The vent system is used during deep fording operations.

POSSIBLE PROBLEMS
VENT SYSTEM

KNOW INFO
ENGINE LUBRICATION OK
TRANSMISSION LUBE OK
CHASSIS AND DRIVE LINE
LUBE OK
VENT LINES OK

POSSIBLE PROBLEMS
VENT FILTER

CHECK THE VENT FILTER. IS IT OK?

VISUAL INSPECTION - THE VENT FILTER IS LOCATED BEHIND THE COOLANT SURGE TANK.

REASON FOR QUESTION
A clogged vent filter will cause the fuel tank to be at a vacuum. This could lead to problems with the fuel system.

REPLACE FILTER.

YES

NO

NO FAULTS.
There are vent lines attached to all parts of the vehicle with a lubrication reservoir. These parts are the engine, transmission, transfer case, differentials, geared hubs, and the fuel tank. Removal procedures for the vent lines are given in the repair procedure for the particular component to which the line is attached.
2-27. ELECTRICAL TESTS

Most of the electrical circuits in the vehicle are included in one of the major systems covered by this manual. This is a top level paragraph to help you pick the right one. A number of schematics are also included to help you find the problem. If you go through the flow chart and can't solve the problem, use the schematics to find wires which may be causing trouble.

The electrical system consists of the batteries, which produce electrical power by a chemical reaction between the lead plates and the electrolyte solution (a mixture of acid and water). This power is carried by wires and cables to those parts of the vehicle which require electrical power. The batteries get recharged by the alternator, which generates electrical power by using some of the engine's mechanical power, produced when the engine is running. If you are not too confident about electrical concepts and terminology, you should read para. 2-22, page 2-43.

All electrical systems require a connection to ground (called grounding), which is the completion of the circuit to the battery negative. Pages 2-90, 2-91, and 2-92 are diagrams of the grounding. If your vehicle exhibits strange symptoms that seem to defy all efforts to fix them, the vehicle may have a grounding problem. Grounding problems cause strange symptoms usually because more than one circuit is using the same ground, or because a circuit has more than one ground. For example, looking at the body ground diagram, if wire 58D (a ground for the instruments) is disconnected from the left-side cylinder head, the instruments may still function due to the separate ground, but they would probably be erratic and inaccurate. Usually the problem will be a loose or corroded connection between the circuit, through body ground to battery negative terminal. Be sure to check continuity to battery negative cable rather than simply to the vehicle body or engine block.

After the grounding diagrams are functional flow schematics of the major systems in the vehicle. The shaded areas are the wires and components of the vehicle master power distribution. These are designed to help you find the system giving you problems.
1. **LOOK.**

2. STE/ICE-R TEST 90 (Page 2-507).

### REASON FOR QUESTION

It's important to verify that there are no shorts which could cause things to be powered when they shouldn't be.

---

2. **TURN LIGHTS ON AND LOOK.**

### REASON FOR QUESTION

The lights should work with the rotary switch at STOP. If the lights work, power is making it from the batteries through the PCB to the light circuit.

---

3. **TURN LIGHTS ON AND LOOK.**

### REASON FOR QUESTION

There may be problems which only affect one light, rather than all of them.
REFERENCE INFORMATION

The lights are the only circuit on the vehicle which should work or be drawing any power when the switch is in the STOP position. Check the instruments, try turning on the heater fan, listen for any relay clicking or other sign (includes engine running) that power is on when it shouldn't be. It's best if you use the STE/ICE-R in TK mode to verify that there is no current draw from the batteries. You can't use the DCA mode for this because it will measure this current during the calibration part of the test and read that this is just an offset in the sensor. The lights should work with the rotary switch in any position.

ELECTRICAL

<table>
<thead>
<tr>
<th>DC CURRENT 0-1,500 AMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 90</td>
</tr>
<tr>
<td>1. Connect probe.</td>
</tr>
<tr>
<td>2. Start Test 90, DC amps.</td>
</tr>
<tr>
<td>3. Displayed reading is in amps.</td>
</tr>
</tbody>
</table>
WITH THE ROTARY SWITCH IN THE RUN POSITION, IS THE INSTRUMENT CLUSTER VOLTMETER IN THE YELLOW OR GREEN ZONE?

DO ALL OF THE GAUGES WORK PROPERLY WITH THE ENGINE RUNNING?

DOES THE HEATER FAN WORK WITH THE ROTARY SWITCH IN THE RUN POSITION?
With engine off, turn switch. If the voltmeter is slightly in the yellow zone, you can continue down the YES path, but beware of possible test failures due to the low battery charge.
ELECTRICAL

KNOWN INFO
- ROTARY SWITCH OK
- CIRCUIT BREAKER 1 OK

POSSIBLE PROBLEMS
- BATTERY
- ALTERNATOR
- PCB
- RUN WIRING
- ACCESSORY WIRING

7

START THE ENGINE. WHEN THE ENGINE STARTED, DID THE BATTERY VOLTAGE INCREASE SO THE VOLTMETER IS IN THE GREEN ZONE?

TEST OPTIONS
1. VOLTMETER
2. STE/ICE-R TEST 67 (Page 2-496)
3. MULTIMETER

REASON FOR QUESTION
If the voltage increases, the alternator is connected and working.

GO TO ALTERNATOR, Page 2-199

YES

NO

8

DOES THE HEATER COOLING FAN WORK?

TEST OPTIONS
TRY IT.

REASON FOR QUESTION
The cooling fan should work when the rotary switch is turned to RUN.

GO TO ENGINE COOLING, Page 2-159

YES

NO

9

DOES THE WINDSHIELD WIPER WORK WITH THE ROTARY SWITCH IN THE RUN POSITION?

TEST OPTIONS
TRY IT.

REASON FOR QUESTION
The windshield wiper should work with the rotary switch in the RUN position.

GO TO INSTRUMENTS, Page 2-305

YES

NO

NO FAULTS.
### Battery Voltage

**STMCE-R TEST 67**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Start Test 67, battery voltage.</td>
</tr>
<tr>
<td>2.</td>
<td>Displayed reading is in volts. Batteries should be 23-25.5 volts. Voltage in batteries will drop when glow plugs turn on.</td>
</tr>
</tbody>
</table>
ELECTRICAL

KNOWN INFO
SHORT CIRCUIT IN POWER LINES

POSSIBLE PROBLEMS
BODY CONNECTOR HARNESS
ENGINE CONNECTOR HARNESS
ROTARY SWITCH

A1
DISCONNECT THE PCB BODY CONNECTOR. KEEP THE ROTARY SWITCH IN THE STOP POSITION. IS THERE STILL POWER AT ANY CIRCUITS OTHER THAN THE LIGHTS?

NO
GO TO B, PAGE 2-84

YES

A2
RECONNECT THE BODY CONNECTOR. DISCONNECT THE ENGINE CONNECTOR HARNESS. KEEP THE ROTARY SWITCH AT STOP. IS THERE POWER AT ANY CIRCUITS OTHER THAN THE LIGHTS?

NO
REPLACE PCB.

YES

A3
REPLACE THE ENGINE CONNECTOR HARNESS. GO TO STEP 1, PAGE 2-76 TO CONTINUE TESTING.

TEST OPTIONS
1. STE/ICE-R TEST 90 (Page 2-507)
2. VISUAL

REASON FOR QUESTION
If the problem goes away, the short is in the body connector harness or the rotary switch.

TEST OPTIONS
1. STE/ICE-R TEST 90 (Page 2-507)
2. VISUAL

REASON FOR QUESTION
If the problem stays, it has to be a short in the engine connector harness.
REFERENCE INFORMATION

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting protective control box harness.

**WARNING**
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Replace PCB (para. 4-4).

<table>
<thead>
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<th>DC CURRENT 0-1,500 AMPS</th>
</tr>
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<tr>
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<td>3. Displayed reading is in amps.</td>
</tr>
</tbody>
</table>
**ELECTRICAL**

**DIAGNOSTIC FLOWCHART**

**B1**

**KNOWN INFO**

SHORT ON BODY CONNECTOR SIDE OF PCB

**POSSIBLE PROBLEMS**

ROTARY SWITCH PCB
BODY CONNECTOR BODY CONNECTOR CABLE HARNESS

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

**REASON FOR QUESTION**
Checking the rotary switch first makes it easier to check the other possible problems.

**IS THERE AN OPEN CIRCUIT FROM PIN B TO PIN R AND FROM PIN B TO PIN S ON THE ROTARY SWITCH (WITH THE SWITCH IN THE STOP POSITION)?**

**B2**

**KNOWN INFO**

ROTARY SWITCH OK

**POSSIBLE PROBLEMS**

PCB BODY CONNECTOR BODY CONNECTOR CABLE HARNESS

**TEST OPTIONS**

1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

**REASON FOR QUESTION**
If there is voltage at any of these pins, then the PCB must have a short in it.

**IS THERE ABOUT 0 VOLT AT PINS A, B, D, G AND H OF THE PCB BODY CONNECTOR?**

**B3**

**REPLACE THE BODY CONNECTOR HARNESS.**

GO TO A2, PAGE 2-82, TO CONTINUE TESTING.
REFERENCE INFORMATION

- Replace rotary switch (para. 4-10).
- Replace PCB (para. 4-4).
- Replace harness. Notify DS maintenance (chapter 27).

### RESISTANCE AND CONTINUITY

| 0-4,500 OHMS |
| STE/ICE-R TEST 91 |

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.

### DC VOLTAGE 0-45 VOLTS

| STE/ICE-R TEST 89 |

1. Connect RED clip to the indicated test point. BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

---

**WARNING**

Disconnect negative battery cable before disconnecting and reconnecting protective control box harness.

**WARNING**

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.
ELECTRICAL

C1
CHECK ALL CONNECTIONS FROM THE BATTERIES TO THE LIGHT SWITCH. ARE THEY CLEAN AND TIGHT?

NO SHORTS
LIGHTS DON'T WORK

POSSIBLE PROBLEMS
BAD CONNECTIONS
BATTERIES
WIRES
LIGHTS CIRCUIT

YES

CLEAN AND TIGHTEN.

NO

C2
TURN THE ROTARY SWITCH TO RUN. DO ANY ELECTRICAL SYSTEMS WORK (LIGHTS, INSTRUMENTS, HEATER FAN)?

NO SHORTS
CONNECTIONS OK

POSSIBLE PROBLEMS
BATTERIES
WIRES
LIGHT CIRCUIT

YES

GO TO BATTERY CIRCUIT, Page 2-237

NO

TEST OPTIONS
LOOK AND TOUCH.

REASON FOR QUESTION
Loose or dirty connections won't conduct current.

TEST OPTIONS
LOOK.

REASON FOR QUESTION
This will check if the batteries have enough power to run the lights.

C3
GO TO LIGHTS, PARA. 2-39, PAGE 2-375, THEN CONTINUE TESTING AT STEP 3, PAGE 2-76.
Battery cables to starter.
Bus bar to solenoid.
PCB engine and body connector.
Light switch.
**Known Info**

- Power can be turned off

**Possible Problems**

- Batteries
- Instrument circuit

---

**Diagnostic Flowchart**

**D1**

**Is the battery voltage 23.5 to 25.5 volts?**

**Test Options**

1. STE/ICE-R TEST 67 (Page 2-496)
2. Multimeter

**Reason for Question**

If the battery is supplying full voltage, then there is something wrong with the instrument circuit.

---

**D2**

**Go to instruments, Para. 2-38, Page 2-305, then continue testing at step 4, Page 2-78.**
1. Start Test 67, battery voltage.

2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries' voltage will drop when glowplugs turn on.

---

1. Set the voltmeter to a DC volts scale of at least 40 volts.

2. Connect the RED lead to positive and the BLACK lead to negative.

3. Be sure to read the correct scale.
BATTERY/ENGINE GROUND CIRCUIT
BODY GROUND CIRCUIT

In 95B 0 99E REAR GUTS
I w/s WIPER MTR
TO ALTERNATOR (SEE BATTERY/ENGINE GROUND CIRCUIT)
BATTERY CIRCUIT INTERFACE

SHAD ED ARE A IS VEHICLE MASTER POWER

ELECTRICAL

ALL CIRCUITS MUST RETURN THROUGH VEHICLE GROUND.
ELECTRICAL

SHADED AREA IS VEHICLE MASTER POWER

GROUND STUD

8A TO DCA PIN X

POWER STUD

6A (STEACE-R TEST 67, BATTERY VOLTAGE)

SLAVE CONNECTOR

ENGINE CONNECTOR

81A

ROTARY SWITCH

14A

14B

STARTER CONTROL CIRCUIT

PROTECTIVE CONTROL BOX

STARTER SOLENOID

BUSS BAR

STARTER MOTOR

74B TO DCA PIN S
(STEACE-R TEST 70, STARTER SOLENOID VOLTS)

6A

81A

81B TO DCA PIN T
(STEACE-R TEST 68, STARTER MOTOR VOLTAGE)

3D TO DCA PIN M

ALL CIRCUITS MUST RETURN THROUGH VEHICLE GROUND.

2-94
ENGINE MECHANICAL POWER
FROM CRANKSHAFT VIA BELT AND PULLEYS.

28-VOLT, 200-AMP
ALTERNATOR

TO TP SENSOR
315A

TO COLD ADVANCE
509A

STARTER
LOCKOUT
CKT

CONTROL
CKT

ENGINE RUN
PRIMARY

BATTERIES
2-28. FUEL SYSTEM TESTS

These fuel system tests can be run any time you think there may be a problem with the fuel system or if you were sent here from another test.

If you are running this test because the engine runs rough, remember that air intake and exhaust as well as internal mechanical problems can also cause this condition.

At the bottom of this page is a simplified block diagram which shows how the different fuel system components relate to each other. Refer to fold-out page FP and leave open for reference while you are testing.
**DIAGNOSTIC FLOWCHART FUEL SYSTEM**

**KNOWN INFO**

NOTHING

**POSSIBLE PROBLEMS**

FUEL LINES
FUEL FILTER
FUEL PUMP
FUEL SOLENOID
INJECTION PUMP
INJECTORS

---

**TEST OPTIONS**

VISUAL INSPECTION, SAMPLED
WHILE CRANKING OR RUNNING.
THIS QUESTION ONLY CHECKS
THE SUPPLY OF FUEL IN THE
TANK AND TESTS TO SEE IF IT IS
GETTING TO THE INJECTOR
PUMP. THIS IS NOT A TEST OF
FUEL PRESSURE.

**REASON FOR QUESTION**

Without a supply of good fuel,
none of the components in the
fuel system can be expected to
work properly.

---

**KNOWN INFO**

FUEL AVAILABLE AND
NOT CONTAMINATED

**POSSIBLE PROBLEMS**

COLD ADVANCE
GLOW PLUGS
FUEL LINES
FUEL FILTER
FUEL PUMP
INJECTION PUMP
FUEL SOLENOID
RETURN CHECK VALVE

---

**TEST OPTIONS**

TRY STARTING THE ENGINE.

**REASON FOR QUESTION**

If it starts, you know that there is
fuel available and the fuel
solenoid is working.

---

**KNOWN INFO**

FUEL SOLENOID OK
FUEL OK

**POSSIBLE PROBLEMS**

COLD ADVANCE
FUEL LINES
FUEL FILTER
FUEL PUMP
INJECTION PUMP
INJECTORS

---

**TEST OPTIONS**

TRY STARTING THE ENGINE
WHILE IT'S COLD.

**REASON FOR QUESTION**

Problem may be the cold
advance circuit.

---

**KNOWN INFO**

FUEL SUPPLY AND
QUALITY OK?

---

**POSSIBLE PROBLEMS**

VISUAL INSPECTION, SAMPLED
WHILE CRANKING OR RUNNING.
THIS QUESTION ONLY CHECKS
THE SUPPLY OF FUEL IN THE
TANK AND TESTS TO SEE IF IT IS
GETTING TO THE INJECTOR
PUMP. THIS IS NOT A TEST OF
FUEL PRESSURE.

---

**TEST OPTIONS**

VISUAL INSPECTION, SAMPLED
WHILE CRANKING OR RUNNING.
THIS QUESTION ONLY CHECKS
THE SUPPLY OF FUEL IN THE
TANK AND TESTS TO SEE IF IT IS
GETTING TO THE INJECTOR
PUMP. THIS IS NOT A TEST OF
FUEL PRESSURE.

---

**REASON FOR QUESTION**

Without a supply of good fuel,
none of the components in the
fuel system can be expected to
work properly.

---

**KNOWN INFO**

FUEL AVAILABLE AND
NOT CONTAMINATED

**POSSIBLE PROBLEMS**

COLD ADVANCE
GLOW PLUGS
FUEL LINES
FUEL FILTER
FUEL PUMP
INJECTION PUMP
FUEL SOLENOID
RETURN CHECK VALVE

---

**TEST OPTIONS**

TRY STARTING THE ENGINE.

**REASON FOR QUESTION**

If it starts, you know that there is
fuel available and the fuel
solenoid is working.

---

**KNOWN INFO**

FUEL SOLENOID OK
FUEL OK

**POSSIBLE PROBLEMS**

COLD ADVANCE
FUEL LINES
FUEL FILTER
FUEL PUMP
INJECTION PUMP
INJECTORS

---

**TEST OPTIONS**

TRY STARTING THE ENGINE
WHILE IT'S COLD.

**REASON FOR QUESTION**

Problem may be the cold
advance circuit.
REFERENCE INFORMATION

MAKE SURE ALL ELECTRICAL CONNECTIONS ARE CLEAN AND TIGHT. CHECK FUEL SOLENOID, COLD ADVANCE SOLENOID, BATTERIES, ROTARY SWITCH, ETC.

1. While cranking or running the engine, open the drain fitting and drain some fuel into a clear container.

2. The fuel should come out of the open drain valve in a steady stream. If it doesn't, then answer NO to this question.
   • NOTE: Nothing will come out unless the engine is running or cranking.

3. Close the drain valve and turn the rotary switch to STOP.

4. Check the fuel that came out to be sure that it isn't contaminated with water or dirt.

5. If the fuel didn't come out in a steady stream or if it is contaminated, answer NO to this question.

If you have trouble starting the engine, you should have entered here by way of the startability tests. If you didn't begin there, go back to page 2-43 and run the startability top level test.

At this point, you don't care how well it starts or runs but just that it will run.

The answer to this question is NO if the engine seems to start but stops almost immediately.

Engine temperature may be determined from vehicle temp. gauge (rotary switch must be in RUN position) or by touching the engine. If it is too hot to touch comfortably, it is above 120° F (49° C).

Hard starting can be caused by other things such as fuel in the lines leaking back into the tank while the engine is shut down. This will occur if there is an air leak in the lines.

WARNING

Diesel fuel is highly flammable. Do not perform any procedures near fire, flames, or sparks. Severe injury or death will result.

A hot engine may cause serious burns. Always use caution when approaching a hot engine.
FUEL SYSTEM

KNOWN INFO
- FUEL SOLENOID OK
- COLD ADVANCE OK

POSSIBLE PROBLEMS
- FUEL LINES
- FUEL FILTER
- FUEL PUMP

TEST OPTIONS
1. TESTING R TEST 24
2. PRESSURE GAUGE

REASON FOR QUESTION
This is to verify that the fuel supply lines, fuel pump, and fuel filter are OK.

KNOWN INFO
- FUEL PUMP
- AND FILTER OK

POSSIBLE PROBLEMS
- INJECTION PUMP
- INJECTORS
- FUEL SUPPLY LINES
- FUEL RETURN LINES
- RETURN CHECK VALVE

TEST OPTIONS
WATCH AND LISTEN TO ENGINE.

REASON FOR QUESTION
If it runs smoothly, then it is not an individual cylinder fault such as a bad injector.

KNOWN INFO
- FUEL LINES, PUMP
- AND FILTER OK

POSSIBLE PROBLEMS
- INJECTION PUMP
- INJECTORS
- EXHAUST RESTRICTED

TEST OPTIONS
STE/ICE-R TEST 1

REASON FOR QUESTION
This is to verify that the idle speed is adjusted properly.
REFERENCE INFORMATION

Watch the fuel pump pressure while slowly accelerating the engine from idle to maximum speed. The pressure should always be greater than zero. If you can drive the vehicle while measuring the pressure, check to be sure it is still above zero even during maximum acceleration (maximum engine power). You can use STE/ICE-R test 24 with control function 02 (minimum).

NOTE
Rapidly accelerating the engine with the transmission in neutral doesn’t work for this engine because the fuel supply can’t increase as fast as the engine can accelerate so you won’t get good test results.

Proper engine performance depends upon the availability of the correct fuel volume to the injection pump.

Pay attention to when the engine runs rough. If it runs rough only while warming up after a cold start, it may be a glow plug problem and you should run the Glow Plug Circuit tests. Rough running may also be caused by air leaks in the fuel supply lines. Air in the fuel should purge itself while idling. If rough running occurs after a period of high speed or high power running but seems to go away after idling, then look for air leaks in the fuel supply lines and fittings. If rough running occurs while driving but idles ok, check the fuel return check valve for any malfunctions (para. 3-38).

Try to adjust the engine idle speed by turning the idle speed screw (para. 3-45). Continue testing if you can adjust the speed properly. If you cannot, notify DS maintenance (chapter 14).

Engine must be at normal operating temperature when making speed checks. Air filter must be in place and all accessories (lights, heater fan, etc.) must be turned off. This engine has a min-max governor which controls engine speed at both idle and full throttle.

FUEL SYSTEM

FUEL PUMP VOLUME TEST

1. Disconnect fuel line at injection pump inlet and route fuel line into a suitable 1 quart (1 liter) container.
2. Crank the engine for 30 seconds.
3. If the pump and lines are ok, you should get about 1 pint (1/2 quart) (.5 L) in 30 seconds.

FUEL PUMP PRESSURE STE/ICE-R TEST 24

(STE/ICE already connected to DCA and turned on)
2. Perform CAL.
3. Crank (or start) the engine.

NOTE: STE/ICE-R can display a pressure below 0. Be sure to notice if the display is negative.

FUEL PUMP PRESSURE TEST PRESSURE GAUGE

1. Connect a tee into the fuel line between the fuel filter outlet and the injection pump inlet.
2. Attach gauge to tee.
3. Crank (or start) engine.

ENGINE RPM STE/ICE-R TEST 10

1. Start Test 10, Engine RPM.
2. Crank or start the engine. Displayed reading is RPM. Cranking rpm should be at least 100 rpm. Idle rpm should be 700-750.
FUEL SYSTEM

KNOWN INFO
FUEL LINES, PUMP AND FILTER OK

POSSIBLE PROBLEMS
INJECTION PUMP INJECTORS EXHAUST RESTRICTED

TEST OPTIONS
IS MAXIMUM GOVERNOR SPEED 4,000 RPM NO LOAD? 3,600 LOADED?

REASON FOR QUESTION
Verify governor speed.

IS ENGINE POWER OK?

TEST OPTIONS
1. STE/ICE-R TEST 13
2. ROAD TEST

REASON FOR QUESTION
Some fuel system faults and bad fuel may cause low power and have passed the earlier tests.

IS THE EXHAUST COLORLESS?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Exhaust smoke may indicate conditions such as oil, water, or excessive fuel entering the cylinders.
Governor no-load speed is with the transmission in neutral. Loaded speed is with the transmission in gear and the vehicle moving. It is the maximum rpm the engine will develop. The engine will surge at governor speed since the governor will try to lower the engine speed and the accelerator is trying to increase it.

A number over 75 is passing for STE/CE-R test 13. If the vehicle seems to be low on power while driving, you have to check for other things which could cause this such as the transmission. To try a road test, accelerate the vehicle from 0 to a safe and reasonable speed on a reasonably level road.

If the exhaust is not colorless, it must be either white, blue, or black. If exhaust color is:

WHITE........ Go to G. [Page 2-126] Also could be injector timing. Notify DS maintenance (chapter 14).

BLUE........ Blue smoke is a sign of oil entering the combustion chambers. It usually enters past the piston rings or intake valve stem seals. This is an internal engine problem that can't be handled at this level of maintenance. You may want to run the engine running tests (page 2-51) before you notify DS maintenance (chapter 14).

BLACK........ Air intake/exhaust, page 2-141.
FUEL SYSTEM

DIAGNOSTIC FLOWCHART

11

DOES THE ENGINE SHUT OFF?

YES

GO TO H,
Page 2-128

NO

FROM 10,
Page 2-104

TEST OPTIONS
TURN ROTARY SWITCH TO STOP.

REASON FOR QUESTION
If everything is ok, the engine will shut off with the rotary switch in the stop position.

12

IS THE INJECTION PUMP'S ADVANCE MECHANISM FUNCTIONING PROPERLY?

YES

NOTIFY DS
MAINTENANCE
(CHAPTE14).

NO

TEST OPTIONS
PROCEDURE AT RIGHT

REASON FOR QUESTION
This will let you know if the pump's advance mechanism is ok.

13

DO YOU STILL HAVE A FUEL SYSTEM PROBLEM?

YES

NO FUEL SYSTEM FAULTS FOUND. IF YOU CAME HERE FROM ANOTHER TEST, RETURN TO THAT TEST NOW. OTHERWISE, YOU'RE DONE.

NO

RERUN THESE TESTS TO MAKE SURE YOU DIDN'T MISS ANYTHING.

KNOWN INFO
INJECTORS OK
EVERYTHING SO FAR IS OK

POSSIBLE PROBLEMS
FUEL SOLENOID OTHER INJECTION PUMP FAULTS
INJECTION PUMP ADVANCE MECHANISM
1. Note engine rpm reading (STE/ICE-R TEST 10).
2. Gently depress rocker arm on pump towards injection pump.
3. If mechanism is functioning properly, rpm will decrease.
4. If mechanism doesn't move freely, try putting a drop of oil in the two spots indicated. Gently try to depress rocker arm again.

INJECTION PUMP AS SEEN FROM REAR OF ENGINE. GENTLY PRESS SCREWDRIVER AGAINST ARM. USE A 10-IN. SCREWDRIVER.
FUEL SYSTEM

KNOWN INFO
FUEL SUPPLY PROBLEM

POSSIBLE PROBLEMS
FUEL PUMP
FUEL FILTER
FUEL LINES
VENT LINES

TEST OPTIONS
TRY IT.

REASON FOR QUESTION
This is to determine if there is any fuel available to the filter.

A1

DOES FUEL FLOW FROM THE FILTER DRAIN IN A STEADY STREAM?

NO

GO TO D, Page 2-116

YES

A2

DRAIN THE FILTER AND RECHECK FOR WATER OR OTHER CONTAMINATION IN FUEL.

IS THE FUEL CLEAN?

NO

DRAIN AND REFILL WITH FRESH FUEL. CHANGE FILTER.

YES

DRAIN SOME FUEL.

REASON FOR QUESTION
Water or dirt in fuel can damage fuel system components, especially the injection pump and injectors.

GO TO D, Page 2-116
If no fuel arrives when cranking engine, the diaphragm in the lift pump may be ruptured, allowing the fuel to drain back into the tank.

There may be some water or dirt trapped in the filter already that didn't come from the fuel that is in the tank now. Open the filter drain valve and crank the engine for approximately 5 seconds to purge the filter, then take a fuel sample in a clear container. Inspect the sample for water and dirt. Replace fuel filter (Para. 3-34).
**FUEL SYSTEM**

**DIAGNOSTIC FLOWCHART**

**B1**

**DISCONNECT THE GLOW PLUG CONTROLLER AND WIRE 5698 FROM THE INJECTOR PUMP. MAKE SURE THAT WIRE 54A IS PROPERLY CONNECTED TO THE INJECTOR PUMP. WITH THE ROTARY SWITCH IN RUN POSITION, DO YOU HAVE AT LEAST 17.0 VOLTS DC FLOWING THROUGH WIRE 54A?**

- **TEST OPTIONS**
  - STE/ICE-R TEST 89
    - MULTIMETER
  - REASON FOR QUESTION
    - Current through the wire quickly checks the integrity of the fuel system wiring. The normal reading will be about 1.3 to 1.5 amps.

- **TEST OPTIONS**
  - 1. STE/ICE-R TEST 24
  - 2. FUEL PUMP VOLUME TEST
  - REASON FOR QUESTION
    - Positive pressure and volume indicate that fuel is present and supply lines and filter are not plugged. This is a test of the lift pump.

**B2**

**RECONNECT THE ABOVE WIRES. CHECK FUEL PUMP PRESSURE AND VOLUME DURING CRANKING. IS PUMP PRESSURE GREATER THAN 3 PSI (20.69 kPa) AND FUEL VOLUME AT THE INJECTION PUMP INLET 1 PINT IN 30 SECONDS?**

- **TEST OPTIONS**
  - 1. STE/ICE-R TEST 24
  - 2. FUEL PUMP VOLUME TEST
  - REASON FOR QUESTION
    - Positive pressure and volume indicate that fuel is present and supply lines and filter are not plugged. This is a test of the lift pump.

**B3**

**DOES THE ENGINE START AND STAY RUNNING WITH THE FUEL RETURN LINE (THE SHORT RUBBER LINE AT THE INJECTOR PUMP) DISCONNECTED?**

- **TEST OPTIONS**
  - PUT THE RETURN LINE IN A SUITABLE CONTAINER AND TRY STARTING THE ENGINE.
  - REASON FOR QUESTION
    - A restricted fuel return line will cause a pressure imbalance in the pump and prevent the engine from running.
REFERENCE INFORMATION

When using a multimeter to measure current through wire 54A, disconnect the wire. Set the ammeter to a scale of at least 5 amps DC. Connect the red lead of the multimeter to wire 54A and the black lead to ground. With the rotary switch in the RUN position, measure current. Be sure to read the correct scale. Return the switch to the STOP position. Disconnect the multimeter and reconnect wire 54A.

FUEL SUPPLY PRESSURE (PSI)
STE/ICE-R TEST 24

1. Select Fuel Supply Pressure Test (Test 24).
   Perform CAL.
2. Crank (or start) engine.

FUEL PUMP VOLUME TEST

1. Disconnect fuel line at injection pump inlet and route fuel line into a suitable, 1 quart container.
2. Crank the engine for 30 seconds.
3. If the pump and lines are ok, you should get about 1 pint (1/2 quart) (.5 L) in 30 seconds.

WARNING

Diesel fuel is highly flammable. Do not perform any procedures near fire, flames, or sparks. Severe injury or death will result.

1. Disconnect the return line and direct it into a suitable container.
2. Watch the fuel flow from the return line as you or an assistant try to start the engine.

FUEL SYSTEM

DC CURRENT 0 - 45 VOLTS
STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point; BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

FUEL PUMP PRESSURE TEST
PRESSURE GAUGE

1. Connect a tee into the fuel line between the fuel filter outlet and the injection pump inlet.
2. Attach gauge to tee.
3. Crank (or start) engine.
FUEL SYSTEM

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Plugged fuel return lines cause back pressure which prevents injection pump from working properly.

DOES THE ENGINE RUN POORLY WITH THE RETURN LINE DISCONNECTED?

REPAIR/REPLACE FUEL INJECTOR RETURN LINES.

NO

YES

RUN THE INTAKE/EXHAUST TESTS. RETURN HERE IF NO FAULTS FOUND.

TEST OPTIONS

AIR INTAKE/EXHAUST TESTS

(REASON FOR TESTS

There is still a possibility of air intake/exhaust fault. If you came here from startability, this wasn’t tested.

PERFORM STARTABILITY TEST. RETURN HERE.

TEST OPTIONS

Run Startability Test

(REASON FOR TEST

Startability test will narrow possible problems down to injection pump or injectors.

KNOWN INFO

RETURN LINES OK

POSSIBLE PROBLEMS

INJECTION PUMP INJECTORS

KNOWN INFO

RETURN LINES OK

POSSIBLE PROBLEMS

INJECTION PUMP INJECTORS

KNOWN INFO

RETURN LINES OK

POSSIBLE PROBLEMS

INJECTION PUMP INJECTORS

GO TO B7.

PAGE 112.2
Return lines should be inspected for kinks or crushed lines or anything that might restrict fuel flow.

Inspect fuel return check valve for any restrictions. Replace valve [(para. 3-36)].
Replace fuel lines [(para. 3-26)].

If you came here from the startability tests, return to STEP 5, page 2-48.
If you haven’t run the startability tests yet, go to STEP 1 [(page 2-46)].
**FUEL SYSTEM**

**DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**

Run injection pump test.

**REASON FOR TEST**

Problem has been isolated to fuel injection pump or injectors.

**KNOWN INFO**

RETURN LINES OK

**POSSIBLE PROBLEMS**

INJECTION PUMP

INJECTORS

**TEST OPTIONS**

DOES FUEL INJECTION PUMP FUNCTION PROPERLY?

**REPAIR/REPLACE**

FUEL INJECTION PUMP.

**YES**

REPLACE INJECTORS.

(PAGE 16-2)

**NO**

FROM B6,

(Page 2-112)

*(Page 16-2)*
During high temperature and humidity, early model vehicles can experience difficulty starting while using JP-8 fuel. High temperatures can cause restrictive clearances in some older fuel injection head and rotor assemblies. The engine must be allowed to cool to allow adequate clearance of the pumping plungers to ensure adequate fuel delivery for starting. If this condition persists, run the startability tests. If vehicle passes all startability tests and troubleshooting procedures and still experiences difficulty in hot starting, identify the fuel injection pump and serial numbers.

All fuel injection pumps with P/N DB2831-5209, NSN 2910-01-467-9029 incorporated the improved head and rotor assembly, P/N 31506. If your serial number is less than shown in the Serial Number Break Column of the table below, the manufacturer recommends the fuel injection pump to be replaced, tagged as a “no hot restart” condition, and forward for rebuild. Notify direct support maintenance.

<table>
<thead>
<tr>
<th>Model Pump P/N (NSN)</th>
<th>Serial Number Break</th>
<th>Original P/N</th>
<th>New P/N (NSN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB2831-5079</td>
<td>776848 96 thru 98</td>
<td>29124</td>
<td>31506</td>
</tr>
<tr>
<td>(2910-01-434-8597)</td>
<td></td>
<td></td>
<td>(2910-01-414-5382)</td>
</tr>
<tr>
<td>DB2831-5485</td>
<td>776848 99 and Above</td>
<td>29124</td>
<td>31506</td>
</tr>
<tr>
<td>(2910-01-467-9085)</td>
<td></td>
<td></td>
<td>(2910-01-414-5382)</td>
</tr>
</tbody>
</table>
FUEL SYSTEM

DIAGNOSTIC FLOWCHART

C1

DISCONNECT WIRE 569B FROM COLD ADVANCE SOLENOID. WITH ROTARY SWITCH IN RUN POSITION, IS THERE BATTERY VOLTAGE AT WIRE 569B?

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
Need battery voltage to energize cold advance solenoid.

C2

RECONNECT WIRE 569B. IS THE COLD ADVANCE CIRCUIT WORKING?

TEST OPTIONS
PERFORM CHECKS AT RIGHT.

REASON FOR QUESTION
Cold advance circuit can cause hard cold starting.

C3

RUN GLOW PLUGS CIRCUIT TESTS. IF NO FAULTS FOUND, CONTINUE FUEL SYSTEM TESTS.

TEST OPTIONS
1. GLOW PLUGS CIRCUIT TESTS (Page 2-289)
2. FUEL SYSTEM TESTS

REASON FOR TESTS
The glow plug circuit operates during cold start.

KNOWN INFO
HARD COLD STARTING

POSSIBLE PROBLEMS
COLD ADVANCE CIRCUIT GLOW PLUG CIRCUIT FUEL SYSTEM

KNOWN INFO
POWER TO COLD ADVANCE SOLENOID

POSSIBLE PROBLEMS
COLD ADVANCE CIRCUIT GLOW PLUG CIRCUIT FUEL SYSTEM

KNOWN INFO
COLD ADVANCE CIRCUIT OK

POSSIBLE PROBLEMS
GLOW PLUG CIRCUIT FUEL SYSTEM
The engine temperature must be below 90°F (32°C) to get voltage here. If the engine is warm, either wait for it to cool, or go to step C3 at the bottom of the page and remember that the cold advance may be the problem if everything else checks out OK.

The glow plugs or the intake/exhaust system may be faulty, so you should test them first.

The cold advance circuit advances the fuel injection pump timing approximately 3 to 5 degrees during cold start-up. If engine temperature is less than 90°F (32°C), then advance circuit operation may be checked as follows:

1. Start the engine.
2. Disconnect wire 569B from the advance solenoid. If the circuit is working correctly, then engine rpm should decrease.
3. Look at the advance mechanism on the right side of the fuel injection pump while you connect and disconnect 569B with the engine running. The advance mechanism should move about 1/4 in.
4. If the advance mechanism is stuck, apply some oil at the points shown and try again.

Remember to reconnect any wires that were disconnected during troubleshooting.

### DC VOLTAGE 0-45 VOLS

**STE/ICE-R TEST 89**

1. Connect RED clip to positive, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

### BATTERY VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
FUEL SYSTEM

**KNOWN INFO**
- Low Fuel Pump Pressure

**POSSIBLE PROBLEMS**
- Fuel Pump
- Fuel Filter
- Fuel Lines
- Vent Lines
- Fuel Pressure Transducer

**TEST OPTIONS**

**REASON FOR QUESTION**
A plugged vent line will eventually cause enough negative pressure in the tank to prevent fuel flow.

**VISUAL**

**REPLACE VENT FILTER/REPAIR LINE.**

**D2**

**KNOWN INFO**
- Vent Lines OK
- Low Fuel Pump Pressure

**POSSIBLE PROBLEMS**
- Fuel Pump
- Fuel Lines
- Fuel Filter
- Fuel Pressure Transducer

**TEST OPTIONS**

**VISUAL**

**IS THE TEMPERATURE ABOVE 20°F (-7°C)?**

**REASON FOR QUESTION**
When the temperature is less than 20°F (-7°C), wax flakes can build up on the fuel tank strainer or in the fuel filter.

**CHECK FOR A WAX BUILD-UP IN TANK STRAINER OR FILTER. USE AN ANTIWAX AGENT IF AVAILABLE. BLEED FUEL SYSTEM AND CONTINUE TESTING.**

**D3**

**KNOWN INFO**
- Fuel Filter OK
- No Wax Build-Up
- Vent Lines OK
- Low Fuel Pump Pressure
- Fuel Lines

**POSSIBLE PROBLEMS**
- Fuel Pump
- Fuel Pressure Transducer

**TEST OPTIONS**

1. DCA Troubleshooting (Page 2-479)
2. Use a Pressure Gauge to Measure Fuel Supply.

**REASON FOR QUESTION**
Before condemning fuel pump, make sure that the pressure transducer is working.

**REPAIR/REPLACE AS NECESSARY.**

**GO TO D4, Page 2-118**

2-116
If you hear a hissing noise while removing the fuel filter cap, either the vent filter is plugged, the vent line is restricted, or the vent valve is restricted. The vent filter is located behind the coolant surge tank.

Replace vent lines or vent line filter (para. 3-25).

Replace vent valve (para. 3-25).

Diesel fuel is sensitive to temperature. All diesel fuel has a certain amount of paraffin-like components which have high energy value and help improve fuel economy. When temperatures are less than 20°F (-7°C), these components begin turning into wax flakes that can build up on the fuel tank strainer or in the fuel filter. If wax build-up is found, replace the fuel in the tank with a winter grade of fuel if available. You will have to remove the fuel tank if you need to inspect the tank strainer (para. 3-25).
FUEL SYSTEM

DIAGNOSTIC FLOWCHART

FROM D3, Page 2-116

D4

INSPECT THE FUEL LINES. ARE THE LINES OK?

KNOWN INFO
- FUEL FILTER OK
- NO WAX BUILD-UP
- VENT LINES OK
- LOW FUEL PUMP PRESSURE

POSSIBLE PROBLEMS
- FUEL PUMP
- FUEL LINES
- FUEL PRESSURE
- TRANSDUCER

NO

REPAIR/REPLACE LINES.

YES

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
Kinked fuel lines will restrict fuel flow.

D5

INSPECT THE FUEL FILTER. REMOVE THE FILTER ELEMENT AND CHECK IT FOR DIRT AND OTHER CONTAMINATION. IS THE FILTER ELEMENT CLEAN?

KNOWN INFO
- NO WAX BUILD-UP
- VENT LINES OK
- LOW FUEL PUMP PRESSURE

POSSIBLE PROBLEMS
- FUEL PUMP
- FUEL LINES
- FUEL FILTER
- FUEL PRESSURE
- TRANSDUCER

NO

REPLACE FUEL FILTER.

YES

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
A dirty filter will restrict fuel flow.

D6

REMOVE FUEL PUMP. INSPECT FUEL PUMP PUSHROD AND CAMSHAFT Lobe. ARE ALL OF THESE PARTS IN GOOD CONDITION?

KNOWN INFO
- FUEL LINES OK
- FUEL FILTER OK
- NO WAX BUILD-UP
- VENT LINES OK
- LOW FUEL PUMP PRESSURE
- TRANSDUCER OK

POSSIBLE PROBLEMS
- FUEL PUMP

NO

SEE NOTE AT RIGHT.

REPLACE THE FUEL PUMP. RETURN TO THE TEST YOU CAME FROM AND CONTINUE TESTING.
Fuel lines should be inspected for kinks, cracks, or anything that would restrict fuel flow or allow air to enter the lines. Be sure to check the lines all the way back to the tank and remember that there is a strainer inside the tank which can become plugged. You will have to remove the tank if it becomes necessary to check this.

Replace fuel lines (para. 3-25).

Poor starting and excessive smoke after start-up can be the result of a restricted fuel supply. This restriction most likely will be from a plugged fuel filter but can also be caused by a pinched or kinked fuel line. After the engine warms up, it generally will run satisfactorily. If the restriction gets progressively worse, top speed and performance will also be affected.

FUNGUS
In warm or humid weather, fungi and/or bacteria in the fuel can cause fuel system damage by plugging the fuel lines, filter, or injection nozzles.

For removal, replacement, and torques, refer to para. 3-24 or notify DS maintenance (chapter 16).

Excessive roughness on any of these parts is an indication of wear. The pushrod should slide smoothly in the engine block. If you notice any roughness on the end of the pushrod, be sure to check the lobe on the camshaft.

NOTE

If the pump or rod is worn, replace (para. 3-24). If the lobe on the camshaft is worn, notify DS maintenance (chapter 16).

Rerun Test Chain

You may have corrected some problems but there may be others including the fuel pump.

For removal, replacement and torques, refer to para. 3-24.
FUEL SYSTEM

RUN THE GLOW PLUG TESTS. RETURN HERE IF NO FAULTS FOUND.

E1

TEST OPTIONS
RUN GLOW PLUGS CIRCUIT TESTS (Page 2-289). IF YOU ARE SURE THAT THE PROBLEM EXISTS WHEN THE ENGINE IS WARM, YOU CAN SKIP THIS QUESTION.

REASON FOR QUESTION
Glow plug failures can cause rough running when cold.

E2

TEST OPTIONS
COLD ADVANCE TESTS (Page 2-114)

REASON FOR QUESTION
A faulty cold advance circuit can cause rough running.

KNOWN INFO
GLOW PLUGS OK

POSSIBLE PROBLEMS
COLD ADVANCE
FUEL LINES
FUEL PUMP
FUEL FILTER
INJECTION PUMP
INJECTORS

GO TO E3, Page 2-122

FROM 6, Page 2-102

DIAGNOSTIC FLOWCHART
Injection pump timing that is too far advanced can cause glow plugs failure because it increases cylinder temperature. Usually several, but not all, glow plugs will fail.
FUEL SYSTEM

FUEL SYSTEM

TEST OPTIONS

KNOWLEDGE

COLD ADVANCE OK

POSSIBLE PROBLEMS

FUEL LINES
FUEL PUMP
FUEL FILTER
INJECTION PUMP
INJECTORS
RETURN CHECK VALVE

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Air leaks, lack of fuel, or restricted check valve can cause rough running at different speeds.

REPAIR/REPLACE LINES.

KNOWLEDGE

SUPPLY LINES OK

POSSIBLE PROBLEMS

FUEL LINES
FUEL PUMP
FUEL FILTER
INJECTION PUMP
INJECTORS
RETURN CHECK VALVE

REPAIR/REPLACE LINES.

KNOWLEDGE

FUEL PUMP OK

POSSIBLE PROBLEMS

INJECTION PUMP
INJECTORS

A COMPLETE CHECK OF THE INJECTION PUMP AND INJECTORS CANNOT BE DONE AT THIS LEVEL OF MAINTENANCE, BUT YOU HAVE COVERED MOST FUEL SYSTEM PROBLEMS THAT WOULD CAUSE THIS CONDITION. IF YOU STILL HAVE A PROBLEM, YOU MAY WANT TO RUN THE COMPRESSION/MECHANICAL TESTS BEFORE YOU NOTIFY DS MAINTENANCE (CHAPTER 14).

COMPRESS/MECHANICAL TESTS (Page 2-147)

ARE THE FUEL SUPPLY LINES OK?

E3

ARE THE FUEL RETURN LINES OK?

E4

ARE THE FUEL RETURN LINES OK?

E5

2-122
CAUTION

Be sure to keep the line clear of moving engine parts (fan, pulleys, etc.) and DO NOT place the line on the exhaust manifold.

Replace fuel lines (para. 3-26).

Check the filter vent screw for tightness.

Check the supply lines for kinks, cracks, leaks, or loose connections that could restrict fuel flow or allow air to enter the system. Remember that under certain operating conditions parts of the fuel system can be under vacuum so that loose connections that may not leak fuel can let air in.

To test for air leaks in the supply lines, disconnect the return line from the injection pump and connect a line that is long enough to reach the ground. Place the end of the line into a bucket containing diesel fuel, making sure that the end of the line is below the level of fuel in the bucket. Run the engine and watch for air bubbles in the bucket. You can also replace the short return line from the injector pump with a clear piece of tubing to check for bubbles.

Inspect the return lines for kinks or any other blockage that may restrict fuel flow.

Inspect fuel return check valve for any restrictions (para. 3-26).

Replace fuel line (para. 3-26).
FUEL SYSTEM

KNOWN INFO
FUEL FILTER OK

POSSIBLE PROBLEMS
FUEL PUMP
ACCELERATOR LINKAGE
FUEL LINES
INJECTION PUMP
INJECTORS
INTAKE/EXHAUST
RETURN CHECK VALVE

DIAGNOSTIC FLOWCHART

F1
INSPECT FUEL SUPPLY AND RETURN LINES. ARE THE LINES OK?

NO
REPAIR/REPLACE LINES.

YES

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Kinked fuel lines will restrict fuel flow. Partially blocked return lines may cause the injection pump to malfunction. Air leaking into the fuel will also cause loss of power.

AIR INTAKE/EXHAUST TESTS (Page 2-141)

The intake and exhaust systems affect vehicle operation under all conditions.

F2
ARE THE INTAKE AND EXHAUST SYSTEMS OK?

NO
GO TO AIR INTAKE/EXHAUST TESTS, Page 2-141

YES

TEST OPTIONS
VISUAL

REASON FOR QUESTION

F3
WITH ENGINE NOT RUNNING, CHECK MOVEMENT OF ACCELERATOR PEDAL. DOES PEDAL HAVE FULL TRAVEL?

NO
SEE NOTE AT RIGHT.

YES

NOTIFY DS MAINTENANCE (CHAPTER 14).

IF THE PEDAL STICKS, YOU MAY NOT BE ABLE TO FULLY OPEN THE THROTTLE.
Be sure to keep the line clear of moving engine parts (fan, pulleys, etc.) and DO NOT place the line on the exhaust manifold.

Fuel lines should be inspected for kinks, cracks, or anything that would restrict fuel flow or allow air into the lines. Be sure to check the lines all the way back to the tank and remember that there is a strainer inside the tank which can also become plugged.

To test for air leaks in the supply lines, disconnect the return line from the injection pump and connect a line that is long enough to reach the ground. Place the end of the line into a bucket containing diesel fuel, making sure that the end of the line is below the level of fuel in the bucket. Run the engine and watch for air bubbles in the bucket. Replace fuel line (para. 3-26).

An important function of all hoses, lines, and fittings is to carry fuel without admitting air to the system. When the fuel tank cap is in place and the fuel pump and injection pump are drawing fuel through the lines, a low vacuum of 0-1 PSI is created. This occurs because the fuel which the engine uses must be replaced by air. During this vacuum condition, the slightest leak, which may not leak fuel out, could draw air into the system and, depending on the volume of air, cause a wide variety of engine malfunctions.

COLD WEATHER OPERATION

Diesel fuel is sensitive to temperature. All diesel fuel has a certain amount of wax-like components which have high energy value and help improve fuel economy. When temperatures are less than 20°F (-7°C), these components begin turning into flakes that can build up on the fuel tank strainer or in the fuel filter.

FUNGUS

In warm or humid weather, fungi and/or bacteria can cause fuel system damage by plugging the fuel lines, filter, or injection nozzles.

ODOR

Old fuel smells like varnish.

Check the accelerator pedal for full movement with no sticking or binding. If you have sticking or binding, lubricate accelerator pedal bushing and bearing with seasonal grade OE oil (TM 9-2320-387-10). If you do not have full pedal travel, disconnect the accelerator linkage from the fuel injection pump and recheck the travel. If you now have full travel, the problem is in the fuel injection pump and cannot be handled at this level of maintenance.

Operation of the injection pump and injectors cannot be verified at this level of maintenance.
**FUEL SYSTEM**

**DIAGNOSTIC FLOWCHART**

**G1**

**TEST OPTIONS**

PUT A PIECE OF PAPER IN THE EXHAUST STREAM THEN LOOK AT AND SMELL IT FOR SIGNS OF UNBURNED FUEL.

**REASON FOR QUESTION**

White smoke indicates fuel not being burned in the cylinders, or possible loss of coolant to the exhaust.

**G2**

**TEST OPTIONS**

VISUAL

**REASON FOR QUESTION**

Some white smoke after a cold start is normal. The colder it is, the more white smoke you'll see. The glow plugs keep cycling after the engine starts which will reduce this smoking. If you think that there is too much smoke after a cold start, run the glow plugs circuit tests (Page 2-289), paying special attention to the afterglow operation.

**G3**

**TEST OPTIONS**

GLOW PLUGS CIRCUIT TESTS (Page 2-289)

**REASON FOR QUESTION**

If the glow plugs are not functioning properly, the cylinders will not warm up as rapidly as they should.
REFERENCE INFORMATION

WARNING

Be careful when performing this test. Exhaust gas can be extremely hot and severe burns can result.

Put a piece of paper in the exhaust stream for a few moments with the engine at idle. Then look at the paper to see if there is any condensed fuel on it. Then smell the paper to see if it smells like raw fuel. If it smells like fuel, the engine could be very cold or else it has a DS level fuel system fault or compression fault.

White smoke for a short time after start-up, especially on a cold day, is a normal condition. It is caused by incomplete combustion of the fuel because of low cylinder temperature. It should clear up in a few minutes. If not, you may have a bad head gasket, cracked block, or a restricted check valve. Check for restricted check valve [para. 3-36].
FUEL SYSTEM

KNOWN INFO
ENGINE WON'T SHUT OFF

POSSIBLE PROBLEMS
FUEL SOLENOID
SOLENOID WIRING
ROTARY SWITCH
CONTROL BOX

TEST OPTIONS
LISTEN.

REASON FOR QUESTION
If the engine doesn't shut off, the solenoid is mechanically stuck open.

H1
DISCONNECT WIRE 54A FROM FUEL SOLENOID. DOES THE ENGINE SHUT OFF?

GO TO K, Page 2-132

H2
TURN ROTARY SWITCH TO STOP. DISCONNECT BODY CONNECTOR AT PROTECTIVE CONTROL BOX. IS VOLTAGE 0 AT WIRE 54A AT FUEL SOLENOID?

NO
GO TO L, Page 2-132

YES

H3
RECONNECT BODY CONNECTOR. DISCONNECT WIRE 11A FROM ROTARY SWITCH. IS VOLTAGE 0 AT WIRE 54A AT FUEL SOLENOID?

NO
REPAIR SHORT IN BODY CONNECTOR HARNESS.

YES

TEST OPTIONS
1. STE/ICE-R TEST 89
(Pt. 2-506)
2. MULTIMETER

REASON FOR QUESTION
If voltage is 0, the problem is in the wiring harness to the switch or in the switch.

SOLENOID WIRING
ROTARY SWITCH
CONTROL BOX

TEST OPTIONS
1. STE/ICE-R TEST 89
(Pt. 2-506)
2. MULTIMETER

REASON FOR QUESTION
This wire supplies power to the rotary switch. There should be no power to the solenoid with it disconnected.

CONTROL BOX OK
FUEL SOLENOID OK
ENGINE WON'T SHUT OFF

POSSIBLE PROBLEMS
SOLENOID WIRING
ROTARY SWITCH

SYSTEM TEST TO VERIFY THERE ARE NO OTHER FAULTS.

2-128
REFERENCE INFORMATION

WARNING

Keep hands away from engine fan. Moving fan blades can cause serious injury. Use extreme caution when engine is running.

WARNING

Disconnect negative battery cable before disconnecting and reconnecting protective control box harness.

WARNING

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Rotary switch must remain in STOP position for the rest of these tests.

NOTE

Carefully inspect the body connector end of the harness for a short. Check for pushed out pins, broken or stripped insulation, or any other bare wires. If everything checks out OK, you have to replace the harness.

Remember to reconnect any wires that may have been disconnected during troubleshooting.

Repair harness (para. 4-80).

Replace rotary switch (para. 4-13).

FUEL SYSTEM

DC VOLTAGE 0-45 VOLTS
STEICE-R TEST 89

1. Connect RED clip to positive, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

DC VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

 tắm

REAR OF ROTARY SWITCH

WIRE 54A

INJECTION PUMP
FUEL SYSTEM

KNOWN INFO
- FUEL SUPPLY OK
- FUEL RETURN OK
- SOLENOID WIRING

POSSIBLE PROBLEMS
- FUEL SOLENOID
- INJECTION PUMP
- INJECTORS

DIAGNOSTIC FLOWCHART

I1
DID A STREAM OF FUEL COME OUT OF THE INJECTOR PUMP RETURN LINE WHILE IT WAS CRANKING?

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
To see if there is fuel available to the injection pump.

SEE INFORMATION AT RIGHT.

NO

I2
IS THE GLOW PLUGS CIRCUIT OK? (IF YOU DON'T KNOW, RUN THE GLOW PLUGS CIRCUIT TESTS: RETURN HERE IF NO FAULTS FOUND).

TEST OPTIONS
- GLOW PLUGS CIRCUIT TESTS

REASON FOR QUESTION
On a cool day a faulty glow plug circuit will prevent the engine from starting.

GO TO GLOW PLUGS, Page 2-289

NO

YES

I3
DISCONNECT WIRE 569B FROM THE COLD ADVANCE SOLENOID.

WITH ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 569B?

TEST OPTIONS
1. STE/ICE-R TEST 80
   (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
On a cold day, a faulty cold advance circuit will prevent the engine from starting.

REPAIR 569B or REPLACE HARNESS.

NO

YES

FAULTY INJECTION PUMP; NOTIFY DS MAINTENANCE (CHAPTER 14).

2-130
Check the rubber return line from the injection pump to the steel tubing return line.

If the rubber line is not clogged, go to D1, page 2-116.

If the line is clogged, replace it. Start the engine and see if it stays running. If it doesn't start or stay running, return to J1 and continue testing. There may be another fuel system fault preventing fuel from reaching this point.

If the cold advance solenoid is getting power, the only possibilities that would keep the engine from starting are that fuel is not reaching the cylinders due to a fault in the high-pressure side of the fuel system or nearly all the cylinders have very low compression. It is unlikely that all the cylinders would lose compression at the same time, but you may want to run a Compression Unbalance test (STE/ICE-R Test 14) to check this.

Repair/replace harness (para. 4-80).
**FUEL SYSTEM**

**Diagnosis Flowchart**

**Known Info**
- White Smoke

**Possible Problems**
- Coolant in cylinders

---

**Test Options**

**J**
- Does the engine lose excessive coolant?

**Test Options**
- Look at coolant level in surge tank.

**Reason for Question**
- If the engine loses coolant but not from leaks in the lines, hoses, heater or radiator, it may have a crack or blown gasket in the engine.

---

**Test Options**

**K**
- If the engine loses coolant but not from leaks in the lines, hoses, heater or radiator, it may have a crack or blown gasket in the engine.

**Reason for Question**
- There is an internal injector pump problem that is preventing procedure will cause it to stall.

---

**Test Options**

**L**
- Use pliers to squeeze fuel return line at injection pump.

**Reason for Test Step**
- There is an internal injector pump problem that is preventing shutting off the engine. This procedure will cause it to stall.

---

**Test Options**

**M**
- Reconnect body connector, disconnect engine connector from protective control box. Is voltage 0 at wire 54A at the fuel solenoid?

**Reason for Question**
- If there is a voltage reading, there is a short in the wiring harness.

---

**Test Options**

**N**
- Repair short in engine connector harness.

**Reason for Question**
- If there is a voltage reading, there is a short in the wiring harness.

---

**Test Options**

**O**
- Replace protective control box.

---

**Test Options**

**P**
- 1. STE/ICE-R Test 89
- 2. Multimeter

---

**Test Options**

**Q**
- Notify DI, Maintenance (Chapter 14).

---

**Test Options**

**R**
- Notify DS, Maintenance (Chapter 14).

---

**Test Options**

**S**
- See Information at Right.

---

**Test Options**

**T**
- None
If you are getting white smoke due to coolant entering the cylinders, you should notice a loss of coolant in the radiator or bubbles in the radiator tank while the engine is running. You may need to fill the radiator to proper level and recheck a day later to determine if there is a coolant loss.

If you don't detect coolant loss, you may have missed a fuel problem. Rerun the fuel system tests paying attention for a raw exhaust smell.

If you still find nothing, you may have a small or inconsistent leak. Notify DS maintenance (chapter 14).

**WARNING**

Keep hands away from engine fan. Moving fan blades can cause serious injury. Use extreme caution when engine is running.

If the engine doesn't shut off with the solenoid disconnected, fuel is still reaching the cylinders—probably because the fuel solenoid is stuck open. When you squeeze the return line tight enough to prevent fuel flowing through it, you create a pressure imbalance inside the injection pump that will cause the engine to stall.

**WARNING**

Disconnect negative battery cable before disconnecting and reconnecting protective control box harness.

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Remember to reconnect any wires that may have been disconnected during troubleshooting.

Repair/replace harness (para. 4-80).

Replace PCS (para. 4-4).

---

**DC VOLTAGE 0-45 VOLTS STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

**BATTERY VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
FUEL SYSTEM

KNOWN INFO

ENGINE CRANKS
NO VOLTAGE AT ADVANCE SOLENOID

POSSIBLE PROBLEMS

PCB
COLD-ADVANCE SWITCH
WIRING

TEST OPTIONS

WITH ROTARY SWITCH IN RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 5A AT THE ALTERNATOR OUTPUT?

YES

RUN ALTERNATOR DIAGNOSTICS.

NO

DIAGNOSTIC FLOWCHART

TEST OPTIONS

1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
With rotary switch in RUN position, WSA is connected to battery voltage through the PCR and it supplies power to the cold-advance switch.

M2

KNOWLEDGE

PCB OK
ENGINE CRANKS
NO VOLTAGE AT ADVANCE SOLENOID

POSSIBLE PROBLEMS

COLD-ADVANCE SWITCH
WIRING

TEST OPTIONS

DISCONNECT WIRE 569 AT COLD ADVANCE SWITCH. WITH ROTARY SWITCH IN RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 569?

YES

REPAIR 569, REPLACE HARNESS.

NO

REASON FOR QUESTION
If you have no voltage here, the problem may be the cold-advance switch.

M3

KNOWLEDGE

PCB OK
ENGINE CRANKS
NO VOLTAGE AT ADVANCE SOLENOID

POSSIBLE PROBLEMS

COLD-ADVANCE SWITCH
WIRING

TEST OPTIONS

RECONNECT WIRE 569. DISCONNECT WIRE 569B FROM COLD-ADVANCE SWITCH WITH ROTARY SWITCH IN RUN POSITION. DO YOU HAVE BATTERY VOLTAGE AT SWITCH LEAD?

YES

REPLACE COLD-ADVANCE SWITCH.

NO

REPAIR 569B, REPLACE HARNESS.

REASON FOR QUESTION
If you don't have voltage here, the problem is the switch.
REFERENCE INFORMATION

You should only run the engine long enough to determine the gauge reading because engine temperature must stay below 90°F (33°C) for the cold-advance circuit to function.

<table>
<thead>
<tr>
<th>DC VOLTAGE 0-45 VOLS</th>
<th>STE/ICE-R TEST 89</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Connect RED clip to positive, BLACK clip to negative or ground.</td>
<td></td>
</tr>
<tr>
<td>2. Start Test 89, DC volts.</td>
<td></td>
</tr>
<tr>
<td>3. Displayed reading is in volts.</td>
<td></td>
</tr>
</tbody>
</table>

BATTERY VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

1. Shut off engine.
2. Disconnect wire 569 at cold-advance switch.
3. Turn rotary switch to RUN position.
4. Check for battery voltage at wire 569.

Repair/replace harness (para. 4-80).

NOTE

Engine temperature must be less than 90°F (33°C) when testing the switch.

Replace cold-advance switch (para. 4-31).

Repair/replace harness (para. 4-80).

Cold-advance switch is closed when engine temperature is below 90°F (33°C) and open when it goes above 120°F (49°C).

The cold-advance solenoid advances the injection pump timing when it receives power from the switch. This helps the engine run better when it is cold.
FUEL SYSTEM

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If you have continuity here, the problem may be the PCB.

DIAGNOSTIC FLOWCHART

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If you have continuity, you may have a problem with the rotary switch or the wiring.

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
You need to find the open circuit between the PCB and rotary switch.
REFERENCE INFORMATION

WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Repair wiring (para. 4-80).
Inspect wiring to be sure that all the wires are connected in their proper places.

PCB ENGINE CONNECTOR
(ON LEFT FENDER LINER)

PCB BODY CONNECTOR
(LOCATED UNDER DASHBOARD)

Repair wiring (para. 4-80).
Remember to reconnect any wires that were disconnected during troubleshooting.

FUEL SYSTEM

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question.
   RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays 9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

REAR OF ROTARY SWITCH

2-137
**FUEL SYSTEM**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**

29C OK

**POSSIBLE PROBLEMS**

PCB

**ROTARY SWITCH**

**WIRING**

**N4**

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (Page 2-509)
2. MULTIMETER

**REASON FOR QUESTION**

If this wire is ok, the problem may be in the rotary switch.

**DISCONNECT WIRE 11A FROM THE ROTARY SWITCH. DO YOU HAVE CONTINUITY BETWEEN WIRE 11A AT THE SWITCH AND SOCKET G IN THE BODY CONNECTOR HARNESS?**

**NO**

REPAIR W11A OR REPLACE HARNESS.

**YES**

**RECONNECT THE BODY CONNECTOR HARNESS THEN THE ENGINE CONNECTOR HARNESS. DO YOU HAVE CONTINUITY BETWEEN WIRE 29A AT THE ROTARY SWITCH AND WIRE 54A AT THE FUEL SOLENOID?**

**N5**

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (Page 2-509)
2. MULTIMETER

**REASON FOR QUESTION**

If the rotary switch is ok, the problem is the PCB.

**WITH THE ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE CONTINUITY BETWEEN THE TERMINALS FOR WIRES 11A AND 29A ON THE ROTARY SWITCH?**

**NO**

REPLACE ROTARY SWITCH.

**YES**

!!

**N6**

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (Page 2-509)
2. MULTIMETER

**REASON FOR QUESTION**

If there is no continuity, there is an open inside the PCB.

**RECONNECT THE BODY CONNECTOR HARNESS THEN THE ENGINE CONNECTOR HARNESS. DO YOU HAVE CONTINUITY BETWEEN WIRE 29A AT THE ROTARY SWITCH AND WIRE 54A AT THE FUEL SOLENOID?**

**NO**

REPLACE PCB.

**YES**

**REPLACE PCB.**

**NO FAULTS.**
REFERENCE INFORMATION

PCS BODY CONNECTOR

Repair/replace harness.  (Para. 4-80).

REAR OF ROTARY SWITCH

Repair/replace rotary switch.  (Para. 4-10).

WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Be sure to reconnect the wires at the rotary switch and the fuel solenoid.

Replace PCB.  (Para. 4-1).

FUEL SYSTEM

FUEL SOLENOID WIRING

RESISTANCE AND CONTINUITY

0-4500 OHMS

STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
These air intake/exhaust system tests can be run any time you think there may be a problem with the air intake or exhaust systems, or if you were sent here from another test.

At the bottom of this page is a simplified block diagram of the intake air/exhaust system. A detailed functional flow is not applicable to this system.

The air intake/exhaust system is a very simple system that can cause very annoying problems. Whether the vehicle is hard to start or runs rough or never develops full power, it's worth the few minutes that it takes to check the components of this system. You can run through the diagnostic logic for this system almost any time you open the hood or check the underside of your vehicle.
INTAKE AIR/ EXHAUST

DIAGNOSTIC FLOWCHART

START

1

IS THE AIR FILTER ELEMENT OK?

YES

NO

REPLACE AIR FILTER ELEMENT.

TEST OPTIONS
1. VISUAL
2. DASHBOARD INDICATOR
3. REMOVE AND INSPECT ELEMENT.

REASON FOR QUESTION
If the air filter is clogged, the engine will not develop full power. Engine may emit black smoke or it may not start at all.

KNOWN INFO
NOTHING

POSSIBLE PROBLEMS
AIR FILTER INDUCTION SYSTEM EXHAUST PIPE MUFFLER

2

IS THE INDUCTION SYSTEM INTACT AND NOT BLOCKED? ARE ALL HOSE CONNECTORS TIGHT?

YES

NO

REPAIR/REPLACE INDUCTION SYSTEM COMPONENTS AS REQUIRED.

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If the induction system is broken, debris may enter the engine past the air filter.

KNOWN INFO
AIR FILTER OK

POSSIBLE PROBLEMS
INDUCTION SYSTEM EXHAUST PIPE MUFFLER

3

IS THE EXHAUST PIPE AND/OR CATALYTIC CONVERTER INTACT AND NOT BLOCKED?

YES

NO

REPAIR/REPLACE INDUCTION SYSTEM COMPONENTS AS REQUIRED.

TEST OPTIONS
1. VISUAL
2. CHECK FOR BENT OR DENTED EXHAUST PIPES OR CATALYTIC CONVERTER.

REASON FOR QUESTION
If the exhaust is broken or blocked, the engine will not develop full power or it may not start.

KNOWN INFO
AIR FILTER OK INDUCTION SYSTEM OK

POSSIBLE PROBLEMS
EXHAUST MUFFLER

GO TO 4, Page 2-144
First, check the air filter restriction gauge on the dashboard, just to the left of the steering wheel, and make a note of its reading. Open the air cleaner cannister, remove the air cleaner element and inspect it for dirt and other contaminants. Replace air filter (para. 3-13). A clean air filter is white. If the condition of the filter does not agree with the gauge on the dashboard, make a note to check the gauge. See instruments tests, page 2-305.

Make sure that all mounting bolts are in place and tight. Look for obvious things like a crushed or cracked air filter or air induction tube and check gaskets where possible. Replace induction system components (para. 3-12).

Look for damage caused by rocks such as bent pipes or holes and loose or broken clamps.

Small dents (depth less than 1/4 the diameter of the exhaust pipes) should not cause the pipes to be replaced as long as the pipes are intact. Replace induction system components (para. 3-12).
INTAKE AIR/ EXHAUST

KNOWN INFO

| AIR FILTER OK  |
| EXHAUST PIPE OK |

POSSIBLE PROBLEMS

MUFFLER

DIAGNOSTIC FLOWCHART

FROM 3, Page 2-142

IS THE MUFFLER INTACT AND NOT BLOCKED?

TEST OPTIONS

VISUAL

REASON FOR QUESTION

If the muffler is damaged or blocked, the engine will not develop full power or it may not start.

NO FAULTS FOUND.

NO

REPAIR/ REPLACE MUFFLER.

YES
Look for damage caused by rocks such as bent pipes or holes, loose or broken clamps.

Replace muffler (para. 3-45).
2-30. COMPRESSION/MECHANICAL TESTS

The main intent of this paragraph is to determine if the engine has internal compression or mechanical problems and to fix everything possible without having to notify DS maintenance (chapter 14).
DOES THE ENGINE CRANK AT NORMAL SPEED?

**REASON FOR QUESTION**
No cranking or slow cranking may indicate a seized or tight engine, weak batteries or a bad starter circuit.

**POSSIBLE PROBLEMS**
- ENGINE
- FUEL SYSTEM
- INTAKE/EXHAUST
- STARTER CIRCUIT
- LUBRICATION

**KNOWN INFO**
- NOTHING

**TEST OPTIONS**
- STE/ICE-R TEST 10 (Page 2-490)

---

DOES THE VEHICLE START?

**REASON FOR QUESTION**
If the engine starts, then most of the fuel system is OK and the intake/exhaust system is probably OK.

**POSSIBLE PROBLEMS**
- FUEL SYSTEM
- ENGINE
- INTAKE/EXHAUST

**KNOWN INFO**
- BATTERY CIRCUIT OK
- STARTER CIRCUIT OK
- ENGINE NOT SEIZED

**TEST OPTIONS**
- FOLLOW NORMAL STARTING PROCEDURE.

---

IS THE ENGINE OIL PRESSURE 40-45 PSI (276-310 kPa) AT 2,000 RPM AND THE ENGINE WARM?

**REASON FOR QUESTION**
Without proper oil pressure, the engine won't be lubricated properly.

**POSSIBLE PROBLEMS**
- LUBRICATION
- ENGINE
- FUEL SYSTEM
- INTAKE/EXHAUST

**KNOWN INFO**
- BATTERY CIRCUIT OK
- STARTER CIRCUIT OK
- ENGINE NOT SEIZED

**TEST OPTIONS**
- 1. OIL PRESSURE GAUGE
- 2. STE/ICE-R TEST 50 (Page 2-495)

---

GO TO STARTABILITY, Page 2-45

---

GO TO LUBRICATION, Page 2-49

---

GO TO 4, Page 2-150
REFERENCE INFORMATION

A healthy engine should crank at least 100 rpm when it's cold and at least 180-200 rpm when it's warm.

If the engine doesn't crank at normal speed, it could be due to a starter or battery circuit fault or it may be due to an internal engine problem.

Oil pressure may go as high as 80 psi (552 kPa) if the engine is cold and should be 10 psi minimum at idle speed. You should check the oil pressure with the STE/ICE-R (test 50) using 1,000 psi (6,895 kPa) transducer (blue stripe). Check pressure at idle and at 2,000 rpm. If pressure is low, check oil level and condition. Add or change oil as required.

COMPRESSON / MECHANICAL

ENGINE RPM 
STE/ICE-R TEST 10

1. Start Test 10, Engine RPM.
2. Crank or start the engine. Displayed reading is RPM. Cranking rpm should be approximately 100-200. Idle rpm should be 625 - 675.

OIL PRESSURE 
STE/ICE-R TEST 50

1. Install STE/ICE-R 0 to 1000 PSI (0-6,895 kPa) transducer (blue stripe) in place of oil pressure sending unit.
2. Connect to STE/ICE-R TK connector J2 or J3.
3. CAL with engine off.
4. Start engine. Run test 50. With the engine warm, oil pressure should be 10 psi (69 kPa) minimum at idle and 40-45 psi (275-310 kPa) at 2,000 rpm. Pressure may go as high as 80 psi (552 kPa) when the engine is cold.
**Diagnostic Flowchart**

**Compression / Mechanical**

**Known Info**
- Battery circuit OK
- Starter circuit OK
- Engine not seized
- Air and fuel to cylinders

**Possible Problems**
- Intake/exhaust
- Fuel system
- Engine

**Test Options**

1. **Does the engine sound normal and have normal vibrations at all speeds?**
   - Rev the engine, drive the vehicle.

2. **Reason for question**
   - The first indication of a mechanical problem is an abnormal noise or vibration. Before running other tests to check for engine problems, this is to try to make sure that you don’t make a bad problem worse.

3. **Possible Problems**
   - Engine

4. **Test Options**
   - If the engine fails the cylinder unbalance test, it indicates an individual cylinder problem such as a bad fuel injector, excessive blowby, etc.

5. **Reason for question**
   - Loss of power can be caused by internal engine problems, fuel system, air intake/exhaust, or drivetrain problems.

**Test Options**

6. **Does the engine pass the power test?**
   - Go to C, page 2-156

**Reason for question**

**Test Options**

**No faults found. If you were sent here from another test, return to it.**

2-150
This is not to evaluate driving performance. If the engine or the vehicle makes strange noises or vibrations at idle speed, don't rev the engine. If there is a problem internal to the engine, revving the engine could cause major damage (like a rod coming through the engine block).

### COMPRESSION UNBALANCE

**STE/ICE-R TEST 14**

1. Run tests 72, 73, and 74 to verify that the batteries are ok.
2. Disconnect wire 54A at injection pump to prevent starting.

**CAUTION**
The glow plug controller and the control valve electrical connector must be disconnected prior to running this test.

3. Disconnect glow plug controller and control valve electrical connector.
4. Start Test 14, Compression Unbalance.
5. Wait for the GO message. Crank the engine.
6. Release the rotary switch when the VFM displays OFF. A number less than 25% is passing.

If the vehicle passes the STE/ICE-R Compression Unbalance test, it may still have a compression problem, but it would mean that every cylinder has low compression. This is possible, but not too likely. If you don't find a problem and suspect compression, notify DS maintenance (chapter 14) to measure compression.

If STE/ICE R is not available, accelerate under full power to a reasonable speed on a flat, level, paved surface. You have to decide from your own experience whether or not the engine is developing full power. A number greater than 75 is passing for Test 13.

### POWER TEST (PERCENT)

**STE/ICE-R TEST 13**

1. Start and idle engine.
2. Run STE/ICE R test 10 to set idle and governor speed as necessary
3. Start STE/ICE-R test 13
4. When CIP appears on the display, press down sharply on the accelerator and hold it to the floor until the VTM displays OFF.
5. Displayed value is % POWER
**KNOWN INFO**

ENGINE DOESN'T CRANK PROPERLY

**POSSIBLE PROBLEMS**

ENGINE
STATER CIRCUIT
BATTERY CIRCUIT

**TEST OPTIONS**

1. STE/ICE-R TEST 67, 73, 75 (Pages 2-496, 2-502, 2-504)
2. BATTERY CIRCUIT TESTS (Page 2-237)

**REASON FOR QUESTION**

A faulty battery circuit can cause slow or no cranking.

**IS THE BATTERY CIRCUIT OK?**

**TEST OPTIONS**

1. STE/ICE-R TESTS 71, 72, 74 (Pages 2-500, 2-501, 2-503)
2. STARTER CIRCUIT TESTS (Page 2-247)

**REASON FOR QUESTION**

A faulty starter circuit can cause slow or no cranking.

**IS THE STARTER CIRCUIT OK?**

**TEST OPTIONS**

1. STE/ICE-R TESTS 71, 72, 74 (Pages 2-500, 2-501, 2-503)
2. STARTER CIRCUIT TESTS (Page 2-247)

**REASON FOR QUESTION**

A faulty starter circuit can cause slow or no cranking.

**CAN YOU TURN THE CRANKSHAFT MANUALLY?**

**TEST OPTIONS**

- USE A BREAKER BAR AND SOCKET ON CRANKSHAFT PULLEY BOLT.

**REASON FOR QUESTION**

If you can't turn the engine by hand, the engine is probably seized.

**NOTIFY DS MAINTENANCE (CHAPTER 14).**

**NO FAULTS FOUND, GO TO STEP 2, PAGE 2-148.**
1. Start Test 67, Battery Voltage.
2. Displayed reading is in volts. Batteries should be 23-25 volts. Batteries voltage will drop when glow plugs turn on.

The starter circuit tests begin on page 2-247. Internal engine problems (tight main or rod bearings for example) or drivetrain problems could still cause the engine to crank slowly even if the starter and battery circuits are OK.

**WARNING**

Be sure to disconnect fuel solenoid (wire 54A) to prevent accidental starting. Failure to do so may result in injury to personnel or damage to equipment.

A breaker bar and socket placed on the crankshaft pulley can be used to try to turn the crankshaft. The crankshaft pulley is located directly under the engine cooling fan. It can be reached from under the HMMWV.

If the engine won't turn, remove the glow plugs and try again. If the engine turns now, try cranking it and look for fuel at the eight glow plug holes. If you see fuel at any of the holes, the engine may have had hydrostatic lock. Crank the engine for about 15 seconds to clear the fuel, re-install the glow plugs and try to start the engine. If it still won't crank, notify DS maintenance (chapter 14).

---

**STARTER FIRST PEAK CURRENT**

**STE/ICE-R TEST 72**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plugs controller and fan solenoid.
3. Start Test 72, Current First Peak.
4. Wait for the GO message. Crank the engine.
5. Result is displayed in amps. Starter first peak should be over 400 amps.

**BATTERY INTERNAL RESISTANCE**

**STE/ICE-R TEST 73**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plugs controller and fan solenoid.
3. Start Test 73, Battery Internal Resistance.
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms. Battery resistance should be 25 milliohms max.

**STARTER CIRCUIT RESISTANCE**

**STE/ICE-R TEST 74**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plugs controller and fan solenoid.
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms. Starter circuit resistance should be 25 milliohms max.
**COMPRESSION / MECHANICAL**

**TEST OPTIONS**
- DRIVE THE VEHICLE.
- LOOK, LISTEN, AND FEEL

**REASON FOR QUESTION**
- If the problem occurs only when the vehicle is being driven, it's probably not an engine problem.
- There are many problems that can cause noise or vibration.

**B1**
- **DOES THE NOISE OR VIBRATION CONTINUE WHEN THE VEHICLE IS STOPPED AND THE TRANSMISSION IS IN NEUTRAL?**
  - **NO**
    - **RUN TRANSMISSION/SUSPENSION/STEERING TESTS.**
  - **YES**
    - **!!**

**B2**
- **CHECK THE ITEMS LISTED ON THE RIGHT HAND PAGE. IS EVERYTHING OK?**
  - **NO**
    - **REPAIR OR REPLACE THE FAULTY COMPONENT(S) IF AUTHORIZED. OTHERWISE, NOTIFY DS MAINTENANCE (CHAPTER 14).**
  - **YES**
    - **RETURN TO 5, PAGE 2-150**
REFERENCE INFORMATION

Try the following steps:

1. Determine what noises or vibrations are there when the engine is running with the transmission in neutral.

2. Keep the engine running, put the transmission in drive, and take note of any changes in the noises or vibrations.

3. If it's safe to drive, drive the vehicle and take note of any changes in the noises or vibrations. Drive vehicle through all gears and ranges within speed rates listed in TM 9-2320-387-10.

WARNING

A hot engine may cause serious burns. Always use caution when approaching a hot engine.

Engine Mounts
Transmission Mounts
Cooling Fan
Serpentine Belt
Water Pump
Power Steering Pump
Fuel Pump
Alternator
Air Induction Components
Exhaust Components
**Compression / Mechanical**

**Known Info**
- Battery and Starter Circuits OK

**Possible Problems**
- Engine
- Drivetrain
- Fuel System

**Test Options**
- Air Intake/Exhaust Tests
  (Page 2-141)

**Test Options**
- Fuel System Tests
  (Page 2-99)

**Reason for Question**
- Intake or exhaust restrictions will prevent the engine from producing full power. A NO answer means the test passed with no air filter.

**Reason for Question**
- Many fuel system faults will allow the engine to start and run but prevent it from producing full power.

**Diagram**
- C1
  - Run a power test with the air filter removed. Does the test still fail?
  - If not, go to Air Intake/Exhaust Tests, Page 2-141.
  - If yes, go to Fuel System Tests, Page 2-99.

**Known Info**
- Battery and Starter Circuits OK
- Air Intake/Exhaust OK

**Possible Problems**
- Engine
- Drivetrain

**Reason for Question**
- If everything checks out OK to this point, then you probably have an engine mechanical problem that can't be handled at this level of maintenance. Notify DS Maintenance (Chapter 14).
If faults are found and corrected, go to STEP 2, page 2-148.

If no faults are found, go to B2, page 2-154.

If faults are found and corrected, go to STEP 2, page 2-148.

If no faults are found, go to B2, page 2-154.
2-31. ENGINE COOLING TESTS (SERIAL NUMBERS 299999 AND BELOW)

These engine cooling tests may be run any time you think you have an engine cooling problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary. Please note that this paragraph is NOT for diagnoses of problems with the temperature sending unit or the gauge.

Once you are sure that the cooling system is OK, run the instruments test in paragraph 2-38 to find out if the gauge is OK.

Fold-out page FP-6.1 contains a functional diagram of the engine cooling system. This page may be left open for reference while testing.

The engine cooling system is a pressure-type cooling system with thermostatic control of coolant circulation. The cooling system dissipates heat generated from combustion and maintains the engine operating temperature at its most efficient level. When the engine is cold and the thermostat is closed, coolant is recirculated through the water pump and engine. As the engine coolant reaches 215°F (102°C), the thermostat opens, allowing coolant to flow through the radiator before returning to the water pump and engine. Any air or vapor in the cooling system will be forced to the surge tank under the liquid level and leave through a vent tube. As the system cools, the extra coolant in the tank will be drawn back to the radiator. Normally a 50-50 mixture of water and ethylene glycol-based antifreeze will be used. The fan is activated when coolant temperature reaches approximately 220°F (104°C). A separate oil cooler is mounted in front of the radiator. This cooler is divided into two parts. The top half is for transmission oil. The bottom half is for engine oil. When the cooling system pressure reaches approximately 15 psi (103 kPa), a valve in the surge tank cap opens and lets excess pressure escape to the atmosphere.

**ETHYLENE GLYCOL INHIBITED (MIL-A-46153)**

<table>
<thead>
<tr>
<th>LOWEST EXPECTED AMBIENT TEMPERATURE °F</th>
<th>PINTS PER GALLON OF COOLANT CAPACITY</th>
<th>SPECIFIC GRAVITY (68°F) (20°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+20</td>
<td>1-1/2</td>
<td>1.022</td>
</tr>
<tr>
<td>+10</td>
<td>2</td>
<td>1.036</td>
</tr>
<tr>
<td>0</td>
<td>2-3/4</td>
<td>1.047</td>
</tr>
<tr>
<td>-10</td>
<td>3-1/4</td>
<td>1.055</td>
</tr>
<tr>
<td>-20</td>
<td>3-1/2</td>
<td>1.062</td>
</tr>
<tr>
<td>-30</td>
<td>4</td>
<td>1.067</td>
</tr>
<tr>
<td>-40</td>
<td>4-1/4</td>
<td>1.073</td>
</tr>
<tr>
<td>-50</td>
<td>4-1/2</td>
<td></td>
</tr>
<tr>
<td>-55</td>
<td>4-3/4</td>
<td></td>
</tr>
<tr>
<td>BELOW -60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ARCTIC GRADE ANTIFREEZE (-90°F) (-68°C)**

<table>
<thead>
<tr>
<th>Temple Midland Antifreeze 2000 (MIL-A-11755)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use only when temperatures are below -60°F</td>
</tr>
</tbody>
</table>

Freezing point -90°F (-68°C).

Issued ready-for-use and must not be mixed with any other liquid.
ENGINE COOLING
(5/N 299999 AND BELOW)

START

1

IS THE COOLANT MIXTURE CORRECT?
(SEE CHART ON PAGE 2-159.)

NO

YES

DRAIN & REFILL COOLANT.

TEST OPTIONS
1. COOLANT MIXTURE TEST
   KIT NSN 6630-00-169-1506
2. COOLANT TESTER
   NSN 6630-00-105-1418

REASON FOR QUESTION
The cooling system will not operate properly if the mixture is incorrect.

2

IS THE COOLANT AT THE CORRECT LEVEL?

NO

YES

FILL TO PROPER LEVEL.

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Low coolant levels may cause overheating.

3

IS THE THERMOSTAT WORKING PROPERLY?

NO

YES

REPLACE THERMOSTAT.

TEST OPTIONS
FEEL FOR COOLANT IN UPPER RADIATOR HOSE WHEN ENGINE IS HOT, OR REMOVE THERMOSTAT, EXPOSE IT TO 190°F (88°C) TEMPERATURES. SEE IF IT OPENS.

REASON FOR QUESTION
An improperly functioning thermostat can cause operating temperatures that are either too hot or too cold.

GO TO 4,
Page 2-162
REFERENCE INFORMATION

WARNING
Do not remove surge tank filler cap before releasing internal pressure when engine temperature is above 190°F (88°C). Steam or hot coolant under pressure will cause injury.

Drain and refill coolant (para. 3-61).

WARNING
Do not remove surge tank filler cap before releasing internal pressure when engine temperature is above 190°F (88°C). Steam or hot coolant under pressure will cause injury.

Fill coolant to proper level (para. 3-61).

WARNING
Always use caution when approaching a hot engine. Failure to do so may result in serious burns.

Remove and replace the thermostat (para. 3-76).
ENGINE COOLING
(S/N 299999 AND BELOW)

4

INSPECT THE PRESSURE CAP. IS IT IN GOOD CONDITION?

TEST OPTIONS
PRESSURE TESTER

REASON FOR QUESTION
A defective pressure cap may cause overheating.

NO

REPLACE PRESSURE CAP.

YES

5

INSPECT ALL RADIATOR HOSES, COOLANT HOSES, SURGE TANK, RADIATOR, OIL COOLER, AND FITTINGS FOR DAMAGE, BLOCKAGE, OR LARGE LEAKS. IS EVERYTHING IN GOOD SHAPE?

TEST OPTIONS
LOOK.

REASON FOR QUESTION
Physical damage and blocked passages can cause cooling problems.

NO

REPAIR/REPLACE AS AUTHORIZED. FLUSH SYSTEM IF BLOCKED. OTHERWISE, NOTIFY DS MAINTENANCE (CHAPTER 14).

YES

6

IS THE ENGINE FAN WORKING PROPERLY?

TEST OPTIONS
LOOK -- SEE DESCRIPTION OF OPERATION AT RIGHT.

REASON FOR QUESTION
The engine fan helps cool the engine.

NO

GO TO A, Page 2-168

YES

GO TO 7, Page 2-164
REFERENCE INFORMATION

WARNING
Do not remove surge tank filler cap before releasing internal pressure when engine temperature is above 190°F (88°C). Steam or hot coolant under pressure will cause injury.

Check seal and spring on pressure cap.

Replace pressure cap (para. 3-61).

Flush cooling system (para. 3-61).

For surge tank and radiator support replacement procedures, refer to paras. 3-64 and 3-65.

For oil cooler and oil cooler hose replacement procedures, refer to paras. 3-7 and 3-8.

Notify DS maintenance to repair radiator (chapter 17).

ENGINE COOLING
(S/N 299999 AND BELOW)

ENGINE COOLING FAN DESCRIPTION OF OPERATION
An external line from the power steering gear brings hydraulic fluid to the clutch fan solenoid through control valve (normally open) and then to the fan drive, keeping it disengaged. The action of the valve is controlled by the time-delay module and the fan temperature switch.

During normal operation, the fan timer switch is closed. This keeps the control valve in the open position and the drive disengaged. As the engine reaches a temperature of about 215°F (102°C), the temperature switch opens and the control valve closes. This engages the fan. If the fan is engaged and the accelerator is floored, the throttle position sensor disengages the fan drive for a period of 20 seconds.

The easiest way to determine if the fan is engaged is to stand outside the driver's door and gently work the accelerator. If the fan is engaged, you will feel a breeze from the engine area. If the fan is not engaged, you won't feel the breeze.
ENGINE COOLING  (S/N 299999 AND BELOW)

**DIAGNOSTIC FLOWCHART**

**7**

**KNOWN INFO**
- COOLANT OK
- PRESSURE CAP OK
- HOSES OK
- SURGE TANK OK
- OIL COOLER OK
- ENGINE FAN OK

**POSSIBLE PROBLEMS**
- RADIATOR
- WATER PUMP & PULLEY
- SERPENTINE BELT

**TEST OPTIONS**
- LOOK.

**REASON FOR QUESTION**
- Bent or blocked fins prevent efficient cooling of the coolant.

**INSPECT THE RADIATOR. IS IT IN GOOD CONDITION (FINS NOT BADLY BENT OR BLOCKED)?**

- **YES**
  - STRAIGHTEN AND CLEAN.

- **NO**
  - STRAIGHTEN AND CLEAN.

**8**

**KNOWN INFO**
- COOLANT OK
- PRESSURE CAP OK
- RADIATOR/HOSES OK
- SURGE TANK OK
- OIL COOLER OK
- ENGINE FAN OK

**POSSIBLE PROBLEMS**
- WATER PUMP & PULLEY
- SERPENTINE BELT

**TEST OPTIONS**
- LOOK AND LISTEN.

**REASON FOR QUESTION**
- A bad pulley and water pump won’t cool the engine efficiently.

**INSPECT THE WATER PUMP AND PULLEY. ARE THEY IN GOOD CONDITION?**

- **YES**
  - REPLACE PULLEY OR PUMP.

- **NO**
  - REPLACE PULLEY OR PUMP.

**9**

**KNOWN INFO**
- RADIATOR/HOSES OK
- SURGE TANK OK
- OIL COOLER OK
- ENGINE FAN OK
- PUMP & PULLEY OK

**POSSIBLE PROBLEMS**
- SERPENTINE BELT
- INTERNAL ENGINE LEAKS

**TEST OPTIONS**
- VISUAL INSPECTION OF BELT TENSIONER POSITION.

**REASON FOR QUESTION**
- If belt tensioner has fully retracted, belt is to be replaced because it will not drive the fan properly.

**IS THE SERPENTINE BELT IN GOOD CONDITION?**

- **YES**
  - REPLACE BELT.

- **NO**
  - REPLACE BELT.

GO TO 10, Page 2-166
REFERENCE INFORMATION

ENGINE COOLING
(S/N 299999 AND BELOW)

Listen for noisy bearings in the water pump, or an in-and-out motion to the fan. You can also check the pump and pulley by trying to move it in and out laterally with the engine off.

Replace the water pump pulley (para. 3-77).
Replace the water pump (para. 3-78).

Replace serpentine belt (para. 3-81).
ENGINE COOLING
(S/N 299999 AND BELOW)

**DIAGNOSTIC FLOWCHART**

**KNOWLEDGE INFO**
- EVERYTHING IS OK SO FAR.

**POSSIBLE PROBLEMS**
- HEAD GASKET OR OTHER INTERNAL ENGINE PROBLEMS.

**TEST OPTIONS**
- LOOK.

**ARE THE HEAD GASKETS OK?**
- YES → NOTIFY DS MAINTENANCE (CHAPTER 14).
- NO → NO FAULTS.

**REASON FOR QUESTION**
Defective head gaskets can allow coolant into the combustion chambers, oil into the cooling system, or other problems.

FROM 9, Page 2-164
REFERENCE INFORMATION

ENGINE COOLING
(S/N 299999 AND BELOW)

WARNING
Always use caution when approaching a hot engine. Failure to do so may result in serious burns.

Look for excessive white exhaust smoke, steam leaks in the engine compartment, and oil in the coolant. Other signs include excess condensation in the exhaust system, or white joints in the exhaust system. You can also feel the coolant hoses to see if they have high pressure caused by leaking combustion gasses. Also, if the glow plugs turn off very quickly after starting the engine, or if the engine overheats, or has excessive coolant consumption, you may have a head gasket problem.
ENGINE COOLING
(S/N 299999 AND BELOW)

DIAGNOSTIC FLOWCHART

A1

INSPECT THE COOLING FAN. ARE THE FAN BLADES ALL INTACT?

TEST OPTIONS
LOOK FOR CRACKED OR BROKEN BLADES.

REASON FOR QUESTION
A damaged fan does not cool efficiency and could be dangerous to bystanders.

YES
REPLACE FAN.

NO

A2

IS THE SERPENTINE BELT IN GOOD CONDITION?

TEST OPTIONS
VISUAL INSPECTION OF BELT TENSIONER POSITION.

REASON FOR QUESTION
If belt tensioner has fully retracted, belt is to be replaced because it will not drive the fan properly.

YES
REPLACE BELT.

NO

A3

WITH THE VEHICLE OFF, TRY TO TURN THE FAN BY HAND. ARE YOU UNABLE TO TURN IT?

TEST OPTIONS
TRY IT.

REASON FOR QUESTION
You should not be able to turn the fan by hand. If you can, the fan drive is bad.

YES
REPLACE FAN DRIVE.

NO

GO TO A4, Page 2-170
REFERENCE INFORMATION

ENGINE COOLING
(S/N 299999 AND BELOW)

Replace fan (para. 3-80).

Replace serpentine belt (para. 3-81).

Replace fan drive (para. 3-80).

A YES answer to this question means that you were not able to turn the fan by hand.
ENGINE COOLING
(S/N 299999 AND BELOW)

FROM A3, Page 2-168

!!

TEST OPTIONS
LOOK

REASON FOR QUESTION
Disconnecting 458B from the switch simulates a hot engine.

NO

GO TO B, Page 2-174

A4

DISCONNECT WIRE 458B FROM THE FAN TEMPERATURE SWITCH. WITH THE ENGINE RUNNING, IS THE FAN ENGAGED?

YES

GO TO A5, Page 2-178

KNOWN INFO
FAN BLADES OK
SERPENTINE BELT OK
FAN DRIVE OK

POSSIBLE PROBLEMS
FAN WIRING
TIME-DELAY MODULE
CONTROL VALVE
FAN TEMPERATURE SWITCH
PCB

TEST OPTIONS
TRY IT. JUMP THE WIRES USING A SHORT PIECE OF WIRE WITH TWO MALE CONNECTORS.

REASON FOR QUESTION
Having battery voltage on 458A simulates a cold engine.

NO

A5

DISCONNECT WIRE 458A FROM THE FAN TEMPERATURE SWITCH, JUMPER 458A TO 458B. DOES THE FAN DISENGAGE?

YES

GO TO C, Page 2-178

KNOWN INFO
FAN BLADES OK
SERPENTINE BELT OK
DRIVE ENGAGES

POSSIBLE PROBLEMS
FAN WIRING
TIME-DELAY MODULE
CONTROL VALVE
PCB

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
To check the switch operation. Ideally, check the switch for open and closed operation.

NO

A6

MEASURE THE CONTINUITY THROUGH THE FAN TEMPERATURE SWITCH. THE SWITCH SHOULD BE OPEN AT TEMPERATURES ABOVE 215°F (102°C) AND CLOSED BELOW. IS THE SWITCH OK?

YES

REPLACE FAN TEMPERATURE SWITCH.

GO TO A7, Page 2-172

NO

NO
REFERENCE INFORMATION

WARNING

Keep hands and arms away from fan blades and serpentine belt when engine is running or serious injury may result.

See page 2-163 for a description of the fan system operation and to see if it’s engaged or not.

If you know the engine is cold and the fan temperature switch is good, you can reconnect 458B to the switch and see if the fan disengages.

Replace the fan temperature switch (para. 4-34).

You can also remove the switch to test it hot and cold.

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
ENGINE COOLING
(S/N 299999 AND BELOW)

FROM A6,
Page 2-170

A7

IS THERE CONTINUITY FROM WIRE 315D AT THE TIME-DELAY MODULE TO WIRE 315B AT THE TP SENSOR OR FAN CUT-OFF SWITCH? (DISCONNECT THE WIRES TO MAKE THE MEASUREMENT.)

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
The TP sensor and fan cut-off switch will disengage the fan for 20 seconds.

REPAIR/REPLACE WIRES 315D AND 315B.

YES

NO

A8

HOLD THE INJECTOR PUMP WIDE OPEN WITH THE ROTARY SWITCH IN RUN. IS THERE BATTERY VOLTAGE ON THE TIMER END OF WIRE 315D?

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
This will simulate the TP sensor and fan cut-off system's ability to disengage the fan.

NO

YES

GO TO E,
Page 2-188

NO FAULTS.
CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

RESISTANCE AND CONTINUITY 0-4,500 OHMS STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

Disconnect the four-way connector at the time-delay module and measure the voltage on wire 315D.

DC VOLTAGE 0-45 VOLTS STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.
DIAGNOSTIC FLOWCHART

ENGINE COOLING
(S/N 299999 AND BELOW)

B1
DISCONNECT THE CONTROL VALVE ELECTRICAL CONNECTOR AT THE TIME-DELAY MODULE. DOES THE FAN ENGAGE?

TEST OPTIONS
TRY IT.

REASON FOR QUESTION
With no power to the solenoid, the fan should engage.

REPLACE CONTROL VALVE.

B2
DISCONNECT THE 4-WIRE CONNECTOR AT THE TIME-DELAY MODULE. IS THERE CONTINUITY FROM 458B AT THE 4-WIRE HARNESS TO 458B AT THE FAN TEMPERATURE SWITCH?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
Wire 458B connects the switch and the timer.

REPAIR/REPLACE WIRE 458B.

B3
WITH THE ROTARY SWITCH IN RUN, IS THERE BATTERY VOLTAGE AT WIRE 583B IN THE TIME-DELAY MODULE 4 WIRE CONNECTOR?

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
Wire 583B connects battery voltage to the delay module.

REPAIR/REPLACE WIRE 583B.

GO TO B4,
Page 2-176
# Reference Information

## Engine Cooling

### Resistance and Continuity

**0-4,500 Ohms**  
**STE/ICE-R Test 91**

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

Replace control valve (para. 8-25).

### Continuity (Resistance) MultiMeter

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

Repair/replace wire (para. 4-80).

### DC Voltage 0-45 Volts

**STE/ICE-R Test 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

Repair/replace wire (para. 4-80).

### Voltage MultiMeter

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
ENGINE COOLING
(S/N 299999 AND BELOW)

FROM B3,
Page 2-174

DIAGNOSTIC FLOWCHART

B4

IS THERE CONTINUITY FROM WIRE 93B IN THE 4-WAY CONNECTOR TO ENGINE GROUND?

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
Wire 93 provides the time-delay module's connection to ground.

NO

REPAIR/REPLACE WIRES 93 AND 93B.

YES

B5

IS THERE CONTINUITY OF ENGINE WIRING HARNESS WIRE 315B BETWEEN THE TIME-DELAY MODULE AND THE FAN CUT-OFF SWITCH?

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
The fan cut-off switch has some control of the engine fan.

NO

REPAIR/REPLACE WIRES 315B.

YES

B6

IS THERE ABOUT ZERO VOLTAGE ON THE TIMER END OF WIRE 458B WITH WIRE 458A DISCONNECTED FROM THE FAN TEMPERATURE SWITCH?

TEST OPTIONS

1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
If wire 458B is shorted to some other live wire, the fan will not engage.

NO

REPAIR/REPLACE WIRE 458B OR HARNESS.

YES

NO FAULTS.
REFERENCE INFORMATION

ENGINE COOLING
(S/N 299999 AND BELOW)

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

Repair/replace wires (para. 4-80).

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

Repair/replace wires (para. 4-80).

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

Repair/replace wires (para. 4-80).

VOLTAGE
MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
DIAGNOSTIC FLOWCHART

ENGINE COOLING
(S/N 299999 AND BELOW)

KNOWN INFO
DRIVE OK FAN ENGAGES BUT WON'T DISENGAGE

POSSIBLE PROBLEMS
PCB TIME-DELAY MODULE WIRING HYDRAULIC SYSTEM

C1

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
Wire 458A connects battery voltage to the switch.

C FROM A5, Page 2-170

YES

GO TO D, Page 2-186

NO

C2

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
Wire 458B connects the switch and the time delay.

IS THERE CONTINUITY FROM WIRE 458B AT THE HARNESS SIDE OF THE TIME-DELAY MODULE 4-WAY CONNECTOR TO WIRE 458B AT THE FAN TEMPERATURE SWITCH?

KNOWN INFO
DRIVE OK FAN ENGAGES BUT WON'T DISENGAGE

POSSIBLE PROBLEMS
PCB TIME-DELAY MODULE WIRING HYDRAULIC SYSTEM

NO

REPAIR/REPLACE WIRES 458 & 458B.

YES

C3

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
Wire 583B connects battery voltage to the delay module.

TURN THE ROTARY SWITCH TO RUN. IS THERE BATTERY VOLTAGE AT THE HARNESS SIDE OF WIRE 583B IN THE 4-WAY CONNECTOR OF THE TIME-DELAY MODULE?

KNOWN INFO
DRIVE OK FAN ENGAGES BUT WON'T DISENGAGE

POSSIBLE PROBLEMS
PCB TIME-DELAY MODULE WIRING HYDRAULIC SYSTEM

NO

REPAIR/REPLACE WIRE 583B.

YES

GO TO C4, Page 2-180
## REFERENCE INFORMATION

### ENGINE COOLING

**S/N 299999 AND BELOW**

#### DC VOLTAGE 0-45 VOLTS

**STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

#### VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

#### RESISTANCE AND CONTINUITY

**0-4,500 OHMS**

**STE/ICE-R TEST 91**

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.

Repair/replace wires (para. 4-80).

#### CONTINUITY (RESISTANCE)

**MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
DIAGNOSTIC FLOWCHART

ENGINE COOLING (S/N 299999 AND BELOW)

FROM C3, Page 2-178

C4

DISCONNECT THE 2-WIRE COUPLING AT THE TIMER. MEASURE THE RESISTANCE THROUGH THE CONTROL VALVE ELECTRICAL CONNECTOR. IS IT ABOUT 65 OHMS?

REPLACE CONTROL VALVE.

TEST OPTIONS
MULTIMETER - WITH AN ANALOG MULTIMETER, YOU MAY GET 65 TO 100 OHMS ONE WAY AND UNDER 30 OHMS THE OTHER WAY. THIS IS OK.

REASON FOR QUESTION
The need to check out the windings in the control valve to see if they're OK.

KNOWLEDGE
FAN DRIVE OK
FAN WON'T DISENGAGE

POSSIBLE PROBLEMS
TIME-DELAY MODULE WIRING
CONTROL VALVE HYDRAULIC SYSTEM

GO TO C5, Page 2-182

YES

NO
When checking coil resistance, use an analog-type multimeter.

For an accurate ohms reading, perform this check when the system is at room temperature. Heat will increase resistance, resulting in a higher ohms reading.

Replace control valve (para. 8-25).

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
ENGINE COOLING
(S/N 299999 AND BELOW)

FROM C4,
Page 2-180

DISCONNECT THE 4-WIRE CONNECTOR ON THE TIMER.
IS THERE CONTINUITY FROM WIRE 93B ON THE HARNESS SIDE
OF THE 4-WAY CONNECTOR-TO-ENGINE GROUND?

REPLACE WIRING 93B.

REASON FOR QUESTION
The need to test out the ground connection of the time-delay
module and control valve.

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

NO

YES

KNOWLEDGE INFO
FAN DRIVE OK
FAN WON'T DISENGAGE CONTROL VALVE OK

POSSIBLE PROBLEMS
TIME-DELAY MODULE WIRING HYDRAULIC SYSTEM

C5

KNOWLEDGE INFO
FAN DRIVE OK
FAN WON'T DISENGAGE CONTROL VALVE OK

POSSIBLE PROBLEMS
TIME-DELAY MODULE WIRING HYDRAULIC SYSTEM

C6

RECONNECT THE 4-WIRE CONNECTOR. IS THERE ABOUT
580Ω FROM WIRE 93B ON THE TIMER SIDE OF THE 2-WIRE
COUPLING TO ENGINE GROUND?

REPLACE TIME-DELAY MODULE.

NO

YES

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
This measurement will help to tell you if the time-delay module is OK.

KNOWLEDGE INFO
FAN DRIVE OK
FAN WON'T DISENGAGE CONTROL VALVE OK

POSSIBLE PROBLEMS
TIME-DELAY MODULE WIRING HYDRAULIC SYSTEM

C7

IS THERE CONTINUITY FROM WIRE 458B IN THE 4-WIRE
CONNECTOR HARNESS TO WIRE 458B AT THE FAN TEMPERATURE
SWITCH?

REPLACE TIME-DELAY MODULE.

NO

YES

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
This measurement will help to tell you if the time-delay module is OK.

GO TO C8,
Page 2-184
REFERENCE INFORMATION

ENGINE COOLING
(S/N 299999 AND BELOW)

**RESISTANCE AND CONTINUITY**

| 0-4,500 OHMS |
| STE/ICE-R TEST 91 |

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9999.

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

**FAN TEMPERATURE SWITCH**

Replace time-delay module (para. 4-35).

Replace wire or replace harness (para. 4-80).
DIAGNOSTIC FLOWCHART

ENGINE COOLING

(S/N 299999 AND BELOW)

FROM C7, Page 2-182

C8

LOOK FOR LEAKY HOSES GOING TO AND FROM THE CONTROL VALVE AND FAN DRIVE. ARE ALL OF THE HOSES LEAK-FREE?

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Leaky hydraulic hoses may prevent the drive from disengaging.

NO

REPAIR AS REQUIRED.

YES

C9

IS THE PRESSURE IN THE CONTROL VALVE Supply HOSE AT LEAST 90 PSI (621 kPa)?

TEST OPTIONS

1. STE/ICE-R TEST 50 (Page 2-495)
2. PRESSURE GAUGE

REASON FOR QUESTION

90 PSI (621 kPa) is the minimum required to disengage the drive.

NO

GO TO STEERING, Page 2-481

YES

C10

CONNECT BOTH TIME-DELAY MODULE ELECTRICAL CONNECTORS, JUMPER 458A TO 458B. IS THE PRESSURE IN THE FAN DRIVE HOSE AT LEAST 90 PSI (621 kPa)?

TEST OPTIONS

1. STE/ICE-R TEST 50 (Page 2-495)
2. PRESSURE GAUGE

REASON FOR QUESTION

Check to see if control valve is open.

NO

SEE NOTE AT RIGHT.

YES

SEE NOTE AT RIGHT.
Replace hoses (para. 8-25).

---

STE/ICE-R TEST 50
0 TO 1,000 PSIG PRESSURE


2. Connect BLUE pressure transducer to A W4 cable. Make sure the system under test is not pressurized.

3. Turn on system and read pressure.

Measure the pressure at the valve outlet. Remove the fan drive hose and connector from the valve body and screw transducer into the valve. Start the engine and look for leaks.

Replace control valve and/or fan drive (para. 8-25 or 3-80). Check to see if hoses are blocked prior to replacing parts, and perform back flush procedure (para. 8-25).

If pressure in the fan drive hose is not at least 90 psi (621 kPa), perform back flush procedure (para. 8-25). Recheck pressure. If pressure is not at least 90 psi (621 kPa), replace control valve.

If pressure in the fan drive hose is at least 90 psi (621 kPa), check for blockage in hose between the control valve and fan drive. If hose is not blocked, replace fan drive (para. 3-80).
ENGINE COOLING
(S/N 299999 AND BELOW)

DIAGNOSTIC FLOWCHART

![Flowchart Diagram]

**Known Info**
- No battery voltage at 458A

**Possible Problems**
- Wire 458A Electrical System

**Test Options**
1. STE/ICE-R Test 91 (Page 2-508)
2. Multimeter

**Reason for Question**
Wire 458A connects the switch to the PCB.

**Flowchart Directions**
- **D1**
  - **Test Question:** Disconnect PCB engine connector harness. Is there continuity from wire 458A at the fan temperature switch to the PCB engine connector harness socket A?
  - **Test Options:**
    1. STE/ICE-R Test 91 (Page 2-508)
    2. Multimeter

**Flowchart Branches**
- **Yes**
  - Repair/replace wires 458A and 54B.
  - **Replace the PCB.**
- **No**
  - **D1** (From C1, Page 2-178)
REFERENCE INFORMATION

WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Replace PCB (refer to para. 4-4).

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question.
   RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
ENGINE COOLING
(S/N 299999 AND BELOW)

DIAGNOSTIC FLOWCHART

KNOWN INFO
FAN DOESN'T DISENGAGE WHEN FAN CUT-OFF SWITCH ACTIVATES

POSSIBLE PROBLEMS
TIME-DELAY MODULE WIRING FAN CUT-OFF SWITCH

E1
WITH THE VEHICLE OFF AND THE ROTARY SWITCH IN RUN, HOLD THE INJECTOR PUMP WIDE OPEN. IS THERE BATTERY VOLTAGE IN THE WIRE 315B END OF THE FAN CUT-OFF SWITCH?

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
This will tell you if the time-delay module is getting an input from the fan cut-off switch.

GO TO TRANSMISSION, Page 2-385

REPLACE TIME-DELAY MODULE.

NO

YES

E FROM A8, Page 2-172
Replace time-delay module (para. 4-35).

**DC VOLTAGE 0-45 VOLTS**

**STE/ACE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.

2. Start Test 89, DC Volts.

3. Displayed reading is in volts.

**VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.

2. Connect the RED lead to positive and the BLACK lead to negative.

3. Be sure to read the correct scale.
These engine cooling tests may be run any time you think you have an engine cooling problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary. Please note that this paragraph is NOT for diagnoses of problems with the temperature sending unit or the gauge.

Once you are sure that the cooling system is OK, run the instruments test in paragraph 2-38 to find out if the gauge is OK.

Fold-out page FP-7 contains a functional diagram of the engine cooling system. This page may be left open for reference while testing.

The engine cooling system is a pressure-type cooling system with thermostatic control of coolant circulation. The cooling system dissipates heat generated from combustion and maintains the engine operating temperature at its most efficient level. When the engine is cold and the thermostat is closed, coolant is recirculated through the water pump and engine. As the engine coolant reaches 190°F (87.7°C), the thermostat opens, allowing coolant to flow through the radiator before returning to the water pump and engine. Any air or vapor in the cooling system will be forced to the surge tank under the liquid level and leave through a vent tube. As the system cools, the extra coolant in the tank will be drawn back to the radiator. Normally a 50-50 mixture of water and ethylene glycol-based antifreeze will be used. The fan is activated when coolant temperature reaches approximately 220° F (104°C). A separate oil cooler is mounted in front of the radiator. This cooler is divided into two parts. The top half is for transmission oil. The bottom half is for engine oil. When the cooling system pressure reaches approximately 15 psi (103 kPa), a valve in the surge tank cap opens and lets excess pressure escape to the atmosphere.

**ETHYLENE-GLYCOL MIXTURE TABLE**

<table>
<thead>
<tr>
<th>LOWEST EXPECTED AMBIENT TEMPERATURE °F</th>
<th>ETHYLENE-GLYCOL (-60°F, -51°C) INHIBITED (A-A-52624)</th>
<th>ARCTIC GRADE ANTIFREEZE (-90°F, -68°C) (A-A-52624)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PINTS PER GALLON OF COOLANT CAPACITY</td>
<td>SPECIFIC GRAVITY (68°F) (20°C)</td>
</tr>
<tr>
<td>+20</td>
<td>1 1/2</td>
<td>1.022</td>
</tr>
<tr>
<td>+10</td>
<td>2</td>
<td>1.036</td>
</tr>
<tr>
<td>0</td>
<td>2 3/4</td>
<td>1.047</td>
</tr>
<tr>
<td>-10</td>
<td>3 1/4</td>
<td>1.055</td>
</tr>
<tr>
<td>-20</td>
<td>3 1/2</td>
<td>1.062</td>
</tr>
<tr>
<td>-30</td>
<td>4</td>
<td>1.067</td>
</tr>
<tr>
<td>-40</td>
<td>4 1/4</td>
<td>1.073</td>
</tr>
<tr>
<td>-50</td>
<td>4 1/2</td>
<td></td>
</tr>
<tr>
<td>-55</td>
<td>4 3/4</td>
<td></td>
</tr>
<tr>
<td>BELOW -60</td>
<td>USE ARCTIC GRADE ANTIFREEZE (-90°F, -68°C)</td>
<td></td>
</tr>
<tr>
<td>BELOW -51</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ENGINE COOLING (S/N 300000 AND ABOVE)

DIAGNOSTIC FLOWCHART

START

1. IS THE COOLANT MIXTURE CORRECT? (SEE CHART ON PAGE 2-190.1).
   - TEST OPTIONS
     1. COOLANT MIXTURE TEST KIT NSN 6630-00-169-1506
     2. COOLANT TESTER NSN 6630-00-105-1418
   - REASON FOR QUESTION
     The cooling system will not operate properly if the mixture is incorrect.
   - DRAIN & REFILL COOLANT.

2. IS THE COOLANT AT THE CORRECT LEVEL?
   - TEST OPTIONS
     VISUAL
   - REASON FOR QUESTION
     Low coolant levels may cause overheating.
   - FILL TO PROPER LEVEL.

3. IS THE THERMOSTAT WORKING PROPERLY?
   - TEST OPTIONS
     FEEL FOR COOLANT IN UPPER RADIATOR HOSE WHEN ENGINE IS HOT, OR REMOVE THERMOSTAT, EXPOSE IT TO 190°F (88°C) TEMPERATURES. SEE IF IT OPENS.
   - REASON FOR QUESTION
     An improperly functioning thermostat can cause operating temperatures that are either too hot or too cold.
   - REPLACE THERMOSTAT.

GO TO 4, Page 2-190.4
Do not remove surge tank filler cap before releasing internal pressure when engine temperature is above 185°F (85°C). Steam or hot coolant under pressure will cause injury.

Drain and refill coolant (para. 3-61).

Always use caution when approaching a hot engine. Failure to do so may result in serious burns.

Remove and replace the thermostat (para. 3-76.1).
ENGINE COOLING (S/N 300000 AND ABOVE)

KNOWLEDGABLE INFO
- COOLANT OK
- THERMOSTAT OK

POSSIBLE PROBLEMS
- COOLING COMPONENTS
- SERPENTINE BELT
- WATER PUMP & PULLEY

4

INSPECT THE PRESSURE CAP. IS IT IN GOOD CONDITION?

TEST OPTIONS
- PRESSURE TESTER

REASON FOR QUESTION
- A defective pressure cap may cause overheating.

REPLACE PRESSURE CAP.

YES

NO

5

INSPECT ALL RADIATOR HOSES, COOLANT HOSES, SURGE TANK, RADIATOR, OIL COOLER, AND FITTINGS FOR DAMAGE, BLOCKAGE, OR LARGE LEAKS. IS EVERYTHING IN GOOD SHAPE?

TEST OPTIONS
- LOOK

REASON FOR QUESTION
- Physical damage and blocked passages can cause cooling problems.

REPAIR/REPLACE AS AUTHORIZED. FLUSH SYSTEM IF BLOCKED. OTHERWISE, NOTIFY DS MAINTENANCE (CHAPTER 14)

YES

NO

6

IS THE ENGINE FAN WORKING PROPERLY?

TEST OPTIONS
- LOOK — SEE DESCRIPTION OF OPERATION AT RIGHT.

REASON FOR QUESTION
- The engine fan helps cool the engine.

YES

NO

GO TO A1, Page 2-190.10

GO TO 7, Page 2-190.6
REFERENCE INFORMATION

WARNING
Do not remove surge tank filler cap before releasing internal pressure when engine temperature is above 190°F (88°C). Steam or hot coolant under pressure will cause injury.

Check seal and spring on pressure cap.

Replace pressure cap [para. 3-61].

Flush cooling system [para. 3-61].

For surge tank replacement procedures, refer to para. 3-65. For radiator support procedures, refer to para. 3-64.1.

For oil cooler and oil cooler hose replacement procedures, refer to paras. 3-7.1 and 3-8.1.

Notify DS maintenance to repair radiator (Chapter 17).

ENGINE COOLING FAN DESCRIPTION OF OPERATION

When the thermostat detects the coolant is hot, the thermostat opens, and allows the coolant to be pumped to the radiator where it is routed through a series of fins and tubes. A fan draws in the outside air to help dissipate the heat before the coolant is recirculated back through the engine.

The fan is driven from the engine crankshaft via the geared fan drive and a viscous drive. The geared fan drive unit is supported by the front rear crossmember, connects to the harmonic balancer of the engine and places the viscous drive and fan assembly on the same plane as, and close to, the radiator for maximum cooling efficiency. A helical gearset is utilized within the geared fan drive to change the drive angle from the crankshaft to the fan. Gear lube with friction modifier lubricates the internal components of the geared fan drive using an integral reservoir and pump. Two constant velocity joints and a torsional driveshaft connect the geared fan drive to the engine crankshaft at the harmonic balancer.
ENGINE COOLING (S/N 300000 AND ABOVE)

FROM 6, Page 2-190.4

7

TEST OPTIONS
LOOK.

REASON FOR QUESTION
Bent or blocked fins prevent efficient cooling of the coolant.

INSPECT THE RADIATOR. IS IT IN GOOD CONDITION (FINS NOT BADLY BENT OR BLOCKED)?

NO

STRAIGHTEN AND CLEAN.

YES

8

TEST OPTIONS
LOOK AND LISTEN.

REASON FOR QUESTION
A bad pulley and water pump won't cool the engine efficiently.

INSPECT THE WATER PUMP AND PULLEY. ARE THEY IN GOOD CONDITION?

NO

REPLACE PULLEY OR PUMP.

YES

9

TEST OPTIONS
VISUAL INSPECTION OF BELT TENSIONER POSITION.

REASON FOR QUESTION
If belt tensioner has fully retracted, belt is to be replaced because it will not drive the fan properly.

IS THE SERPENTINE BELT IN GOOD CONDITION?

NO

REPLACE BELT.

YES

GO TO 10, Page 2-190.8
Listen for noisy bearings in the water pump, or an in-and-out motion to the fan. You can also check the pump and pulley by trying to move it in and out or laterally with the engine off.

Replace the water pump pulley (para. 3-77).
Replace the water pump (para. 3-78).

Replace the serpentine belt (para. 3-81.7).
ENGINE COOLING
(S/N 300000 AND ABOVE)

DIAGNOSTIC FLOWCHART

TEST OPTIONS
LOOK.

REASON FOR QUESTION
Defective head gaskets can allow coolant into the combustion chambers, oil into the cooling system, or other problems.

ARE THE HEAD GASKETS OK?

REPLACE HEAD GASKET (Para. 15-4 or Para. 15-5).

NO FAULTS.

FROM 9,
Page 2-190.6

TEST OPTIONS

NO

YES

KNOWLEDGE INFO
EVERYTHING IS OK SO FAR.

POSSIBLE PROBLEMS
HEAD GASKET OR OTHER INTERNAL ENGINE PROBLEMS.
REFERENCE INFORMATION

ENGINE COOLING
(S/N 300000 AND ABOVE)

WARNING

Always use caution when approaching a hot engine. Failure to do so may result in serious burns.

Look for excessive white exhaust smoke, steam leaks in the engine compartment, and oil in the coolant. Other signs include excess condensation in the exhaust system, or white joints in the exhaust system. You can also feel the coolant hoses to see if they have high pressure caused by leaking combustion gasses. Also, if the glow plugs turn off very quickly after starting the engine, or if the engine overheats, or has excessive coolant consumption, you may have a head gasket problem.
ENGINE COOLING
(S/N 300000 AND ABOVE)

A1

INSPECT THE COOLING FAN. ARE THE FAN BLADES ALL INTACT?

TEST OPTIONS
LOOK FOR CRACKED OR BROKEN BLADES.

REASON FOR QUESTION
A damaged fan does not cool efficiently and could be dangerous to bystanders.

NO

REPLACE FAN BLADE.

YES

A2

IS THE SERPENTINE BELT IN GOOD CONDITION?

TEST OPTIONS
VISUAL INSPECTION OF BELT TENSIONER POSITION.

REASON FOR QUESTION
If belt tensioner has fully retracted, belt is to be replaced because it will not drive the water pump properly.

NO

REPLACE BELT.

YES

A3

WITH THE VEHICLE OFF, TRY TO TURN THE FAN BY HAND. ARE YOU ABLE TO TURN IT?

TEST OPTIONS
TRY IT.

REASON FOR QUESTION
You should be able to turn the fan by hand. If you can't, the fan clutch is bad.

NO

REPLACE FAN CLUTCH.

YES

NO FAULTS
Replace fan blade (para 3-80.1).

Replace serpentine belt (para. 3-81.2).

Replace fan clutch (para. 3-80.1).

A NO answer to this question means that you were not able to turn the fan by hand.
2-32. ENGINE LUBRICATION TESTS

These engine lubrication tests may be run any time there is an engine lubrication problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary.

Fold-out page FP-9 shows the location of the major components of the engine lubrication system in case you are not familiar with them. This page may be left open for reference while testing.
ENGINE LUBRICATION

IS THE CRANKCASE FILLED
TO THE CORRECT LEVEL
WITH OIL THAT IS CLEAN
AND OF THE RIGHT TYPE,
AND IS THE OIL FILTER CLEAN?

TEST OPTIONS
CHECK DIPSTICK.
SEE TABLE 2-1 (PAGE 2-12)
FOR OIL AND FILTER CHANGE
REQUIREMENTS.

REASON FOR QUESTION
To make sure the engine has the
right oil, and it's clean.

IS THE VEHICLE FREE FROM
LARGE OIL LEAKS?

TEST OPTIONS
CHECK THE LIST OF
ITEMS TO THE RIGHT.

REASON FOR QUESTION
Any large oil leaks could affect oil
pressure. Small leaks should be
taken care of after you make sure
everything else is OK.

IS THE OIL PRESSURE AT THE
CORRECT VALUE?
(SEE CHART AT RIGHT.)

TEST OPTIONS
1. STE/ICE-R TEST 50 (Page 2-493)
INTERLAVED WITH RPM
2. LOOK AT THE GAUGE AND USE
STE/ICE-R TEST 10 (Page 2-493).

REASON FOR QUESTION
Low oil pressure will cause excessive
wear on the engine. High pressure
could indicate clogs in the system. If
you use the gauge, you can let
the engine run a few minutes to
make sure the gauge is OK.

GO TO 4,
Page 2-194

GO TO 4,
Page 2-194
Incorrect oil level and type can cause pressure problems, leaks, excessive blowby, and other problems.

Inspect the oil cooler, oil cooler supply return lines, CDR valve hoses, oil pan, and oil filter. Test CDR valve (para. 3-9). See the location on parts page to find these parts.

**ENGINE RPM STE/ICE-R TEST 10**

1. Start Test 10, Engine RPM.
2. Crank or start the engine. Displayed reading is rpm. Cranking rpm should be approximately 200. Idle rpm should be 700-750.

**OIL PRESSURE CHART**

<table>
<thead>
<tr>
<th>ENGINE RPM</th>
<th>APPROXIMATE OIL PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP</td>
<td>0 PSI (0 kPa)</td>
</tr>
<tr>
<td>IDLE (725 ± 25)</td>
<td>15-20 PSI (103-138 kPa)</td>
</tr>
<tr>
<td>2,000</td>
<td>40-50 PSI (276-345 kPa)</td>
</tr>
</tbody>
</table>

Remove sending unit (para. 4-29).

**ENGINE RPM INTERLEAVE WITH 0-1,000 PSI PRESSURE**

1. Connect BLUE transducer in place of oil pressure sending unit. Dial test 50 (0-1,000 psi (0-6,895 kPa)). Perform offset test.
2. Dial test 01, interleave with RPM. Dial test 50.
3. Start engine and observe display. VTM will display RPM, then PSI.
**Engine Lubrication**

**Known Info**
- Oil gauge ok
- No oil leaks
- Oil ok
- Filter ok
- Pressure ok

**Possible Problems**
- Internal engine problems

**Diagnostic Flowchart**

**Is the exhaust colorless? (Especially no blue smoke?)**

- **No**
  - See note at right.

- **Yes**
  - No faults found. If you still have a problem, you may want to rerun the test chain to make sure you didn't miss anything.

**Reason for question**
Blue smoke indicates oil in the exhaust.

**Test Options**
Look.

*From 3, Page 2-192*
NOTE

If the exhaust is not colorless, it must be either white, blue, or black. If exhaust color is:

WHITE........Go to fuel system \textit{para. 2-28}. Could be injector timing, DS level fault.

BLUE........Blue smoke is a sign of oil entering the combustion chambers. It usually enters past the piston rings or intake valve stem seals. This is an internal engine problem that can't be handled at this level of maintenance. You may want to run the engine running test, \textit{para. 2-29}, before you notify DS maintenance (chapter 14).

BLACK........Air Intake/exhaust \textit{para. 2-29}. 
ENGINE LUBRICATION

DIAGNOSTIC FLOWCHART

A1
DID YOU USE THE VEHICLE'S ON-BOARD GAUGE TO MEASURE THE PRESSURE IN QUESTION 3?

TEST OPTIONS
NONE

REASON FOR QUESTION
If you used the STE/ICE-R to measure the pressure, then the engine has an internal fault.

A2
MEASURE THE OIL PRESSURE DIRECTLY. IS IT CORRECT?

TEST OPTIONS
1. STE/ICE-R TEST 50 AND RPM INTERLEAVED (Page 2-495)
2. EXTERNAL GAUGE AND STE/ICE-R TEST 19 (Page 2-490)

REASON FOR QUESTION
Direct verification of the engine's oil pressure will tell you if the problem is in the gauge or the engine.

A3
THE PROBLEM IS IN THE OIL PRESSURE SENDING SYSTEM. GO TO INSTRUMENTS. Page 2-305

KNOWN INFO
WRONG OIL PRESSURE

POSSIBLE PROBLEMS
OIL PRESSURE GAUGE
OIL PRESSURE SENSOR
INTERNAL ENGINE PROBLEMS

KNOWN INFO
WRONG PRESSURE USING VEHICLE GAUGE

POSSIBLE PROBLEMS
GAUGE AND SENDER
ENGINE PROBLEMS

KNOWN INFO
OIL PRESSURE OK

POSSIBLE PROBLEMS
GAUGE
SENDER
WIRING
REFERENCE INFORMATION

ENGINE LUBRICATION

OIL PRESSURE CHART

<table>
<thead>
<tr>
<th>ENGINE RPM</th>
<th>APPROXIMATE OIL PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP</td>
<td>0 PSI (0 kPa)</td>
</tr>
<tr>
<td>IDLE (725 ± 25)</td>
<td>15-20 PSI (103-138 kPa)</td>
</tr>
<tr>
<td>2,000</td>
<td>40-50 PSI (276-345 kPa)</td>
</tr>
</tbody>
</table>

1. Connect BLUE transducer in place of oil pressure sending unit. Dial test 50 (0-1000 psi (0-6,895 kPa)). Perform offset test.

2. Dial test 01, interleave with RPM. Dial test 50.

3. Start engine and observe display. VTM will display RPM, then PSI.

Remove sending unit (para. 4-29).

ENGINE RPM
INTERLEAVE WITH 0-1,000 PSI PRESSURE

1. Connect BLUE transducer in place of oil pressure sending unit. Dial test 50 (0-1000 psi (0-6,895 kPa)). Perform offset test.

2. Dial test 01, interleave with RPM. Dial test 50.

3. Start engine and observe display. VTM will display RPM, then PSI.

ENGINE RPM
STE/ICE-R TEST 10

1. Start Test 10, Engine RPM.

2. Crank or start the engine. Displayed reading is RPM. Cranking rpm should be approximately 200. Idle rpm should be 700-750.

2-197/(2-198 blank)
2-33. ALTERNATOR TESTS

These alternator tests can be run any time you think there may be a problem with the alternator or battery charging or if you were sent here from another system chain.

These tests are NOT for the batteries. These tests are strictly for the alternator, its operation, and its associated wiring. Tests for the batteries are in Battery Circuit, Para. 2-35.

**NOTE**

Dual voltage 200 and 400 amp alternators can be installed in a single voltage system. See chart below for hookup procedures.

A simplified block diagram for the alternator system is given below. A detailed functional flow schematic is provided as foldout FP-11 to help you understand the system as you perform the tests.

After preliminary common tests, the model of alternator must be identified for specific testing to determine if alternator or regulator is defective.

<table>
<thead>
<tr>
<th>ALTERNATOR FLOW SCHEMATIC</th>
<th>Adoption of dual voltage alternator on a single voltage system chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGINE MECHANICAL POWER</td>
<td>Dual Voltage Alternator</td>
</tr>
<tr>
<td>(SERPENTINE BELT)</td>
<td>200 Amp</td>
</tr>
<tr>
<td></td>
<td>400 Amp</td>
</tr>
</tbody>
</table>

200-AMP DUAL VOLTAGE NIEHOFF ALTERNATOR/REGULATOR

400-AMP DUAL VOLTAGE NIEHOFF ALTERNATOR/REGULATOR
ALTERNATOR

START

1

IS SERPENTINE BELT IN GOOD CONDITION (NO CRACKS, FRAYS, OR GLAZE)?

TEST OPTIONS

VISUAL INSPECTION OF BELT TENSIONER POSITION.

REASON FOR QUESTION

If belt tensioner has fully retracted, belt will not drive the alternator fast enough to recharge the batteries.

NO

REPLACE SERPENTINE BELT. IF YOU STILL HAVE A PROBLEM, CONTINUE TESTING.

YES

2

ARE ALL WIRE CONNECTIONS TO ALTERNATOR CLEAN, TIGHT, AND MAKING GOOD CONNECTION?

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Loose or dirty connections can prevent a good alternator from charging the batteries.

NO

CLEAN AND TIGHTEN. IF YOU STILL HAVE A PROBLEM, CONTINUE TESTING.

YES

3

WITH ROTARY SWITCH IN RUN POSITION (ENGINE NOT RUNNING), DO YOU HAVE BATTERY VOLTAGE AT ALTERNATOR OUTPUT TERMINAL?

TEST OPTIONS

1. STE/ICE-R TESTS 67, 80 (INTERLEAVE) (Pages 2-496, 2-506)
2. MULTIMETER

REASON FOR QUESTION

The alternator must be connected to batteries to be able to recharge the batteries.

NO

GO TO A, Page 2-206

YES

GO TO 4, Page 2-202
Replace serpentine belt (para. 3-81).

BAD CONNECTIONS ARE THE MOST COMMON PROBLEM!

Sometimes, just disconnecting, cleaning, and reconnecting will solve a problem. BE THOROUGH! The time you save may be your own.

Refer to the functional flow schematic and check the following:

1. BATTERY - make sure all connections are clean and tight, including the shunt and power stud.

2. STARTER - check the high current wire (heavy gauge wire 6A) at the starter. Don't just check for voltage; a loose connection will have voltage but can't carry much current.

3. PROTECTIVE CONTROL BOX

 WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

 WARNING

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Remove BOTH connectors and look for bent or broken pins, pins pushed out of their socket, or dirt and corrosion in the connections.

INTERLEAVE TESTS 67 AND 89
BATTERY VOLTAGE AND DC VOLTAGE

USE CONTROL FUNCTION 06 TO INTERLEAVE TESTS ON THE STE/ICE-R. DIAL 06, PRESS THE TEST BUTTON. WHEN PROMPTED BY THE VTM, DIAL IN TEST 67 AND PRESS THE BUTTON. WHEN PROMPTED AGAIN, DIAL IN TEST 89 AND PRESS THE BUTTON. VTM WILL DISPLAY RESULT FOR TEST 67, THEN 89, THEN 6789, AND THEN REPEAT. SEE TM 9-4810-571-12&P FOR MORE INFORMATION.
START ENGINE. DOES ENGINE IDLE AT CORRECT SPEED (700 ± 25 RPM)?

NO

ADJUST IDLE RPM. SEE NOTE AT RIGHT.

YES

LOCK THROTTLE AT 1,200-1,500 RPM.

IS VOLTAGE AT ALTERNATOR OUTPUT TERMINAL 27-29 VOLTS?

NO

GO TO B, Page 2-208

YES

IS VOLTAGE AT BATTERY TERMINALS 27-29 VOLTS? (SAME AS ALTERNATOR OUTPUT).

NO

REPAIR/REPLACE WIRING. SEE NOTE AT RIGHT.

YES

GO TO 7, Page 2-204

TEST OPTIONS
STE/ICE-R TEST 10 (Page 2-490)

REASON FOR QUESTION
If engine idles too low, alternator is not driven fast enough to charge batteries.

TEST OPTIONS
1. STE/ICE-R TEST 10, 69 (Pages 2-490, 2-506)
2. MULTIMETER

REASON FOR QUESTION
Alternator voltage must be slightly higher than battery voltage to recharge batteries.

TEST OPTIONS
1. STE/ICE-R TEST 67 (Page 2-496)
2. MULTIMETER

REASON FOR QUESTION
If battery voltage is much lower than alternator output, wiring resistance is too high.
If the engine doesn't start on its own power, you should check the battery and starter circuits.

A charged battery in good condition is a prerequisite for testing an alternator/regulator system. If battery is suspect, substitute a known good battery in the vehicle.

Alternators have a large stud on side of housing as output terminal to connect wire 6.

NOTES
Check the wiring and the pins at pins E & F at PCB engine connector.
Check the wiring and the pins at pins D & G at PCB body connector.
Check and clean starter solenoid and battery box power stud.
Check and clean battery cables and clamps.

If terminal voltage is still low, harness should be replaced. Notify DB maintenance (chapter 15).
ALTERNATOR

FROM 6, Page 2-202

TEST OPTIONS
STE/ICE-R TEST 80 (Page 2-505)

REASON FOR QUESTION
Alternator must supply enough current to power vehicle loads.

7
WITH ENGINE RUNNING, MEASURE CURRENT FROM ALTERNATOR WIRE OUTPUT TERMINAL.

IS CURRENT GREATER THAN 30 AMPS?

YES
REPLACE ALTERNATOR, RERUN ALTERNATOR TESTS.

NO

8
IF YOU STILL HAVE A PROBLEM, RERUN THESE TESTS TO MAKE SURE YOU DIDN'T MISS ANYTHING. IF EVERYTHING CHECKS OUT, RUN BATTERY TESTS AND ELECTRICAL TESTS.

POSSIBLE PROBLEMS
ALTERNATOR

KNOWN INFO
BATTERIES OK
SERPENTINE BELT OK
ALTERNATOR CONNECTIONS OK
CONTROL BOX OK
ALTERNATOR DRIVE OK
ALTERNATOR OUTPUT OK
NOTE
All alternators have large stud on alternator case as output connector for wire 6. Alternator current will go up as you turn on vehicle accessories.

Turn on the lights, wipers, heater, etc., to make sure alternator can supply enough current to power the loads.

To replace alternator, refer to para. 4-5.

<table>
<thead>
<tr>
<th>BATTERY CURRENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/CE-R TEST 80</td>
</tr>
<tr>
<td>1. Start Test 80, Battery Current.</td>
</tr>
<tr>
<td>2. Displayed reading is in amps. The reading will be greater than 30 amps, depending on how many accessories you have on.</td>
</tr>
</tbody>
</table>
ALTERNATOR

DIAGNOSTIC FLOWCHART

A1
IS THE STARTER MOTOR VOLTAGE THE SAME AS BATTERY VOLTAGE?

TEST OPTIONS
1. STE/ICE-R TESTS 67, 68 (Pages 2-496, 2-497)
2. MULTIMETER

REASON FOR QUESTION
The cable connecting the batteries to the alternator goes to the starter first.

A2
DISCONNECT THE BATTERY NEGATIVE CABLE. DISCONNECT ENGINE CONNECTOR AT PCB. RECONNECT THE BATTERY NEGATIVE CABLE. IS THERE BATTERY VOLTAGE AT PIN E OF THE PCB ENGINE CONNECTOR HARNESS?

TEST OPTIONS
1. STE/ICE-R TESTS 67, 89 (Pages 2-496, 2-506)
2. MULTIMETER

REASON FOR QUESTION
This checks the wire from the starter to the PCB engine connector.

A3
REMOVE THE BATTERY NEGATIVE CABLE. IS THERE CONTINUITY (LESS THAN 20 OHMS RESISTANCE) FROM PIN F OF PCB ENGINE CONNECTOR HARNESS TO WIRE 6 END AT ALTERNATOR?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
If the box is connected to the alternator, the relay in the PCB is no good.

KNOWN INFO
BATTERY IS NOT CONNECTED TO ALTERNATOR WHEN ROTARY SWITCH IS IN RUN POSITION.

POSSIBLE PROBLEMS
PCB WIRING

KNOWN INFO
BATTERY IS NOT CONNECTED TO ALTERNATOR WHEN ROTARY SWITCH IS IN RUN POSITION. BATTERIES CONNECTED TO STARTER

POSSIBLE PROBLEMS
PCB WIRING

KNOWN INFO
BATTERY IS NOT CONNECTED TO ALTERNATOR WHEN ROTARY SWITCH IS IN RUN POSITION. BATTERIES CONNECTED TO STARTER

POSSIBLE PROBLEMS
PCB WIRING

REPAIR/REPLACE WIRE 6A.

NO
YES

REPAIR/REPLACE WIRE 81A.

NO
YES

SEE NOTE ON RIGHT HAND PAGE.

REPLACE PCB.
REFERENCE INFORMATION

INTERLEAVE TEST 67 AND 68
BATTERY VOLTAGE AND DC VOLTAGE

USE CONTROL FUNCTION 06 TO INTERLEAVE TESTS ON THE STE/ICE-R. DIAL 06, PRESS THE TEST BUTTON. WHEN PROMPTED BY THE VTM, DIAL IN TEST 67 AND PRESS THE BUTTON. WHEN PROMPTED AGAIN, DIAL IN TEST 68 AND PRESS THE BUTTON. VTM WILL DISPLAY RESULT FOR TEST 67, THEN 68, THEN 6788, AND THEN REPEAT. SEE TM 9-4910-571-12&P FOR MORE INFORMATION.

WARNIMG
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

NOTE
When checking for voltage or continuity in a harness connector (steps A2 and A3), check the wiring at the connector carefully for broken wires. Check to see that the connector pins are not bent, broken, or pushed out of place. Check that the connections are clean and tight. Use the STE/ICE-R in TK mode for this measurement. DO NOT USE THE DCA. Leave the negative battery cable off for the measurement. If there is an open circuit, the STE/ICE-R will measure close to 500 ohms. If you don't have continuity or voltage, and the wires and connections are all OK, then the harness must have a broken wire. In this case, you have to replace the wiring harness. Replace harness and notify DS maintenance (chapter 18).

Replace PCB (para. 4-4).

INTERLEAVE TEST 67 AND 89
BATTERY VOLTAGE AND DC VOLTAGE

USE CONTROL FUNCTION 06 TO INTERLEAVE TESTS ON THE STE/ICE-R. DIAL 06, PRESS THE TEST BUTTON. WHEN PROMPTED BY THE VTM, DIAL IN TEST 67 AND PRESS THE BUTTON. WHEN PROMPTED AGAIN, DIAL IN TEST 89 AND PRESS THE BUTTON. VTM WILL DISPLAY RESULT FOR TEST 67, THEN 89, THEN 6789, AND THEN REPEAT. SEE TM 9-4910-571-12&P FOR MORE INFORMATION.

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.
ALTERNATOR DIAGNOSTIC FLOWCHART

B1
IS THIS A NIEHOFF 200 AMP DUAL VOLTAGE ALTERNATOR?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Must know model of alternator to perform proper tests.

NO
SEE NOTE ON OPPOSITE PAGE

YES

B2
START ENGINE AND ALLOW TO IDLE AT 1200-1500 RPM FOR 2-3 MINUTES.
RECHECK VOLTAGE OUTPUT.
IS ALTERNATOR OUTPUT LESS THAN 26 VOLTS?

TEST OPTIONS
STE/ICE-R TEST 10, and 89 (pages 2-491 and 2-506)

NO

REASON FOR QUESTION
Determine if high or low output voltage.

YES
IF OUTPUT VOLTAGE IS OVER 30.5 VOLTS, REPLACE REGULATOR [PARA 4-8]

NO

KNOWN INFO
VOLTAGE OUTPUT INCORRECT

POSSIBLE PROBLEMS
WIRING
ALTERNATOR
REGULATOR

GO TO B3, Page 2-208.2
NOTE
For 200 amp dual voltage Niehoff alternator, continue with B.
For 400 amp dual voltage Niehoff alternator, go to C, page 210.2.

NOTE
The regulator for this model alternator has overvoltage protection. Any output voltage over 30.5 volts is an overvoltage.
Output voltage of 26-30.5 is acceptable for this alternator.

NOTE
The regulator for this alternator has overvoltage protection. Any output voltage over 30.5 volts is an overvoltage.
Output voltage of 26-30.5 is acceptable for this alternator.

<table>
<thead>
<tr>
<th>ENGINE RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 10</td>
</tr>
<tr>
<td>1. Start test 10, Engine RPM.</td>
</tr>
<tr>
<td>2. Crank or start the engine. Displayed reading is rpm. Engine rpm should be 1,200-1,500.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DC VOLTAGE 0-45 VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 89</td>
</tr>
<tr>
<td>1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.</td>
</tr>
<tr>
<td>2. Start Test 89, DC Volts.</td>
</tr>
<tr>
<td>3. Displayed reading is in volts.</td>
</tr>
</tbody>
</table>
ALTERNATOR DIAGNOSTIC FLOWCHART

STOP ENGINE. CHECK WIRE 6 AT ALTERNATOR AND STARTER FOR LOOSENESS OR CORROSION. ARE TERMINAL CONNECTIONS OK?

CLEAN AND SECURE TERMINAL CONNECTIONS.

YES

GO TO B5. [Page 2-210]

NO

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Determine if connections are good at alternator and starter.

KNOWN INFO

VOLTAGE OUTPUT INCORRECT

POSSIBLE PROBLEMS

WIRING

ALTERNATOR

REGULATOR

TEST OPTIONS

MULTIMETER

REASON FOR QUESTION

Determine if high or low output voltage.

KNOWN INFO

VOLTAGE OUTPUT INCORRECT

REGULATOR HAS ENERGIZING VOLTAGE

POSSIBLE PROBLEMS

ALTERNATOR

REGULATOR

WIRING

IDLE ENGINE AT 1200-1500 RPM. DOES VOLTAGE ON 14 VOLT OUTPUT TERMINAL (YELLOW INSULATOR) MEASURE BETWEEN 13.4-14.6 VOLTS?

IF OUTPUT VOLTAGE IS NOT CORRECT, REPLACE REGULATOR [Para 4-8] RECHECK VOLTAGE. IF VOLTAGE IS STILL NOT CORRECT, REPLACE ALTERNATOR [Para 4-5]
NOTE
Wire 6 connects alternator output stud to starter terminal. A poor connection at these points will cause a low or no alternator output condition.
**ALTERNATOR**

FROM B4.

**Page 2-208.2**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**

VOLTAGE OUTPUT INCORRECT

**POSSIBLE PROBLEMS**

ALTERNATOR REGULATOR

**TEST OPTIONS**

1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

**REASON FOR QUESTION**

As wire 568A is stubbed off, the voltage from wire 5A on red terminal signals regulator to turn on.

**B5**

TURN ROTARY SWITCH TO RUN POSITION. CHECK FOR BATTERY VOLTAGE AT RED (ENERGIZED) TERMINAL ON REGULATOR. IS BATTERY VOLTAGE PRESENT?

**NO**

NOTIFY DS MAINTENANCE TO REPAIR OR REPLACE WIRING HARNESS

**YES**

**B6**

DISCONNECT ALTERNATOR-TO-REGULATOR CABLE. START ENGINE AND SET IDLE 1200-1500 RPM. USING 15-AMP CAPACITY JUMPER WIRE, MOMENTARILY CONNECT PIN A OF ALTERNATOR CONNECTOR TO ENGINE GROUND. DOES CURRENT AND VOLTAGE RISE DURING CONNECTION?

**NO**

REPLACE ALTERNATOR (Para 4-5). THEN GO TO 5, Page 2-202

**YES**

REPLACE REGULATOR (Para 4-8). THEN GO TO 5, Page 2-202

**KNOWN INFO**

VOLTAGE OUTPUT INCORRECT

REGULATOR HAS ENERGIZING VOLTAGE

**POSSIBLE PROBLEMS**

ALTERNATOR REGULATOR

**TEST OPTIONS**

STE/ICE-R TEST 10 and 90 (pages 2-493 and 2-507)

**REASON FOR QUESTION**

This connection applies full current loading to field coil. Alternator current output should be near maximum.
REFERENCE INFORMATION

1. Slide boot back from wire lug to expose red terminal.
2. Make contact at stud.

<table>
<thead>
<tr>
<th>0-45 DC VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 89</td>
</tr>
<tr>
<td>1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.</td>
</tr>
<tr>
<td>2. Start Test 89, DC volts.</td>
</tr>
<tr>
<td>3. Displayed reading is in volts.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENGINE RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 10</td>
</tr>
<tr>
<td>1. Start Test 10, Engine RPM.</td>
</tr>
<tr>
<td>2. Crank or start the engine. Displayed reading is RPM. Set engine to fast idle of 1200-1500 RPM.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0-1500 AMPS DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 90</td>
</tr>
<tr>
<td>1. Connect probe.</td>
</tr>
<tr>
<td>2. Start Test 90, DC amps.</td>
</tr>
<tr>
<td>3. Displayed reading is in amps.</td>
</tr>
</tbody>
</table>
NOTE
For 200 amp dual voltage Niehoff alternator, go to B, page 2-208.
For 400 amp dual voltage Niehoff alternator, continue with C.

NOTE
The regulator for this model alternator has overvoltage protection. Any output voltage over 30.5 volts is an overvoltage.
Output voltage of 26-30.5 is acceptable for this alternator.

NOTE
The regulator for this alternator has overvoltage protection. Any output voltage over 30.5 volts is an overvoltage.
Output voltage of 26-30.5 is acceptable for this alternator.

ENGINE RPM
STE/ICE-R TEST 10
1. Start test 10, Engine RPM.
2. Crank or start the engine. Displayed reading is RPM. Engine RPM should be 1200-1500.

0-45 DC VOLTS
STE/ICE-R TEST 89
1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.
**ALTERNATOR**

**KNOWN INFO**
- VOLTAGE OUTPUT INCORRECT

**POSSIBLE PROBLEMS**
- ALTERNATOR
- REGULATOR
- WIRING

**C4**

**TURN ROTARY SWITCH TO RUN POSITION. CHECK FOR BATTERY VOLTAGE AT RED (ENERGIZE) TERMINAL ON REGULATOR. IS BATTERY VOLTAGE PRESENT?**

- **NO**
  - **NOIFY DS MAINTENANCE TO REPAIR OR REPLACE WIRING HARNESS**
- **YES**
  - **FROM C3, Page 2-210.2**

**C5**

**DISCONNECT ALTERNATOR-TO-REGULATOR CABLE. START ENGINE AND SET IDLE 1200-1500 RPM. USING 15-AMP CAPACITY JUMPER WIRE, MOMENTARILY CONNECT TO PIN A OF ALTERNATOR CONNECTOR. DOES CURRENT AND VOLTAGE RISE DURING CONNECTION?**

- **NO**
  - **REPLACE ALTERNATOR (Para 4-8.3). THEN GO TO 5, Page 2-202**
- **YES**
  - **REPLACE REGULATOR (Para 4-8.1). THEN GO TO 5, Page 2-202**

**TEST OPTIONS**

1. STE/ICE-R TEST 89 (page 2-506)
2. MULTIMETER

**REASON FOR QUESTION**
As wire 568A is stubbed off, the voltage from wire 5A on red terminal signals regulator to turn on.

**TEST OPTIONS**

STE/ICE-R TEST 10 AND 90 (pages 2-490 and 2-507)

**REASON FOR QUESTION**
This connection applies full current loading to field coil. Alternator current output should be near maximum.
REFERENCE INFORMATION

**ALTERNATOR**

1. Slide boot back from wire lug to expose red terminal.
2. Make contact at stud.

<table>
<thead>
<tr>
<th>0-45 DC VOLTS</th>
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</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 89</td>
</tr>
<tr>
<td>1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.</td>
</tr>
<tr>
<td>2. Start Test 89, DC Volts.</td>
</tr>
<tr>
<td>3. Displayed reading is in volts.</td>
</tr>
</tbody>
</table>

**ENGINE RPM**

<table>
<thead>
<tr>
<th>STE/ICE-R TEST 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Start Test 10, Engine RPM.</td>
</tr>
<tr>
<td>2. Crank or start the engine. Displayed reading is RPM. Set engine to fast idle of 1200-1500 RPM.</td>
</tr>
</tbody>
</table>

**0-1500 AMPS DC**

<table>
<thead>
<tr>
<th>STE/ICE-R TEST 90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Connect probe.</td>
</tr>
<tr>
<td>2. Start Test 90, DC amps.</td>
</tr>
<tr>
<td>3. Displayed reading is in amps.</td>
</tr>
</tbody>
</table>
These Protective Control Box tests can be run any time you think there may be a problem with the protective control box, or if you were sent here from another system chain.

**NOTE**

- To perform PCB diagnostics, a PCB test module is needed.
- For fabrication of PCB test module, refer to Appendix D, Figures 47-60.
1. Engage parking brake. Ensure all vehicle grounds affecting protective control box are secure.

2. Ensure all engine and electrical accessory switches are in the off position.

3. Place transmission and transfer case shift levers in neutral drive position.

Go to 4, Page 2-216
1. Remove instrument panel (para. 4-15).
2. Remove nut and lockwasher assembly and engine harness ground lead 3C from body. Remove nut and lockwasher assembly, capscrew, and harness ground leads 57A and 79A from body. Discard nut and lockwasher assemblies.
3. Inspect and clean wires and connection points.
4. Apply antiseize compound to harness ground leads 57A and 79A and install on body with capscrew and nut and lockwasher assembly. Apply antiseize compound to engine harness ground lead 3C and install on body with nut and lockwasher assembly.
5. Cover leads 3C, 57A, and 79A with RTV.
6. Install instrument panel (para. 4-15).
DISCONNECT BATTERY GROUND CABLE.

DISCONNECT THE BODY AND ENGINE WIRING HARNESS CANNON PLUGS FROM PROTECTIVE CONTROL BOX.

CONNECT DIAGNOSTIC TEST MODULE HARNESS RECEPTACLE AND CONNECTORS TO BODY AND ENGINE WIRING HARNESS CANNON PLUGS.

GO TO 7, Page 2-218
REFERENCES INFORMATION

WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.
PROTECTIVE CONTROL BOX

FROM 6, Page 2-216

TEST OPTIONS
1. TRY IT.
2. VISUAL

REASON FOR QUESTION
If no LEDs are ON, that would indicate malfunctioning batteries.

CONNECT BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE OFF POSITION. ARE ANY LEDs ON? (REFER TO TABLE AT RIGHT.)

GO TO 1, Page 2-238

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If these LEDs are not ON, that would indicate PCB malfunctions.

ARE LEDS 3 AND 4 ON?

REPLACE PROTECTIVE CONTROL BOX

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If this LED is not ON, that would indicate a bad connection to ground.

IS LED 7 ON?

REPAIR GROUND BODY HARNESS WIRE 57B.

GO TO 10, Page 2-220
## WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace PCB (para. 4-24).

Repair lead connectors (para. 4-80).
Repair lead (para. 4-60).
# Diagnostic Flowchart

## Protective Control Box

### Known Info
- Batteries OK
- Lead 57B Ground OK

### Possible Problems
- Parking Brake Switch Bad
- Body Harness Wires Bad
- Glow Plug Controller Bad
- Alternator Bad
- Harness Wire 2A Bad
- Ignition Switch Bad
- Harness Wire 29A Bad
- Harness Wire 29C Bad
- Protective Control Box Bad

### Test Options
1. Try It.
2. Visual

### Reason for Question
- If no LEDs are ON, that would indicate malfunctioning batteries.

## Flowchart

1. **WITH THE IGNITION SWITCH IN RUN (ENGINE NOT RUNNING) POSITION, ARE ANY LEDS ON? (REFER TO TABLE AT RIGHT.)**

   - **GO TO 1, Page 2-238**
   - **NO**
   - **YES**

2. **IS LED 7 ON?**

   - **VISUAL**
   - **NO** -> **REPAIR GROUND BODY HARNESS WIRE 57B.**
   - **YES**

3. **ARE LEDS 2, 3, AND 4 ON?**

   - **VISUAL**
   - **NO** -> **REPLACE PROTECTIVE CONTROL BOX.**
   - **YES**

---

**Notes:**
- With the ignition switch in run (engine not running) position, are any LEDs on? (Refer to table at right.)
- Reason for question: If no LEDs are ON, that would indicate malfunctioning batteries.
- If these LEDs are not ON, that would indicate a bad connection to ground.
- If those LEDs are not ON, that would indicate a PCR malfunction.
REFERENCE INFORMATION

PROTECTIVE CONTROL BOX

<table>
<thead>
<tr>
<th>IGNITION SWITCH POSITION</th>
<th>DIAGNOSTIC CHECKS (GO TASKS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>LEDs 1,3,4,6,7 - ON; Remaining LEDs OFF.</td>
</tr>
<tr>
<td>RUN</td>
<td>LEDs 1,2,3,4,5,6,7,8,11,13 - ON.</td>
</tr>
<tr>
<td>(ENGINE NOT RUNNING)</td>
<td>LED 13 - OFF (if engine is at operating temperature).</td>
</tr>
<tr>
<td></td>
<td>LED 11 - CYCLING ON and OFF (glow plug controller operation).</td>
</tr>
<tr>
<td></td>
<td>LEDs 9,10,12 - OFF.</td>
</tr>
<tr>
<td></td>
<td>Release parking brake lever. LED 6 - OFF.</td>
</tr>
<tr>
<td></td>
<td>Engage parking brake lever. LED 6 - ON.</td>
</tr>
<tr>
<td>START (ENGINE CRANKING)</td>
<td>LED 10 - Momentarily ON and then remains OFF (starter motor frequency lockout).</td>
</tr>
<tr>
<td>RUN (ENGINE RUNNING)</td>
<td>LEDs 1,2,3,4,5,6,7,8,9,12 - ON.</td>
</tr>
<tr>
<td></td>
<td>LED 11 - Cycling ON and OFF (glow plug controller operation).</td>
</tr>
<tr>
<td></td>
<td>OFF time interval increases as engine warms up.</td>
</tr>
<tr>
<td></td>
<td>LED 11 - OFF (when engine is at operating temperature).</td>
</tr>
<tr>
<td></td>
<td>LED 11 may remain OFF (when engine is at operating temperature from previous run).</td>
</tr>
<tr>
<td></td>
<td>LED 13 - OFF.</td>
</tr>
<tr>
<td></td>
<td>Release parking brake lever. LED 6 - OFF.</td>
</tr>
<tr>
<td></td>
<td>Engage parking brake lever. LED 6 - ON.</td>
</tr>
</tbody>
</table>

Repair lead connectors (para. 4-80).
Replace PCB (para. 4-4).

WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

2-221
**PROTECTIVE CONTROL BOX**

**KNOWN INFO**
- Batteries OK
- Lead 57B ground OK

**POSSIBLE PROBLEMS**
- Parking brake switch bad
- Body harness wires bad
- Glow plug controller bad
- Alternator bad
- Harness wire 2A bad
- Ignition switch bad
- Harness wire 29A bad
- Harness wire 29C bad
- Protective control box bad

**DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**
1. Try it.
2. Visual

**REASON FOR QUESTION**
If this LED is not ON, that would indicate either malfunctioning ignition switch, damaged harness wires 29A and 29C, or malfunctioning PCB.

**IS LED 13 ON?**
- IF ENGINE IS AT OPERATING TEMPERATURE, LED 13 WILL NOT COME ON.

**IS LED 5 ON?**
- VISUAL

**REASON FOR QUESTION**
If this LED is not ON, that would indicate PCB malfunctions.

**IS LED 6 ON?**
- VISUAL

**REASON FOR QUESTION**
If this LED is not ON, that would indicate a parking brake switch malfunction or damage to body harness wires.

**DIRECT OPTIONS**
- Replace parking brake switch and/or repair wires in body harness.

**GO TO 16. Page 2-224**
WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace PCB (para. 4-4).

Repair lead connectors (para. 4-80).

Repair leads (para. 4-80).
WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace PCB (para. 4-4).
PROTECTIVE CONTROL BOX DIAGNOSTIC FLOWCHART

FROM 18, Page 2-224

DOES LED 10 MOMENTARILY COME ON THEN STAY OFF?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If this LED is not ON, that would indicate a PCB malfunction.

19

YES

REPLACE
PROTECTIVE
CONTROL
BOX.

NO

!!

20

WITH THE IGNITION SWITCH IN THE RUN (ENGINE RUNNING) POSITION, ARE LEDs 2, 3, 4, 5, AND 8 ON?

TEST OPTIONS
1. TRY IT.
2. VISUAL

REASON FOR QUESTION
If these LEDs are not ON, that would indicate a PCB malfunction.

!!

NO

REPLACE
PROTECTIVE
CONTROL
BOX.

YES

21

IS LED 7 ON?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If this LED is not ON, that would indicate a bad connection to ground.

!!

NO

REPAIR GROUND
BODY HARNESS
WIRE 57B.

YES

GO TO 22, Page 2-228
**REFERENCE INFORMATION**

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace PCB (para. 4-4).

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

Repair lead connectors (para. 4-80).

Repair leads (para. 4-84).
PROTECTIVE CONTROL BOX

KNOWN INFO
- BATTERIES OK
- LEAD 578 GROUND OK
- IGNITION SWITCH OK
- HARNESS WIRE 29A OK
- HARNESS WIRE 29C OK
- PARKING BRAKE SWITCH OK
- BODY HARNESS WIRES OK
- GLOW PLUG CONTROLLER OK

POSSIBLE PROBLEMS
- ALTERNATOR BAD
- HARNESS WIRE 2A BAD
- PROTECTIVE CONTROL BOX BAD

IF THIS LED CONDITION DOES NOT EXIST, THAT WOULD INDICATE A PCB MALFUNCTION.

DIAGNOSTIC FLOWCHART

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
- If this LED condition does not exist, that would indicate a PCB malfunction.

TEST CHAIN AGAIN IF GLOW PLUG CONTROLLER IS BAD

IF THIS LED IS NOT ON, THAT WOULD INDICATE A GLOW PLUG CONTROLLER MALFUNCTION.

GO TO 25, Page 2-230
REFERENCE INFORMATION

PROTECTIVE CONTROL BOX

!!

WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace PCB (para. 4-4).

Repair lead connectors (para. 4-80).
Repair leads (para. 4-80).
PROTECTIVE CONTROL BOX

KNOWN INFO
- BATTERIES OK
- LEAD 578 GROUND OK
- IGNITION SWITCH OK
- HARNESS WIRE 29A OK
- HARNESS WIRE 29C OK
- PARKING BRAKE SWITCH OK
- BODY HARNESS WIRES OK
- GLOW PLUG CONTROLLER OK
- ALTERNATOR OK
- HARNESS WIRE 2A OK

POSSIBLE PROBLEMS
- PROTECTIVE CONTROL BOX BAD

DIAGNOSTIC FLOWCHART

IS LED 11 CYCLING ON AND OFF?

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
If LED is not cycling ON and OFF, that would indicate a PCB malfunction.

NO

REPLACE PROTECTIVE CONTROL BOX.

YES

AT ENGINE OPERATING TEMPERATURE, DOES LED 11 STOP CYCLING ON AND OFF?

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
If LED does not stop cycling ON and OFF, that would indicate a glow plug controller malfunction.

NO

GO TO D1, Page 2-300 AND BEGIN TEST CHAIN AGAIN IF GLOW PLUG CONTROLLER IS REPLACED.

YES

NO PROTECTIVE CONTROL BOX FAULT FOUND.

GO TO 28, Page 2-232
WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace PCB (para. 4-4).
DISCONNECT BATTERY GROUND CABLE.

DISCONNECT BODY AND ENGINE WIRING HARNESS CANNON PLUGS FROM DIAGNOSTIC TEST MODULE.
DISCONNECT CONNECTORS FROM PROTECTIVE CONTROL BOX.

CONNECT BODY AND ENGINE WIRING HARNESS CANNON PLUGS TO PROTECTIVE CONTROL BOX.
CONNECT BATTERY GROUND CABLE.
WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB harness. Failure to do so may result in injury to personnel or damage to equipment.
If LED 5 is on, replace protective control box, or else repair/replace ignition switch and/or harness wires 29A and 29C.
Replace PCB (para. 4-4).
Repair/replace rotary switch (para. 4-10).
Repair/replace leads 29A and 29C (para. 4-80).
2-35. BATTERY CIRCUIT TESTS

These battery circuit tests may be run any time you think you have a battery problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary.

The fold-out page shows the location of the major components of the battery circuit in case you are not familiar with them. Fold-out page FP-13 may be left open for reference while testing.
**BATTERY CIRCUIT**

**1. ARE ALL BATTERY CONNECTIONS CLEAN AND TIGHT?**

**TEST OPTIONS:**
- VISUAL

**REASON FOR QUESTION:**
A loose or dirty connection can make good batteries look bad and may not allow current to flow.

**Known Info:**
- CONNECTIONS OK

**Possible Problems:**
- BATTERIES
- CABLES
- ALTERNATOR CIRCUIT
- CABLE CONNECTIONS

**2. ARE THE BATTERIES FILLED TO THE PROPER LEVEL?**

**TEST OPTIONS:**
- VISUAL

**REASON FOR QUESTION:**
Batteries need water for the electrolyte solution. Batteries don’t work right if the electrolyte level is low.

**Known Info:**
- CONNECTIONS OK
- WATER LEVEL OK

**Possible Problems:**
- BATTERIES
- CABLES
- ALTERNATOR CIRCUIT

**3. IS BATTERY VOLTAGE 23.5-25.5 VOLTS?**

**TEST OPTIONS:**
1. STE/ACE-R TEST 67
   - (Page 2-496)
2. MULTIMETER

**REASON FOR QUESTION:**
If the battery voltage is not correct, you may have bad batteries or a problem in the alternator circuit.

**Known Info:**
- CONNECTIONS OK
- WATER LEVEL OK

**Possible Problems:**
- BATTERIES
- CABLES
- ALTERNATOR CIRCUIT

**GO TO A, Page 2-242**

**GO TO 4, Page 2-240**
BAD CONNECTIONS ARE THE MOST COMMON PROBLEM!

Sometimes just disconnecting, cleaning, and reconnecting will solve a problem. BE THOROUGH! The time you save may be your own.

Refer to the functional flow schematic and check the following:

1. BATTERY - make sure all connections are clean and tight. This includes the interconnect cables, clamps, shunt, power stud, and the slave connector. Also check wires 6A and 7A under vehicle where they enter shunt.

2. STARTER - check the high current (heavy gauge) wire at the starter. Don't just check for voltage; a loose connection will have voltage but can't carry much current.

There is a ring inside the battery fill plugs. The water level should be at the ring.

**BATTERY VOLTAGE STEACE-R TEST 67**


2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries voltage will drop when glow plugs turn on.
**BATTERY CIRCUIT**

**KNOWN INFO**
- Connections OK
- Water level OK
- Battery voltage OK
- Alternator circuit OK

**POSSIBLE PROBLEMS**
- Batteries
- Cables

**TEST OPTIONS**

1. **STE/ICE-R TESTS 73, 75**
   (Pages 2-602, 2-604)

**REASON FOR QUESTION**
If either resistance reading is too high, the batteries are probably weak and may not produce enough power.

---

**BATTERIES OK**

**ALTERNATOR CIRCUIT OK**

**POSSIBLE PROBLEMS**
- Cables

**TEST OPTIONS**

1. **STE/ICE-R TEST 69**
   (Page 2-496)

2. **MULTIMETER**

**REASON FOR QUESTION**
A large voltage drop indicates high resistance. High resistance means less current flow.

---

**IS THE STARTER NEGATIVE CABLE VOLTAGE DROP LESS THAN 0.25 VOLT?**

**REPAIR/REPLACE WIRE 7A.**

---

**BATTERIES OK**

**NEGATIVE CABLE OK**

**ALTERNATOR CIRCUIT OK**

**POSSIBLE PROBLEMS**
- Cables

**TEST OPTIONS**

1. **STE/ICE-R TEST 89**
   (Page 2-506)

2. **MULTIMETER**

**REASON FOR QUESTION**
A large voltage drop indicates high resistance. High resistance means less current flow.

---

**IS THE VOLTAGE DROP FROM THE POWER STUD TO THE STARTER LESS THAN 0.25 VOLT?**

**REPAIR/REPLACE WIRE 6A.**

---

**NO FAULTS FOUND IN BATTERY CIRCUIT.**
These tests check the strength of the batteries during engine cranking. If you don't have STE/ICE-R, skip this step, but remember that you haven't tested the batteries under load.

**STARTER NEG. CABLE VOLTAGE DROP**

1. Start Test 69, Starter Negative Cable Voltage Drop.
2. Displayed reading is in volt. The cable voltage drop should be less than 0.25 volt max.

Repair/replace wire (para. 4-80).

**BATTERY INTERNAL RESISTANCE**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plug controller and fan solenoid.
3. Start Test 73, Battery Internal Resistance.
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms. Battery resistance should be 25 milliohms max.

**BATTERY RESISTANCE CHANGE**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plug controller and fan solenoid.
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms/second. Battery resistance change should be 50 milliohms/second max.

**DC VOLTAGE 0-45 VOLTS**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

Repair/replace wire (para. 4-80).
BATTERY CIRCUIT

A FROM 3, Page 2-238

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-503)
2. MULTIMETER

REASON FOR QUESTION
A good battery has 12 volts at 70°F (22°C).

DOES EACH BATTERY MEASURE 11-13 VOLTS?

NO

RECHARGE OR REPLACE BATTERY.

YES

CHECK THE VOLTAGE DROP ACROSS EACH CABLE IN THE BATTERY BOX (SEE NOTE AT RIGHT). ARE ALL VOLTAGE DROPS LESS THAN 0.25 VOLT MAX?

NO

REPAIR/REPLACE BAD CABLE OR CABLES.

YES

RECHARGE OR REPLACE BATTERY.

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-503)
2. MULTIMETER

REASON FOR QUESTION
Everything else checks out OK. These cables are the only thing in the battery circuit we haven’t tested.

YOUR BATTERIES ARE OVER-CHARGED OR DISCHARGED. RUN THE ALTERNATOR TESTS. IF NO FAULTS ARE FOUND, REPLACE THE DEFECTIVE BATTERY OR BATTERIES.

KNOWN INFO
BATTERY VOLTAGE IS NOT CORRECT

POSSIBLE PROBLEMS
BATTERY OR BATTERIES
CABLES
ALTERNATOR

KNOWN INFO
BATTERIES OK

POSSIBLE PROBLEMS
CABLES

KNOWN INFO
BATTERY VOLTAGE NOT CORRECT

POSSIBLE PROBLEMS
BATTERIES
ALTERNATOR
REFERENCE INFORMATION

Measure from the positive post to the negative post of each battery.

For battery replacement instructions, refer to para. 4-74.

NOTE

Check these cables:

WIRE 68, connecting the batteries together. Test point is the positive terminal of one of the batteries.

WIRE 49A, connecting the batteries to the power stud. Test point is the power stud.

Wire connecting the battery to the shunt. Test point is the shunt.

Wire connecting shunt to ground stud. Test point is the shunt.

For repair or replacement of cables, refer to para. 4-68.

If you use STE/ICE-R test 67 in Step 3 on page 2-252, you may have a faulty DCA. Try running the tests using STE/ICE-R test 89 with the W2 cable.

See para. 4-74. (Also check each battery's specific gravity in accordance with TM 9-6140-200-14.)

Replace battery (para. 4-74).
**BATTERY CIRCUIT**

**TEST OPTIONS**

1. **REARRANGE BATTERY BOX TO TEST ONE BATTERY.**
2. **RUN STE/ICE-R TESTS 73, 75.** (Pages 2-502, 2-504).

**REASON FOR QUESTION**
If either resistance reading is too high, the batteries are probably weak and may not produce enough power.

---

**KNOWN INFO**

**BATTERY RESISTANCE NO GOOD**

**POSSIBLE PROBLEMS**

BATTERIES
CABLES

---

**B1**

**TEST OPTIONS**

1. **REPLACE DEFECTIVE BATTERY.**

---

**KNOWI INFO**

**BATTERIES OK**

**POSSIBLE PROBLEMS**

CABLES

---

**B2**

**TEST OPTIONS**

1. **STE/ICE-R TEST 89** (Page 2-503)
2. **STE/ICE-R TEST 74 (STARTER CIRCUIT RESISTANCE) OR TEST 69 (NEGATIVE CABLE DROP) OR TEST 68 (STARTER MOTOR VOLTAGE) (Pages 2-503, 2-496, 2-497)**
3. **MULTIMETER**

**REASON FOR QUESTION**
Everything else has checked OK. These cables are the only thing in the battery circuit we haven't tested.

---

**B3**

**NO FAULTS FOUND.**
*(IF YOU USED TESTS 73 & 75 IN STEP 4, P. 2-240, YOU MAY HAVE A PROBLEM WITH THE DCA, CHECK THE DCA CONNECTIONS AND TRY RUNNING STEP 4 USING TESTS 77 & 79.) SEE NOTE TO RIGHT.*
## REFERENCE INFORMATION

- Replace batteries (para. 4-74).

## BATTERY CIRCUIT

### BATTERY INTERNAL RESISTANCE

**STEC/ICE-R TEST 73**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plug controller and fan solenoid (to keep waveform clean).
3. Start Test 73, Battery Internal Resistance.
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms. Battery resistance should be 25 milliohms max.

### BATTERY RESISTANCE CHANGE

**STEC/ICE-R TEST 75**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plug controller and fan solenoid (to keep waveform clean).
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms/second. Battery resistance change should be 50 milliohms/second max.

### DC VOLTAGE 0-45 VOLTS

**STEC/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

---

**NOTE**

- Check these cables:
  - WIRE 66, connecting the batteries together. Test point is the positive terminal of one of the batteries.
  - WIRE 49A, connecting the battery to the power stud. Test point is the power stud.
  - Wire connecting the battery to the shunt. Test point is the negative terminal of the battery.
  - Wire connecting shunt to ground stud. Test point is the shunt.
  - Replace batteries (para. 4-74).

- Tests 77 and 79 are TK tests that do the same thing that DCA tests 73 and 75 do. See TM 9-4910-571-12&P for instructions on how to run these tests.
2-36. STARTER CIRCUIT TESTS

The starter circuit consists of the batteries, starter solenoid, starter motor, rotary switch, parts of the Protective Control Box (PCB) and related electrical wiring. The relationship of these parts is shown in the block diagram below, and a simplified functional flow schematic is provided on the foldout FP-15.

The starter solenoid and starter motor are enclosed in housings to protect them from dirt, icing conditions, and other road hazards.

When the rotary switch is turned to START, the PCB checks if the engine is running. If the engine is not running, the PCB sends a signal to the starter solenoid which energizes the solenoid windings and causes the solenoid contacts to close, sending battery power to the starter motor. The battery power causes the starter motor pinion gear to engage the engine flywheel ring gear and the engine cranks. When the engine starts, the rotary switch should be released, allowing it to return to the RUN position. This tells the PCB to release the starter solenoid which, in turn, disengages the starter motor from the engine.
STARTER CIRCUIT

1. CHECK ALL CABLES AND CONNECTIONS (BATTERY, STARTER, SOLENOID, ROTARY SWITCH, PCB). ARE ABOVE COMPONENTS OK?

   YES

   REPAIR OR REPLACE CABLES, CONNECTORS.

   NO

2. CHECK BATTERY VOLTAGE WHILE TRYING TO CRANK THE ENGINE. IS THE BATTERY VOLTAGE AT LEAST 18 VOLTS?

   YES

   GO TO BATTERY CIRCUIT, Page 2-237

   NO

   GO TO 3, Page 2-250

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Bad connections are a very common problem.

TEST OPTIONS

1. STE/CE-R TEST 67 (Page 2-496)
2. MULTIMETER
3. VOLTMETER

REASON FOR QUESTION

If the engine cranks, you know the engine is not locked and the rotary switch is OK.

KNOWN INFO

ENGINE WON'T CRANK OR CRANKS SLOWLY

POSSIBLE PROBLEMS

WIRING
BATTERIES
STARTER
SOLENOID
ROTARY SWITCH
ENGINE LOCKED
PCB

KNOWN INFO

CABLES & CONNECTORS APPEAR OK

POSSIBLE PROBLEMS

WIRING
BATTERIES
STARTER/SOLENOID
ROTARY SWITCH
ENGINE LOCK
PCB
REFERENCE INFORMATION

BAD CONNECTIONS ARE THE MOST COMMON PROBLEM!

Sometimes just disconnecting, cleaning, and reconnecting will solve a problem. BE THOROUGH!
The time you save may be your own.

Refer to the functional flow schematic and check the following:

1. BATTERY - make sure all connections are clean and tight, including the shunt and power stud.
2. STARTER - check the high current wire (heavy gauge wire 6A) at the starter. Don’t just check for voltage; a loose connection will have voltage but can’t carry much current.

![WARNING]

Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

![WARNING]

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

3. PROTECTIVE CONTROL BOX - Remove BOTH connectors and look for bent or broken pins, pins pushed out of their socket, or dirt and corrosion in the connections.
4. ROTARY SWITCH - Check the wires at the switch. Don’t just look. Feel the connections to make sure they’re snug. Many problems can be solved by seeing with your fingers, not just your eyes.

A cold engine should crank at least 100 rpm.
A warm engine should crank at least 180 rpm.

STARTER CIRCUIT

| BATTERY_VOLTAGE
<table>
<thead>
<tr>
<th>STE/CE-R_TEST_67</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Start Test 67, Battery Voltage.</td>
</tr>
<tr>
<td>2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries voltage will drop when glow plugs turn on.</td>
</tr>
</tbody>
</table>

| BATTERY_VOLTAGE
<table>
<thead>
<tr>
<th>MULTIMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set the voltmeter to a DC volts scale of at least 40 volts.</td>
</tr>
<tr>
<td>2. Connect the RED lead to positive and the BLACK lead to negative.</td>
</tr>
<tr>
<td>3. Be sure to read the correct scale.</td>
</tr>
</tbody>
</table>
STARTER CIRCUIT

DIAGNOSTIC FLOWCHART

1. **KNOWLEDGE**
   - CABLES & CONNECTORS APPEAR OK
   - POSSIBLE PROBLEMS:
     - BATTERIES
     - STARTER/SOLENOID
     - ROTARY SWITCH
     - ENGINE LOCK
     - PCB

2. ** Thảo luận**
   - **POSSIBLE PROBLEMS**:
     - STARTER
     - STARTER SHIMS
     - FLY WHEEL
     - BATTERIES

3. **THÔNG TIN**
   - DOES THE ENGINE CRANK AT LEAST 100 RPM?

   **TEST OPTIONS**
   - 1. LISTEN.
   - 2. STE/ICE-R TEST 10 (Page 2-249)

   **LÝ DO DÀM DÕM**
   If the engine cranks, you know the engine is not locked and the rotary switch is OK.

   **GOTO A**
   - Page 2-254; H, Page 2-262

4. **THÔNG TIN**
   - ROTARY SWITCH OK
   - ENGINE NOT LOCKED
   - PCB OK

   **POSSIBLE PROBLEMS**
   - STARTER
   - STARTER SHIMS
   - FLY WHEEL
   - BATTERIES

   **TEST OPTIONS**
   - LISTEN.

   **LÝ DO DÀM DÕM**
   This is a check for mechanical problems such as improperly shimmed starter, damaged flywheel, or burnt starter.

   **GOTO A**
   - Page 2-255

   **GOTO 5**
   - Page 2-252
STARTER CIRCUIT

1. Start Test 10, Engine RPM.

2. Crank or start the engine. Displayed reading is RPM. Cranking rpm should be approximately 100. Idle rpm should be 625 - 675.
STARTER CIRCUIT

**KNOWN INFO**
- CRANKS OK

**POSSIBLE PROBLEMS**
- ROTARY SWITCH
- STARTER
- PCB

**DIAGNOSTIC FLOWCHART**

5. **DOES THE STARTER STOP CRANKING WHEN THE ROTARY SWITCH IS RETURNED TO THE RUN OR STOP POSITIONS?**
- **YES**
  - **GO TO C, Page 2-262**
- **NO**
  - **TEST OPTIONS**
    - LISTEN.
  - **REASON FOR QUESTION**
    - The starter solenoid could be stuck or, more likely, there may be a short to the solenoid.

6. **IS THE AVERAGE STARTER CURRENT BETWEEN 200 AND 300 AMPS?**
- **YES**
  - **GO TO D, Page 2-268**
- **NO**
  - **TEST OPTIONS**
    - 1. STE/ICE-R TEST 71 (Page 2-500)
    - 2. MULTIMETER
  - **REASON FOR QUESTION**
    - This will tell if the starter is OK and if the batteries have enough power to crank the engine.

7. **IS THE BATTERY VOLTAGE AT LEAST 18.5 VOLTS WHILE CRANKING?**
- **YES**
  - **GO TO BATTERY TESTS, Page 2-237**
- **NO**
  - **TEST OPTIONS**
    - 1. STE/ICE-R TEST 67 (Page 2-498)
    - 2. MULTIMETER
  - **REASON FOR QUESTION**
    - A good cranking voltage, combined with a good starter current, shows that the batteries are OK.

**NO FAULTS FOUND.**
REFERENCE INFORMATION

STARTER CIRCUIT

STARTER AVERAGE CURRENT
STE/ICE-R TEST 71
1. Start Test 71, Starter Average Current.
2. Displayed reading is in amps. The starter should draw at least 200 amps with a peak of over 400 amps.

BATTERY CURRENT
MULTIMETER
1. Set the voltmeter to a DC volts scale of about 1 volt.
2. Connect the BLACK lead to the battery side of the current shunt and the RED lead to the other end of the current shunt.
3. Current shunt voltage is proportional to battery current, 100 millivolts = 1,000 amps. To get current, multiply millivolts x 10.

BATTERY VOLTAGE
STE/ICE-R TEST 67
1. Start Test 67, Battery Voltage.
2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries voltage will drop when glow plugs turn on.

BATTERY VOLTAGE
MULTIMETER
1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
STARTER CIRCUIT

KNOWN INFO
ENGINE DOESN'T CRANK AT 200 RPM

POSSIBLE PROBLEMS
BATTERIES
STARTER
NEUTRAL SAFETY SWITCH
CABLES/WIRING
ENGINE MECHANICAL
ROTARY SWITCH
PCB

A1
DOES THE ENGINE CRANK AT ALL?

NO
GO TO E, Page 2-270

YES

TEST OPTIONS
LISTEN.

REASON FOR QUESTION
If the engine cranks, then the rotary switch, neutral safety switch and PCB are all working.

A2
IS THE BATTERY VOLTAGE 23-25 VOLTS?

NO
REPLACE BATTERIES OR CHECK EACH BATTERY.

YES

TEST OPTIONS
1. STE/ICE-R TEST 67 (Page 2-496)
2. MULTIMETER

REASON FOR QUESTION
If batteries are weak, they can't provide enough current to crank the engine properly.

A3
IS THE BATTERY VOLTAGE AT LEAST 18.5 VOLTS DURING CRANKING?

NO
REPLACE BATTERIES.

YES

TEST OPTIONS
1. STE/ICE-R TEST 67 (Page 2-496)
2. MULTIMETER

REASON FOR QUESTION
Batteries must be able to maintain voltage or the engine won't crank.

GO TO A4, Page 2-256
Connect red to positive = power stud.

Connect black to negative = battery side of current shunt.

Replace batteries \(^{(para: 4-74)}\).
STARTER CIRCUIT

KNOWN INFO
BATTERY VOLTAGE OK
ENGINE CRANKS SLOWLY

POSSIBLE PROBLEMS
WEAK BATTERIES
STARTER
ENGINE MECHANICAL
CABLES/CONNECTIONS

A4
IS THE STARTER AVERAGE CURRENT 200-300 AMPS?

TEST OPTIONS
1. STE/ICE-R TEST 71 (Page 2-500)
2. MULTIMETER AT SHUNT

REASON FOR QUESTION
This is to check the condition of the starter and the batteries.

A5
ARE THE CABLE VOLTAGE DROPS LESS THAN 0.25 VOLT?

TEST OPTIONS
1. STE/ICE-R TESTS 69, 89 (Page 2-498, 2-506)
2. MULTIMETER

REASON FOR QUESTION
High voltage drops indicate bad cables or connections.

A6
IF THE ENGINE STILL CRANKS SLOWLY, YOU PROBABLY HAVE AN INTERNAL ENGINE OR TRANSMISSION PROBLEM THAT IS PREVENTING THE ENGINE FROM CRANKING PROPERLY. RUN THE COMPRESSION/Mechanical TEST, PARAGRAPH 2-30 (Page 2-147).

2-256
STARTER AVERAGE CURRENT
STE/ICE-R TEST 71

1. Start Test 71, Starter Average Current.
2. Displayed reading is in amps. The starter should draw at least 200 amps with a peak of over 400 amps.

Check these cables:

- Starter negative cable - STE/ICE-R test 69
- Wire 66, connecting the batteries together. Test point is the positive battery post.
- Wire 49A, connecting battery to power stud. Test point is the power stud.
- Wire connecting battery to shunt (50A). Test point is the positive battery post.
- Power stud to starter motor (6A). Test point is the power stud.

Replace or repair cables (para. 4-66).

STARTER NEG. CABLE VOLTAGE DROP
STE/ICE-R TEST 69

1. Start Test 69, Starter Negative Cable Voltage Drop.
2. Displayed reading is in volts. The cable voltage drop should be less than 0.25 volt max.

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

BATTERY CURRENT MULTIMETER

1. Set the voltmeter to a DC volts scale of about 1 volt.
2. Connect the BLACK lead to the battery side of the current shunt and the RED lead to the other end of the current shunt.
3. Current shunt voltage is proportional to battery current, 100 millivolts = 1.000 amps. To get current, multiply millivolts x 10.

VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
### STARTER CIRCUIT

#### KNOWN INFO
- Batteries OK
- PCB OK
- Neutral safety switch OK
- Rotary switch OK

#### POSSIBLE PROBLEMS
- Starter
- Flywheel
- Wiring

#### DIAGNOSTIC FLOWCHART

**B1**

**TEST OPTIONS**
- **VISUAL**

**REMOVE STARTER AND INSPECT FOR DEFECTS. IS IT OK?**

- **NO**
  - **REPLACE STARTER.**

- **YES**
  - **B2**

**TEST OPTIONS**
- **VISUAL**

**INSPECT FLYWHEEL FOR MISSING OR DEFECTIVE TEETH. IS IT OK?**

- **NO**
  - **NOTIFY MAINTENANCE (CHAPTER 14).**

- **YES**
  - **B3**

**TEST OPTIONS**
- **NONE**

**PUT STARTER BACK ON ENGINE. BE VERY CAREFUL TO SHIM THE STARTER PROPERLY.**

- **GO TO B4, PAGE 2-260.**
Remove starter motor (para. 4-11).
Check the pinion and gear for missing or broken teeth, unusual wear, bent pieces, etc.
Check the pinion by turning it on the screw shaft.
Check the armature by prying the pinion with a screwdriver. The armature should turn freely.
Replace starter (para. 4-11).

Disconnect the fuel solenoid, wire 54A, to prevent accidental starting. Rotate the engine with a breaker bar and socket on the crankshaft pulley to inspect the engine flywheel for missing or defective teeth.

Replace starter (para. 4-11).
STARTER CIRCUIT

FROM B3, Page 2-258

DOES STARTER ENGAGE AND DISENGAGE PROPERLY?

TEST OPTIONS
1. VISUAL
2. LISTEN.

REASON FOR QUESTION
If starter still does not engage and disengage properly, it must be defective.

POSSIBLE PROBLEMS
STARTER ENGINE

YES
REPLACE STARTER.

NO

B4

RETURN TO STARTER CIRCUIT, RUN STEP 4, Page 2-250.

B5
Replace starter (para 4-11).
**STARTER CIRCUIT**

**KNOWN INFO**
- ENGINE WON'T STOP CRANKING

**POSSIBLE PROBLEMS**
- ROTARY SWITCH
- PCB
- WIRING
- STARTER

**DISCONNECT NEGATIVE BATTERY CABLE TO STOP CRANKING.**

**TEST OPTIONS**
- NONE

**REASON FOR QUESTION**
- No matter what's wrong, the starter can't crank without battery power.

**DISCONNECT WIRES AT ROTARY SWITCH.**

**TEST OPTIONS**
- 1. STE/ICE-R TEST 91
- 2. MULTIMETER

**REASON FOR QUESTION**
- A good switch exhibits these open circuits in the OFF position.

**WITH ROTARY SWITCH IN RUN POSITION, DO YOU GET:**
- OPEN CIRCUIT FROM B TO S?
- OPEN CIRCUIT FROM B TO R?
- OPEN CIRCUIT FROM R TO S?

**TEST OPTIONS**
- 1. STE/ICE-R TEST 91
- 2. MULTIMETER

**REASON FOR QUESTION**
- A good switch has these opens and shorts.

**GO TO C4, Page 2-254**
REFERENCE INFORMATION

Don't forget that your vehicle batteries are disconnected, so you can't run the STE/ICE-R from the DCA. You have to use the power cable and connect directly to the batteries.

When the resistance is too high for STE/ICE-R to measure, as in the case of an open circuit, STE/ICE-R displays .9.9.9.9.

Replace rotary switch (para. 4-10).

STARTER CIRCUIT

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.

2. Start Test 91. 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

REAR OF ROTARY SWITCH

Don't forget that your vehicle batteries are disconnected, so you can't run the STE/ICE-R from the DCA. You have to use the power cable and connect directly to the batteries.

When the resistance is too high for STE/ICE-R to measure, as in the case of an open circuit, STE/ICE-R displays .9.9.9.9.

Replace rotary switch (para. 4-10).
STARTER CIRCUIT

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-505)
2. MULTIMETER

C4

YES NO
REPAIR APPROPRIATE WIRE OR REPLACE HARNESS.

C5
RECONNECT BODY CONNECTOR. DISCONNECT ENGINE CONNECTOR. DISCONNECT WIRE 74A AT STARTER. IS THERE AN OPEN CIRCUIT FROM SOCKET E TO SOCKET I ENGINE CONNECTOR HARNESS?

YES NO
REPAIR WIRES OR REPLACE HARNESS.

C6
IS THERE AN OPEN CIRCUIT FROM SOCKET E OF PCB ENGINE CONNECTOR HARNESS TO ENGINE GROUND?

YES NO
REPLACE STARTER.

GO TO C7, Page 2-266

KNOWN INFO
ROTARY SWITCH OK
POSSIBLE PROBLEMS
PCB WIRING STARTER

KNOWN INFO
ROTARY SWITCH OK
BODY HARNESS OK
POSSIBLE PROBLEMS
PCB WIRING STARTER

KNOWN INFO
ROTARY SWITCH OK
BODY HARNESS OK
POSSIBLE PROBLEMS
PCB WIRING STARTER

REASON FOR QUESTION
Continuity between any of these pins indicates a short between the wires in body harness.

REASON FOR QUESTION
Continuity between these pins indicates a short in the engine harness.

REASON FOR QUESTION
Continuity indicates shorted connector in the starter solenoid.
Don't forget that your vehicle batteries are disconnected, so you can't run the STE/ICE-R from the DCA. You have to use the power cable and connect directly to the batteries.

When the resistance is too high for STE/ICE-R to measure, as in the case of an open circuit, STE/ICE-R displays .9.9.9.9.

Repair wiring or replace harness (para. 4-80).

Check the wires at the connectors for shorts. If there are no visible shorts, you have to replace the harness.

Repair wiring or replace harness (para. 4-80).

Replace starter (para. 4-13).
STARTER CIRCUIT

KNOWN INFO
ENGINE HARNESS OK

POSSIBLE PROBLEMS
PCB
BATTERY

C7

RECONNECT WIRE 74A TO STARTER. IS BATTERY VOLTAGE LESS THAN 20 VOLTS?

DIAGNOSTIC FLOWCHART

FROM C6, Page 2-264

TEST OPTIONS
1. STE/ICE-R TEST 67 (Page 2-266)
2. MULTIMETER

REASON FOR QUESTION
Low battery voltage may, under the proper conditions, cause the starter solenoid to remain energized.

YES

C8

DISCONNECT BATTERY NEGATIVE CABLE. RECONNECT ENGINE CONNECTOR. REPLACE BATTERY NEGATIVE CABLE. REPLACE BATTERIES. TRY CRANKING ENGINE. IF IT WON'T STOP CRANKING, REPLACE PCB. RERUN STARTER CIRCUIT TEST CHAIN (STEP 1 Page 2-248).

NO

REPLACE PCB.
REFERENCE INFORMATION

- Replace PCB (para. 4-4).

- Replace batteries (para. 4-47).

STARTER CIRCUIT

**BATTERY VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

**BATTERY VOLTAGE STE/ICE-R TEST 67**

1. Start Test 67, Battery Voltage.
2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries voltage will drop when glow plugs turn on.
STARTER CIRCUIT

DIAGNOSTIC FLOWCHART

D1

IS BATTERY VOLTAGE 23-25.5 VOLTS?

TEST OPTIONS
1. STE/ICE-R TEST 67 (Page 2-496)
2. MULTIMETER

REASON FOR QUESTION
Low voltage may indicate low battery capacity.

D2

IS BATTERY INTERNAL RESISTANCE LESS THAN 25 MILLIOHMS AND BATTERY RESISTANCE CHANGE LESS THAN 50 MILLIOHMS/SECOND?

TEST OPTIONS
STE/ICE-R TESTS 73, 75 (Pages 2-502, 2-504)

REASON FOR QUESTION
Battery resistance and resistance change is an indication of the ability of the battery to supply current.

D3

ARE THE POSITIVE AND NEGATIVE CABLE DROPS 0.25 VOLT EACH?

TEST OPTIONS
1. STE/ICE-R TESTS 69, 89 (Pages 2-498, 2-506)
2. MULTIMETER

REASON FOR QUESTION
High cable resistance may limit current flow.

REPLACE CABLE.
REFERENCE INFORMATION

STATER CIRCUIT

BATTERY VOLTAGE
STE/ICE-R TEST 67

1. Start Test 67, Battery Voltage.
2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries voltage will drop when glow plugs turn on.

Replace batteries (para. 4-74).

BATTERY INTERNAL RESISTANCE
STE/ICE-R TEST 73

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plug controller and fan solenoid (to keep waveform clean).
3. Start Test 73, Battery Internal Resistance.
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms. Battery resistance should be 25 milliohms max.

Replace cables or starter (para. 4-72 or 4-11).

BATTERY RESISTANCE CHANGE
STE/ICE-R TEST 75

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glow plug controller and fan solenoid (to keep waveform clean).
4. Wait for the GO message. Crank the engine.
5. Result is displayed in milliohms/second. Battery resistance change should be 50 milliohms/second max.

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC volts.
3. Displayed reading is in volts.

VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
STARTER CIRCUIT

E1

**KNOWN INFO**
ENGINE WON'T CRANK

**POSSIBLE PROBLEMS**
BATTERY
STARTER
PCB
ROTARY SWITCH
NEUTRAL SAFETY SWITCH
WIRING/CABLES
LOCKED ENGINE

**THINGS TO CHECK**
IS BATTERY VOLTAGE AT LEAST 20 VOLTS?

**TEST OPTIONS**
1. STE/ICE-R TEST 67
   (Page 2-495)
2. MULTIMETER

**REASON FOR QUESTION**
Low battery voltage can prevent cranking.

**E2**

**KNOWN INFO**
BATTERY SHOULD AT LEAST CRANK ENGINE SLOWLY

**POSSIBLE PROBLEMS**
STARTER
PCB
ROTARY SWITCH
NEUTRAL SAFETY SWITCH
WIRING/CABLES
LOCKED ENGINE

**THINGS TO CHECK**
DO YOU HAVE BATTERY VOLTAGE AT STARTER MOTOR (WIRE 6A)?

**TEST OPTIONS**
1. STE/ICE-R TEST 66
   (Page 2-497)
2. MULTIMETER

**REASON FOR QUESTION**
Must have voltage available at starter to crank.

**E3**

**KNOWN INFO**
VOLTAGE AVAILABLE AT STARTER

**POSSIBLE PROBLEMS**
BATTERY
STARTER
PCB
ROTARY SWITCH
NEUTRAL SAFETY SWITCH
WIRING/CABLES
LOCKED ENGINE

**THINGS TO CHECK**
WITH ROTARY SWITCH IN START POSITION, DO YOU HAVE BATTERY VOLTAGE AT SOLENOID SWITCH TERMINAL (74A)?

**TEST OPTIONS**
1. STE/ICE-R TEST 70
   (Page 2-499)
2. MULTIMETER

**REASON FOR QUESTION**
Must have voltage at switch terminal to energize solenoid.

Go to E4, Page 2-272
REFERENCE INFORMATION

**BATTERY VOLTAGE**
ST/ECE-R TEST 67

1. Start Test 67, Battery Voltage.
2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries voltage will drop when glow plugs turn on.

**BATTERY VOLTAGE**
MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

**STARTER MOTOR VOLTAGE**
ST/ECE-R TEST 68

1. Start Test 68, Starter Motor Voltage.
2. Displayed reading is in volts. Starter motor voltage should be the same as battery voltage, 23-25.5 volts. During cranking, the starter motor voltage should be at least 16 volts.

**STARTER SOLENOID VOLTAGE**
ST/ECE-R TEST 70

1. Start Test 70, Starter Solenoid Voltage.
2. Displayed reading is in volts. Starter solenoid voltage should be the same as battery voltage, 23-25.5 volts. During cranking, the starter solenoid voltage should be at least 18 volts.

Replace batteries (para. 4-74).
STARTER CIRCUIT

Known Info

- Engine Free

Possible Problems

- Starter

Diagnostic Flowchart

Replace Starter.
REFERENCE INFORMATION

Replace starter (para. 4-11).
STARTER CIRCUIT

KNOWN INFO
BATTERY VOLTAGE NOT AVAILABLE AT SOLENOID STUD

POSSIBLE PROBLEMS
CABLES
CONNECTIONS

TEST OPTIONS
NONE

REASON FOR QUESTION
Dirty battery connections can prevent current flow.

F2
IS THE STARTER POSITIVE CABLE (WIRE 6A) VOLTAGE DROP LESS THAN 0.25 VOLT?

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
High voltage drop indicates high resistance in the cable.

NO
REPLACE CABLE.

YES

F3
NO FAULTS FOUND. RUN BATTERY TESTS (Page 2-237).

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CLEAN AND TIGHTEN BATTERY TERMINALS AND CLAMPS.

FROM E2, Page 2-270
Replace cable (para. 4-12).

Put the red lead on the power stud, and the black on the terminal of the starter in order to measure the voltage along wire 6A.

**DC VOLTAGE 0-45 VOLTS STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 69, DC Volts.
3. Displayed reading is in volts.

**VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
STARTER CIRCUIT

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
Current flows to neutral safety switch before reaching solenoid.

KNOWN INFO
NO SOLENOID
CONTROL VOLTAGE

POSSIBLE PROBLEMS
PCB WIRING
ROTARY SWITCH
NEUTRAL SAFETY SWITCH

DISCONNECT WIRE 14A AT THE NEUTRAL SAFETY SWITCH. TURN ROTARY SWITCH TO START. IS THERE BATTERY VOLTAGE AT WIRE 14A (THE NEUTRAL SAFETY SWITCH END)?

GO TO I, Page 2-284

YES

NO

G1

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-509)
2. MULTIMETER

REASON FOR QUESTION
If there is no continuity, then current will not flow through switch.

KNOWN INFO
VOLTAGE AVAILABLE
ROTARY SWITCH OK

POSSIBLE PROBLEMS
NEUTRAL SAFETY SWITCH
PCB WIRING

DISCONNECT WIRE 14B AT NEUTRAL SAFETY SWITCH. IS THERE CONTINUITY ACROSS NEUTRAL SAFETY SWITCH (WIRE 14 TO WIRE 14)?

YES

NO

G2

REPLACE NEUTRAL SAFETY SWITCH.

!!

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-509)
2. MULTIMETER

REASON FOR QUESTION
An open wire here could have prevented current flow between PCB and neutral switch.

KNOWN INFO
NEUTRAL SAFETY SWITCH OK

POSSIBLE PROBLEMS
PCB WIRING

DISCONNECT BODY CONNECTOR FROM PROTECTIVE CONTROL BOX. IS THERE CONTINUITY FROM WIRE 14B AT NEUTRAL SAFETY SWITCH TO BODY CONNECTOR HARNESS SOCKET A?

REPAIR 14B OR REPLACE HARNESS.

YES

NO

G3

GO TO G4, Page 2-278
The connections for the neutral safety switch can be reached by removing the engine cover. The connections are near the gear shift lever.

Replace neutral safety switch (refer to para. 5-6).

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

**WARNING**
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Repair wiring (para. 4-6) or replace switch (para. 5-6).

### DC VOLTAGE 0-45 VOLTS

**STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC volts.
3. Displayed reading is in volts.

### VOLTAGE MULTIMETER

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Set the voltmeter to a DC volts scale of at least 40 volts.</td>
</tr>
<tr>
<td>2.</td>
<td>Connect the RED lead to positive and the BLACK lead to negative.</td>
</tr>
<tr>
<td>3.</td>
<td>Be sure to read the correct scale.</td>
</tr>
</tbody>
</table>

### CONTINUITY (RESISTANCE) MULTIMETER

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Set the voltmeter to an ohms scale of about 1,000 ohms.</td>
</tr>
<tr>
<td>2.</td>
<td>Connect the RED and BLACK leads to the connections stated in the question.</td>
</tr>
<tr>
<td>3.</td>
<td>Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).</td>
</tr>
</tbody>
</table>

### RESISTANCE AND CONTINUITY 0-4,500 OHMS

**STE/ICE-R TEST 91**

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

---

**PCB BODY CONNECTOR**

2-277
STARTER CIRCUIT

FROM G3, Page 2-276

!!

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If this wire doesn't carry battery voltage to the PCB, the PCB will not send battery voltage to the starter solenoid.

DISCONNECT WIRE 29A FROM ROTARY SWITCH. IS THERE CONTINUITY FROM WIRE 29A AT ROTARY SWITCH TO SOCKET B OF PCB BODY CONNECTOR HARNESS?

NO

REPAIR WIRE 29A OR 29C OR REPLACE HARNESS.

YES

REPLACE ROTARY SWITCH.

RECONNECT PCB BODY CONNECTOR HARNESS. DO YOU HAVE BATTERY VOLTAGE AT THE R TERMINAL OF THE ROTARY SWITCH WITH THE SWITCH IN RUN AND IN START?

NO

GO TO G6, Page 2-280

YES

REPLACE ROTARY SWITCH.

TEST OPTIONS
1. STE/ICE-R TEST 69 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If there isn't battery voltage at the RUN terminal in both the RUN and START positions, the vehicle won't start.
REFERENCE INFORMATION

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

**WARNING**
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Check the wires and connections at both ends for broken wires or any kind of bad connection. Repair whatever you can. If the wires and connections seem ok, you have to replace the harness.

Replace rotary switch (para. 4-10).

---

**DC VOLTAGE 0-45 VOLTS**
**STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

**VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

---

**RESISTANCE AND CONTINUITY**
**0-4,500 OHMS**
**STE/ICE-R TEST 91**

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

---

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
STARTER CIRCUIT

DIAGNOSTIC FLOWCHART

KNOWN INFO

POWER AVAILABLE TO PCB

POSSIBLE PROBLEMS

PCB WIRING

G6

DISCONNECT BATTERY NEGATIVE CABLE. RECONNECT NEUTRAL SAFETY SWITCH. DISCONNECT ENGINE CONNECTOR FROM PCB. IS THERE CONTINUITY FROM ENGINE CONNECTOR HARNESS PIN 1 TO THE STARTER SOLENOID WIRE 74A?

G7

REPLACE PCB. IF YOU STILL HAVE A PROBLEM, RERUN THE TEST CHAIN (Page 2-247).

TEST OPTIONS

1. STEACE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If there is continuity there, you know all the wiring is good and the problem is in the PCB.

NO

REPAIR 74A OR REPLACE HARNESS.

YES
REFERENCE INFORMATION

REFERENCE INFORMATION

STARTER CIRCUIT

WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel. Replace harness or PCB (para. 4-4).

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminals indicated in the question.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
STARTER CIRCUIT

KNOWN INFO
CANT TURN ENGINE MANUALLY

POSSIBLE PROBLEMS
INTERNAL MECHANICAL PROBLEM
HYDRAULIC LOCK

H1

TEST OPTIONS
NONE

REASON FOR QUESTION
If the engine is hydrostatically locked, removing the glow plugs will allow the fuel to flow out of the locked cylinder and the engine should turn.

NOTIFY DS MAINTENANCE (CHAPTER 14)

NO

DOES THE ENGINE TURN SMOOTHLY AND WITHOUT ANY UNUSUAL NOISES?

H2

KNOWN INFO
HYDRAULIC LOCK REMOVED

POSSIBLE PROBLEMS
INTERNAL MECHANICAL PROBLEM

NOTIFY DS MAINTENANCE (CHAPTER 14)

NO

YES

REINSTALL GLOW PLUGS AND RERUN STARTER SYSTEM TESTS (GO TO PAGE 2-247). IF ENGINE LOCKS AGAIN, NOTIFY DS MAINTENANCE (CHAPTER 14).

H3

KNOWN INFO
ENGINE CAN ROTATE SMOOTHLY

POSSIBLE PROBLEMS
ENGINE

DIAGNOSTIC FLOWCHART

TEST OPTIONS
NONE

REASON FOR QUESTION
Excessive noise and jerky rotation may indicate binding or broken internal engine components.

NOTIFY DS MAINTENANCE (CHAPTER 14)

YES

PAGE 2-282
WARNING

Disconnect wire 54A to prevent accidental starting. Failure to do so may result in serious injury or death to personnel.
STARTER CIRCUIT

DIAGNOSTIC FLOWCHART

I1

NO VOLTAGE AVAILABLE AT NEUTRAL SAFETY SWITCH

KNOWLEDGE

NO VOLTAGE AVAILABLE AT NEUTRAL SAFETY SWITCH

POSSIBLE PROBLEMS

ROTARY SWITCH

PCB

WIRING

DISCONNECT WIRE 11A AT ROTARY SWITCH. IS THERE BATTERY VOLTAGE AT WIRE 11A?

TEST OPTIONS

1. STE/ICE-R TEST 89
   (Page 2-596)

2. MULTIMETER

REASON FOR QUESTION
Power must be available to rotary switch.

GO TO J, Page 2-286

I2

BATTERY VOLTAGE AVAILABLE TO ROTARY SWITCH

KNOWLEDGE

BATTERY VOLTAGE AVAILABLE TO ROTARY SWITCH

POSSIBLE PROBLEMS

ROTARY SWITCH

PCB

WIRING

DISCONNECT WIRE 14A AT ROTARY SWITCH. WITH THE ROTARY SWITCH TURNED TO START, IS THERE CONTINUITY BETWEEN THE B STUD AND THE S STUD?

TEST OPTIONS

1. STE/ICE-R TEST 91
   (Page 2-609)

2. MULTIMETER

REASON FOR QUESTION
Continuity here indicates rotary switch is OK.

REPLACE ROTARY SWITCH. RECONNECT 14A AT NEUTRAL SAFETY SWITCH.

I3

REPAIR WIRE 14A OR REPLACE HARNESS.
REFERENCE INFORMATION

REAR OF ROTARY SWITCH

VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

RESISTANCE AND CONTINUITY 0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

Replace rotary switch (para. 4-10).

Repair wiring or replace harness (para. 4-80).
STARTER CIRCUIT

**DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**

1. STE/ICE-R TEST 91
   
2. MULTIMETER

**REASON FOR QUESTION**

If this wire is open, no power can get to the rotary switch.

---

**J1**

DISCONNECT BATTERY NEGATIVE CABLE. DISCONNECT BODY CONNECTOR FROM PCB. IS THERE CONTINUITY FROM SOCKET G OF BODY CONNECTOR HARNESS TO WIRE 11A AT ROTARY SWITCH?

**TEST OPTIONS**

1. STE/ICE-R TEST 91
   
2. MULTIMETER

**REASON FOR QUESTION**

If this wire is open, no power can get to the rotary switch.

---

**J2**

RECONNECT WIRE 11A AT ROTARY SWITCH. DISCONNECT ENGINE CONNECTOR OF PCB. RECONNECT BATTERY NEGATIVE CABLE. IS THERE BATTERY VOLTAGE AT SOCKET E OF CONNECTOR HARNESS?

**TEST OPTIONS**

1. STE/ICE-R TEST 89
   
2. MULTIMETER

**REASON FOR QUESTION**

This wire provides power from the batteries directly to the PCB. If there is power here, then this wire is OK and the PCB must be bad.

---

**J3**

REPLACE PROTECTIVE CONTROL BOX.
WARNING
Disconnected negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Replace harness or repair wiring (para. 4-80).

WARNING
Disconnected negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Replace harness or repair wiring (para. 4-80).

WARNING
Disconnected negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Replace PCB (refer to para. 4-4).
2-37. GLOW PLUGS CIRCUIT TESTS

These tests of the glow plugs circuit can be run any time you think there may be a problem with the glow plugs, or if you were sent here from another test.

If you were sent from another test, be sure to mark where you came from so you will be able to return.

If you are running this test because the engine is hard to start when cold, remember that there is also a cold-start advance circuit (part of the fuel system) which is not checked here.

For any starting problem, we recommend running the STARTABILITY test chain just to be sure you don't miss anything.

At the bottom of this page is a simplified block diagram which shows how the different parts of the glow plug circuit depend on each other and on other engine circuits.

Refer to fold-out page FP-17 and leave it open for reference while performing these tests. The fold-out diagram is arranged to allow you to follow the diagnostic logic and understand what you are testing, when, and why.
GLOW PLUGS CIRCUIT

START

TEST OPTIONS

BATTERY TESTS (Page 2-294)

GLOW PLUGS CIRCUIT

TEST OPTIONS

VISUAL

REASON FOR QUESTION
The glow plugs and their control circuits require battery power to work.

KNOWLEDGE INFO

NOTHING

POSSIBLE PROBLEMS

GLOW PLUGS
GLOW PLUG CONTROLLER
PCB
CABLES

KNOWLEDGE INFO

BATTERIES OK

POSSIBLE PROBLEMS

GLOW PLUGS
GLOW PLUG CONTROLLER
PCB
CABLES

KNOWLEDGE INFO

BATTERIES OK
CABLES/CONNECTIONS SEEM OK

POSSIBLE PROBLEMS

GLOW PLUGS
GLOW PLUG CONTROLLER
PCB
CABLES

1. STE/ICE-R TEST 80 (Page 2-292)

2. MULTIMETER

REASON FOR QUESTION
If the current is OK, then the glow plugs and protective control box are OK.

REPAIR AS NECESSARY.

GO TO A, Page 2-294

GO TO 4, Page 2-292

TO RUN THE GLOW PLUG CIRCUIT TESTS, THE BATTERIES MUST BE IN A GOOD STATE OF CHARGE. IF YOU AREN'T SURE, RUN THE BATTERY CIRCUIT TESTS. IF YOU ARE HERE BECAUSE THE WAIT-TO-START LAMP DOESN'T WORK PROPERLY, SEE THE NOTE ON THE RIGHT-HAND PAGE.

CHECK ALL THE GLOW PLUG CIRCUIT CONNECTIONS (GLOW PLUGS, GLOW PLUG CONTROLLER, PROTECTIVE CONTROL BOX). ARE ALL THE CONNECTIONS CLEAN AND TIGHT?

REASON FOR QUESTION
Loose or dirty connections can hinder current flow or cause mixups in the control signals.

TURN THE ROTARY SWITCH TO RUN. DO THE GLOW PLUGS DRAW 75-125 AMPS? (SEE NOTE ON RIGHT-HAND PAGE).

GO TO 4, Page 2-292
REFERENCE INFORMATION

If the engine cranks ok (or starts), then the batteries are
good enough for testing the glow plugs. If the engine
starts, shut it off.

You can use STE/ICE Test 10 to measure cranking speed.
The engine should crank at least 100 rpm in cold weather
and at least 180 rpm in warm weather.

!! WARNING

Disconnect negative battery
cable before disconnecting and
reconnecting PCB harness.

WARNING

There is battery voltage at the
PCB at all times. Failure to
disconnect battery cable will
result in damage to equipment
or injury to personnel.

BAD CONNECTIONS ARE THE MOST COMMON
PROBLEM!

Sometimes just disconnecting, cleaning, and
reconnecting will solve a problem. BE THOROUGH!
The time you save may be your own. Refer to the
functional flow schematic and check the following:
1. BATTERY - make sure all connections are clean and
tight, including the shunt and power stud.
2. PROTECTIVE CONTROL BOX - remove BOTH
connectors and look for bent or broken pins, pins
pushed out of their socket, or dirt and corrosion in the
connections.
3. GLOW PLUG CONTROLLER - pop the controller
connector off (squeeze the sides) and check the pins in
both the controller and the connector. Look for bent,
broken or pushed out pins, dirt, or corrosion. Check for
broken wires at the connector. Take note that pin 2 of
the glow plugs controller connector has no pin in it.
4. GLOW PLUGS - check that all the glow plug wires are
snug. Don’t just look with your eyes. Many problems
are solved by looking with your fingers to be sure a
connection is snug.

NORMAL GLOW PLUG OPERATION

The glow plugs first come ON when the engine temperature
is below 120 °F (49°C) and the rotary switch is turned to
RUN. They stay ON for up to 9 seconds and then go OFF.
They will stay OFF for about 7-15 seconds then come ON
again for about 1 second.

GLOW PLUGS CIRCUIT

NOTE

The WAIT-TO-START lamp is NOT
diagnosed in this section. If the lamp
does not work properly, the glow plug
circuit may be affecting its operation.
Run these tests to check out the glow
plug circuit. If the lamp still does not work
properly, go to the INSTRUMENT section
for a full diagnosis of the lamp’s problem.

WARNING

Disconnect negative battery
cable before disconnecting and
reconnecting PCB harness.

WARNING

There is battery voltage at the
PCB at all times. Failure to
disconnect battery cable will
result in damage to equipment
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BAD CONNECTIONS ARE THE MOST COMMON
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Run these tests to check out the glow
plug circuit. If the lamp still does not work
properly, go to the INSTRUMENT section
for a full diagnosis of the lamp’s problem.

WARNING

Disconnect negative battery
cable before disconnecting and
reconnecting PCB harness.

WARNING

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PCB at all times. Failure to
disconnect battery cable will
result in damage to equipment
or injury to personnel.

BAD CONNECTIONS ARE THE MOST COMMON
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They will stay OFF for about 7-15 seconds then come ON
again for about 1 second.

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does not work properly, the glow plug
circuit may be affecting its operation.
Run these tests to check out the glow
plug circuit. If the lamp still does not work
properly, go to the INSTRUMENT section
for a full diagnosis of the lamp’s problem.

WARNING

Disconnect negative battery
cable before disconnecting and
reconnecting PCB harness.

WARNING

There is battery voltage at the
PCB at all times. Failure to
disconnect battery cable will
result in damage to equipment
or injury to personnel.

BAD CONNECTIONS ARE THE MOST COMMON
PROBLEM!

Sometimes just disconnecting, cleaning, and
reconnecting will solve a problem. BE THOROUGH!
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connection is snug.

NORMAL GLOW PLUG OPERATION

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is below 120 °F (49°C) and the rotary switch is turned to
RUN. They stay ON for up to 9 seconds and then go OFF.
They will stay OFF for about 7-15 seconds then come ON
again for about 1 second.
GLOW PLUGS CIRCUIT

KNOWN INFO
- BATTERIES OK
- PCB OK
- GLOW PLUGS OK

POSSIBLE PROBLEMS
- GLOW PLUG CONTROLLER
- CABLES

TEST OPTIONS
1. STE/ICE: R TEST 80
2. MULTIMETER

REASON FOR QUESTION
If the glow plugs cycle, the glow plug controller is working. Since current draw is OK, the only thing left to check is the cycling.

DIAGNOSTIC FLOWCHART

4

DO THE GLOW PLUGS CYCLE PROPERLY? (SEE THE NORMAL GLOW PLUG OPERATION DESCRIPTION ON THE RIGHT HAND PAGE.)

NO
GO TO B, Page 2-296

YES

5

NO GLOW PLUGS FAULT FOUND.
REFERENCE INFORMATION

NORMAL GLOW PLUG OPERATION
The glow plugs first come ON when the engine temperature is below 120°F (49°C) and the rotary switch is turned to RUN. They stay ON for up to 9 seconds and then go OFF. They will stay OFF for about 7-15 seconds then come ON again for about 1 second, then go OFF again. If you don’t start the engine, the glow plugs should keep cycling like this, due to the glow plug cycle timer in the glow plugs controller. If you start the engine, they will cycle until the engine is warm, due to the afterglow cycle timer in the glow plug controller. When the engine gets up to 120°F (49°C), the glow plugs should stop cycling completely.

ENGINE NOT RUNNING, ROTARY SWITCH IN RUN
If the glow plugs are cycling properly, you should hear a click from the PCB when the glow plugs turn on and when they turn off. This is the glow plug cycle timer, a thermal circuit breaker. A good way to check for cycling is STE/ICE-R test 80, Battery Current. When the glow plugs turn on, STE/ICE-R will measure 74-125 amps. When the glow plugs turn off, the STE/ICE-R will measure 3-8 amps.

ENGINE RUNNING, ROTARY SWITCH IN RUN
If the glow plugs are cycling properly, you can hear a click from the PCB when the glow plugs turn on and when they turn off (you may have to duck your head under the dash). This is the afterglow cycle timer, a thermal circuit breaker. A good way to check for cycling is STE/ICE-R test 80, Battery Current. When the glow plugs turn on, STE/ICE-R will measure 74-125 amps. When the glow plugs turn off, STE/ICE-R will measure 3-8 amps. As the engine gets warmer, the glow plugs turn on less frequently and for less time.

NOTE
If you don’t have a STE/ICE-R or a multimeter for measuring current, you can watch the vehicle volts gauge for indication of glow plug operation. The glow plugs draw so much current that the volts gauge should jump about half-an-inch to the left when the glow plugs come on. Before starting the engine, you should hear the glow plug power relay click open and closed as the glow plugs cycle. (You can hear the relay after the engine has started by leaning your head under the dash near the PCB.) This method won’t tell you if all the glow plugs are working properly, but it at least shows that the glow plugs are trying to work and that the glow plug power relay is working.

EXPECTED GLOW PLUG CURRENT
| ROTARY SWITCH IN RUN POSITION: |
| GLOW PLUGS ON: 74 - 125 AMPS 74 is only for weak batteries. You should get at least 100 amps when glow plugs are working properly. |
| GLOW PLUGS OFF: AT or NEAR ZERO With the rotary switch in the RUN position, other parts of the vehicle are drawing current. You might measure up to 8 amps. |

BATTERY CURRENT STE/ICE-R TEST 80
1. Start Test 80, Battery Current.
2. Displayed reading is in amps. The reading will be greater than 30 amps, depending on how many accessories you have on.

BATTERY CURRENT MULTIMETER
1. Set the voltmeter to a DC volts scale of about 1 volt.
2. Connect the BLACK lead to the battery side of the current shunt and the RED lead to the other end of the current shunt.
3. Current shunt voltage is proportional to battery current, 100 millivolts = 1,000 amps. To get current, multiply millivolts x 10.

2-293
GLOW PLUGS CIRCUIT

**Known Info**
- Glow plugs do not draw enough current

**Possible Problems**
- Glow plugs
- Glow plug controller
- Cables

**DIAGNOSTIC FLOWCHART**

**A1**

**Test Options**
1. STE/ICE-R TEST 80 (Page 2-505)
2. MULTIMETER

**Reason for Question**
A working glow plug draws 12-15 amps. If at least one glow plug is working, the PCB is OK.

**Diagram**

- Turn the rotary switch to run. Do the glow plugs draw at least 15 amps?
  - Yes: Go to B, Page 2-296
  - No: Go to C, Page 2-298

**A2**

**Test Options**
1. STE/ICE-R TEST 80 (Page 2-505)
2. MULTIMETER

**Reason for Question**
- If the glow plugs cycle properly, the glow plug controller is OK.

**Diagram**

- Do the glow plugs cycle properly?
  - Yes: Go to B, Page 2-296
  - No: Go to C, Page 2-298

**A3**

**Test Options**
- See the procedure on the right-hand page and use:
  1. STE/ICE-R TEST 91 (Page 2-508)
  2. MULTIMETER

**Reason for Question**
- Since the glow plugs draw some current and cycle properly, the only reason they wouldn't draw enough current is that the glow plugs themselves are bad or the wires are no good.

**Diagram**

- Check the glow plugs and wires using the procedure on the right-hand page. Repair or replace parts as required. Rerun the main test chain.

---

**Page 2-294**
Dead glow plugs draw virtually no current, but other parts of the vehicle are drawing some current—up to 8 amps. If any glow plugs are drawing any current, then the PCB is probably OK.

For a good description of how glow plugs cycle and how to check for proper cycling, refer to page 2-293.

---

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

**WARNING**
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

If most or all of the glow plugs are bad, you may also have a problem with the PCB or the glow plug controller which caused them to go bad (usually they burn out from being on too long or not turning off at all). After replacing the bad glow plugs, rerun the glow plugs test chain paying special attention to the glow plugs cycling, especially that they turn OFF when they should.

Replace glow plugs, wires, or harness (para. 3-39).
GLOW PLUGS CIRCUIT

DIAGNOSTIC FLOWCHART

B1

TEST OPTIONS

1. STE/ICE-R TEST 80
   (Page 2-505)
2. MULTIMETER

REASON FOR QUESTION
If the glow plug controller is shorted, the glow plug power relay in the PCB will always be closed.

KNOWN INFO
GLOW PLUG CURRENT OK
NOT CYCLING PROPERLY

POSSIBLE PROBLEMS
PCB

TEST OPTIONS

1. STE/ICE-R TEST 89
   (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If there is a short in the harness, this wire will have battery voltage.

B2

MEASURE VOLTAGE AT SOCKET 6 OF GLOW PLUG CONTROLLER CONNECTOR HARNESS. IS THERE BATTERY VOLTAGE AT THIS SOCKET?

KNOWN INFO
GLOW PLUG CURRENT OK
GLOW PLUGS NOT CYCLING
GLOW PLUGS DRAW CURRENT WITH CONTROLLER DISCONNECTED

POSSIBLE PROBLEMS
WIRING SHORT PCB (GLOW PLUG POWER RELAY)

TEST OPTIONS

1. STE/ICE-R TEST 89
   (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If there is a short in the harness, this wire will have battery voltage.

NO

REPLACE PCB.

YES

NO

B3

SHORT IN ENGINE CONNECTOR HARNESS. REPAIR OR REPLACE HARNESS.

FROM 4, Page 2-292 or A2, Page 2-294

GO TO E, Page 2-302

TURN ROTARY SWITCH TO STOP. DISCONNECT GLOW PLUG CONTROLLER. TURN ROTARY SWITCH TO RUN. DO GLOW PLUGS STILL DRAW CURRENT?
Refer to the functional flow schematic. If the glow plug controller is shorted (continuity from pin 6 to pin 3), the glow plug power relay will always be energized and the glow plugs will always be drawing current.

**BATTERY CURRENT STE/ICE-R TEST 80**

1. Start Test 80, Battery Current.
2. Displayed reading is in amps. The reading will be greater than 30 amps, depending on how many accessories you have on.

Since the glow plugs draw current without the glow plug controller connected, there must be a short in the harness or a stuck relay in the PCB. If there were a short in the harness directly to the glow plugs, the glow plugs would have burned out long ago and you wouldn't be here. The only other short in the harness that would make the glow plugs turn on without the glow plug controller installed would show up as battery voltage at pin 6 of the controller's connector.

Replace PCB (para. 4-4).

Check the end of the harness at the PCB, glow plugs, etc., for shorts. Repair whatever you can. If you don't see anything wrong, the short must be in the main body of the harness, which means that you have to replace the harness.

**WARNING**

Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

**WARNING**

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Repair or replace wiring (para. 4-80).
GLOW PLUGS CIRCUIT

DIAGNOSTIC FLOWCHART

**C FROM A1, Page 2-294**

**C1**

**KNOWN INFO**
GLOW PLUGS DON'T DRAW ANY CURRENT

**POSSIBLE PROBLEMS**
GLOW PLUG CONTROLLER WIRING (OPEN CIRCUIT)
8 BAD GLOW PLUGS PCB

**TEST OPTIONS**
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

**REASON FOR QUESTION**
There should not be voltage at glow plugs with switch off.

**C2**

**KNOWN INFO**
NO SHORTS GLOW PLUGS DRAW ZERO AMPS

**POSSIBLE PROBLEMS**
GLOW PLUG CONTROLLER BAD GLOW PLUGS PCB

**TEST OPTIONS**
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

**REASON FOR QUESTION**
To see if power is getting to glow plugs.

**C3**

**KNOWN INFO**
NO SHORTS GLOW PLUGS DRAW NO CURRENT NO VOLTAGE AT GLOW PLUGS

**POSSIBLE PROBLEMS**
OPEN IN PCB OPEN IN GLOW PLUG CONTROLLER OPEN IN WIRING

**TEST OPTIONS**
1. STE/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

**REASON FOR QUESTION**
Continuity indicates the harness and controller are ok. Noncontinuity indicates an open in the harness or controller.
REFERENCE INFORMATION

Replace harness. Notify DS maintenance (chapter 18).

Replace glow plugs (para. 3-39).

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

**WARNING**
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Replace PCB (para. 4-4).

---

**DC VOLTAGE 0-45 VOLTS**  
STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

**VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

**RESISTANCE AND CONTINUITY 0-4,500 OHMS**  
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
GLOW PLUGS CIRCUIT

KNOWN INFO
OPEN CIRCUIT IN GLOW PLUG CONTROLLER OR WIRING

POSSIBLE PROBLEMS
WIRING GLOW PLUG CONTROLLER

DIAGNOSTIC FLOWCHART

D
FROM C3,

Page 2-298; 17, Page 2-224;
24, Page 2-228; 26, Page 2-230

TEST OPTIONS
1. STE/ICE-R TEST 91
   (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
This checks the return wire from the glow plug controller to the Protective Control Box.

IS THERE CONTINUITY BETWEEN PCB ENGINE CONNECTOR HARNESS SOCKET B AND GLOW PLUG CONTROLLER HARNESS CONNECTOR SOCKET 3?

NO
REPAIR/REPLACE WIRE 459B.

YES

NO

D2
IS THERE CONTINUITY BETWEEN PCB ENGINE CONNECTOR HARNESS SOCKET A AND GLOW PLUG CONTROLLER HARNESS CONNECTOR SOCKET 6?

NO
REPLACE WIRE 543 AND/OR 569B.

YES

D3
REPLACE GLOW PLUG CONTROLLER. DOES THE ENGINE START EASILY WHEN COLD?

NO
GO TO C, Page 2-114

YES

NO FAULTS.
REFERENCE INFORMATION

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

**WARNING**
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Repair/replace wiring (para. 4-80).

*ENGINE CONNECTOR HARNESS WITH SOCKETS A AND B HIGHLIGHTED*

- Resistance and Continuity
  - 0-4,500 Ohms
  - STE/ICE-R Test 91
  1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.
  2. Start Test 91. 0-4,500 Ohms.
  3. Displayed reading is in ohms. Less than 5 ohms indicates continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays 9.9.9.9.

- Continuity (Resistance) Multimeter
  1. Set the voltmeter to an ohms scale of about 1,000 ohms.
  2. Connect the RED and BLACK leads to the connections stated in the question.
  3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

*GLOW PLUG CONTROLLER HARNESS WITH SOCKETS 3 AND 6 HIGHLIGHTED*

- Resistance and Continuity
  - 0-4,500 Ohms
  - STE/ICE-R Test 91
  1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.
  2. Start Test 91. 0-4,500 Ohms.
  3. Displayed reading is in ohms. Less than 5 ohms indicates continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays 9.9.9.9.

GLOW PLUG CONTROLLER

- Resistance and Continuity
  - 0-4,500 Ohms
  - STE/ICE-R Test 91
  1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.
  2. Start Test 91. 0-4,500 Ohms.
  3. Displayed reading is in ohms. Less than 5 ohms indicates continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays 9.9.9.9.

- Continuity (Resistance) Multimeter
  1. Set the voltmeter to an ohms scale of about 1,000 ohms.
  2. Connect the RED and BLACK leads to the connections stated in the question.
  3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

GLOW PLUG CONTROLLER
GLOW PLUGS CIRCUIT

DIAGNOSTIC FLOWCHART

TEST OPTIONS

1. STE/ICE-R TEST 91
   (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
Wire 570A controls glow plug cycling.

E1

DISCONNECT BATTERY NEGATIVE CABLE. DISCONNECT PCB ENGINE CONNECTOR. IS THERE CONTINUITY FROM ENGINE CONNECTOR HARNESS SOCKET C TO GLOW PLUG CONTROLLER HARNESS SOCKET 4?

NO

REPAIR WIRE 570A OR REPLACE HARNESS.

YES

E2

RECONNECT PCB ENGINE CONNECTOR. IS THERE CONTINUITY FROM GLOW PLUG CONTROLLER HARNESS SOCKET 5 TO ENGINE GROUND?

NO

REPAIR WIRE 93A OR REPLACE HARNESS.

YES

REPLACE CONTROLLER.

1. STE/ICE-R TEST 91
   (Page 2-508)
2. MULTIMETER

REASON FOR QUESTIONS
The controller can’t work properly without a proper ground.

KNOWN INFO

GLOW PLUG CURRENT OK
PCB OK
GLOW PLUGS NOT CYCLING

POSSIBLE PROBLEMS

WIRING
GLOW PLUG CONTROLLER

KNOWN INFO

GLOW PLUG CURRENT OK
PCB OK
GLOW PLUGS NOT CYCLING

POSSIBLE PROBLEMS

WIRING
GLOW PLUG CONTROLLER
WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Replace wiring or replace harness (para. 4-80).

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays -9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
These instrument tests can be run any time you think there is a problem with the instruments or if you were sent here from another test.

If you get an unusual gauge reading, it is a good idea to check out the system that the gauge monitors to be sure that it is a gauge problem and not a real problem in the engine or electrical system.

Refer to fold-out page FP-19 and leave fold-out open for reference during testing. Diagrams of the individual gauge circuits will be found on the page that deals with that circuit.
INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

1

WITH THE ROTARY SWITCH IN THE ENGINE STOP POSITION, ARE ALL THE GAUGES IN THE OFF POSITION AND WARNING LAMPS OFF?

TEST OPTIONS

VISUAL

REASON FOR QUESTION
If any of the gauges or lamps are functioning, then the electrical system is partially powered in the OFF position.

POSSIBLE PROBLEMS
MASTER POWER INSTRUMENTS WIRING SENDING UNITS

KNOWLEDGE INFO
ONE OR MORE GAUGES AND WARNING LAMPS DON'T WORK

KNOWLEDGE INFO
NO POWER TO THE GAUGES WITH THE ROTARY SWITCH IN THE OFF POSITION

KNOWLEDGE INFO
POWER AVAILABLE TO GAUGES AND WARNING LAMPS

2

TURN THE ROTARY SWITCH OFF. DISCONNECT THE GLOW PLUG CONTROLLER. WITH THE ROTARY SWITCH IN THE RUN POSITION, DO ANY OF THE GAUGES AND WARNING LAMPS FUNCTION?

TEST OPTIONS

VISUAL

REASON FOR QUESTION
If any of the devices work, the master power circuit works.

POSSIBLE PROBLEMS
MASTER POWER INSTRUMENTS WIRING SENDING UNITS

3

TURN THE ROTARY SWITCH OFF. RECONNECT THE GLOW PLUG CONTROLLER. TURN THE ROTARY SWITCH ON. DOES THE WAIT-TO-START LAMP COME ON AT ANY TIME? (ENGINE TEMPERATURE MUST BE BELOW 120 °F (49°C)).

TEST OPTIONS

VISUAL

REASON FOR QUESTION
If the wait-to-start light comes on at any time, the circuit is being powered.

POSSIBLE PROBLEMS
INSTRUMENTS WIRING SENDING UNITS

GO TO 4, Page 2-308

GO TO A, Page 2-314

GO TO B, Page 2-316

GO TO C, Page 2-318
None of the following instruments and accessories should work when the rotary switch is in the STOP position:

- Voltmeter
- Wait-to-start lamp
- Temperature gauge
- Oil pressure gauge
- Fuel gauge
- Windshield wiper/washer
- Brake warning lamp

If any of the instruments and accessories work when the rotary switch is in the RUN position, power is available and the circuit breaker is OK.

The wait-to-start lamp is not an accurate indication of glow plug operation. Make sure the glow plugs are operating properly BEFORE you check out the light. Go to the glow plugs circuit test, page 2-310. Return here if the light still doesn’t operate properly.

The wait-to-start lamp should come on when the engine is below 120°F (49°C) and the rotary switch is first turned to the RUN position.
**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**

1. **WAIT-TO-START LAMP OK**

**POSSIBLE PROBLEMS**

- INSTRUMENTS
- WIRING
- SENDING UNITS

**TEST OPTIONS**

1. **VISUAL**

**REASON FOR QUESTION**

If the brake warning lamp comes on at any time, then the circuit is being powered.

**KNOWN INFO**

2. **VISUAL BRAKE LAMP OK**

**TEST OPTIONS**

1. **VISUAL**

**REASON FOR QUESTION**

If the voltmeter works then the power to the instruments is OK.

**POSSIBLE PROBLEMS**

- INSTRUMENTS
- WIRING
- SENDING UNITS

**TEST OPTIONS**

1. **VISUAL**

**REASON FOR QUESTION**

If the windshield wiper works, then the power to the wiper is OK.

**POSSIBLE PROBLEMS**

- INSTRUMENTS
- WIRING
- SENDING UNITS

**GO TO 7, Page 2-310**

**GO TO F, Page 2-334**

**GO TO E, Page 2-332**

**TURN ROTARY SWITCH TO OFF POSITION. DISCONNECT THE GLOW PLUG CONTROLLER. WITH THE ROTARY SWITCH IN THE RUN POSITION, DOES THE WINDSHIELD WIPER WORK? TURN ROTARY SWITCH TO OFF POSITION. RECONNECT THE GLOW PLUG CONTROLLER.**
The brake warning lamp should come on when the engine is cranking, the parking brake is set, or there is a failure in the brake system. If brake warning lamp stays on, go to page 2-323. If the warning lamp does not come on, go to page 2-324.

The voltmeter may be checked by running STE/ICE-R Test 67 with the engine running. The position in the center of the green area of the volt gauge marked GEN is approximately 28 volts.

The voltmeter is a galvanometer-type gauge. It is conceivable that the coil in the gauge may have a broken wire that only opens when the gauge is heated up. If you are having an intermittent gauge problem, leave the vehicle running for a while and watch the gauge.

If the charging system is ok, but the gauge is reading full scale one way or the other, you may have this type of problem.

Rotary switch has to be in the RUN position for the windshield wiper or washer to operate.
7. WITH THE IGNITION SWITCH IN THE RUN POSITION, DOES THE FUEL GAUGE WORK PROPERLY?

   - KNOWN INFO
     - WINDSHIELD WIPERS OK
   - POSSIBLE PROBLEMS
     - FUEL GAUGE
     - OIL PRESSURE GAUGE
     - TEMPERATURE GAUGE
     - WIRING
     - SENDING UNITS

   - TEST OPTIONS
     - VISUAL

   - REASON FOR QUESTION
     - If the fuel gauge works, the power to the gauge is OK.

   - RESPONSE OPTIONS
     - NO
       - GO TO G, Page 2-338
     - YES
       - GO TO I, Page 2-346

8. DOES THE ENGINE OIL PRESSURE GAUGE WORK WITH THE ENGINE RUNNING?

   - KNOWN INFO
     - FUEL GAUGE OK
   - POSSIBLE PROBLEMS
     - FUEL GAUGE
     - OIL PRESSURE GAUGE
     - TEMPERATURE GAUGE
     - WIRING
     - SENDING UNITS

   - TEST OPTIONS
     - VISUAL

   - REASON FOR QUESTION
     - If the oil pressure gauge works, then the power to the gauge is OK.

   - RESPONSE OPTIONS
     - NO
       - GO TO H, Page 2-342
     - YES
       - GO TO I, Page 2-346

9. DOES THE ENGINE TEMPERATURE GAUGE WORK WITH THE ENGINE WARM?

   - KNOWN INFO
     - OIL PRESSURE GAUGE OK
   - POSSIBLE PROBLEMS
     - TEMPERATURE GAUGE
     - WIRING
     - SENDING UNITS

   - TEST OPTIONS
     - VISUAL

   - REASON FOR QUESTION
     - If the temperature gauge works, the power to the gauge is OK.

   - RESPONSE OPTIONS
     - NO
       - GO TO I, Page 2-346
     - YES
       - GO TO I, Page 2-346

GO TO 10, Page 2-312
These gauges are galvanometer-type gauges. It is conceivable that the coil in the gauge may have a broken wire that only opens when the gauge is warmed up. If you are having an intermittent gauge problem, leave the vehicle running for a while and watch the gauge. If the system the gauge monitors is OK, but the gauge is reading full scale one way or the other, then you may have this type of problem.

Fill the fuel tank, if necessary, to obtain a reading greater than empty.

With the engine running, the oil pressure should be approximately 10 psi (69 kPa) at idle, 40-45 psi (276-310 kPa) at 2,000 rpm, and it should be 0 when stopped.

Make sure shift lever is in neutral before running this test.

With the engine cold, the gauge should read off scale to the left and, when warm, the reading should be 185°-250°F (85°-120°C).
INSTRUMENTS CIRCUIT

DOES THE AIR FILTER RESTRICTION GAUGE WORK?

WITH THE ROTARY SWITCH IN THE RUN POSITION, DOES THE HEATER FAN WORK?

NO FAULTS FOUND IN INSTRUMENTS CIRCUIT.
When vacuum is applied to the line at the air filter, the gauge should read yellow and hold the reading until it is released by pressing the reset button on the gauge.
INSTRUMENTS CIRCUIT

TEST OPTIONS

A1

DISCONNECT WIRE 29B FROM CIRCUIT BREAKER 2. WITH THE ROTARY SWITCH IN THE OFF POSITION, DO YOU HAVE 0 VOLTAGE AT WIRE 29D?

NO

GO TO J, Page 2-350

YES

KNOWN INFO

SOME GAUGES AND LAMPS HAVE POWER WHEN THEY SHOULDN'T

POSSIBLE PROBLEMS

ROTARY SWITCH WIRING

TEST OPTIONS

1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
Voltage here indicates a short circuit to power.

A2

DISCONNECT WIRE 29D FROM CIRCUIT BREAKER 2. WITH THE ROTARY SWITCH IN THE OFF POSITION, DO YOU HAVE 0 VOLTAGE AT WIRE 29D?

REPAIR SHORT 29D OR 27F,G,H,L,K or 567A OR REPLACE HARNESS.

NO

YES

KNOWN INFO

ROTARY SWITCH OK

POSSIBLE PROBLEMS

WIRING

TEST OPTIONS

1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
Voltage here indicates a short circuit to power.

A3

CHECK CONTINUITY FROM ALL GAUGE GROUND TERMINALS TO ENGINE GROUND (WIRES 58E-H). DO YOU HAVE CONTINUITY?

REPAIR 58E-H OR REPLACE HARNESS.

NO

YES

KNOWN INFO

NO SHORTS TO POWER

POSSIBLE PROBLEMS

WIRING

TEST OPTIONS

1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
A good ground circuit is necessary for proper gauge operation.

SEE NOTE AT RIGHT.
The easiest way to reach the circuit breaker and gauge wiring is to remove the gauge panel screws and pull the panel out far enough to work with the wiring.

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

Battery Voltage Multimeter
1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

Resistance and Continuity 0-4,500 Ohms
1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

Continuity (Resistance) Multimeter
1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

You have checked all the wiring that is common to all the gauges and warning lamps. Reconnect wires and return to step 2, page 2-306, and continue testing.
INSTRUMENTS CIRCUIT

KNOWN INFO
ENGINE STARTS AND RUNS SO THERE IS POWER TO THE ROTARY SWITCH

POSSIBLE PROBLEMS
CIRCUIT BREAKER 2 GAUGES LAMPS SENDING UNITS WIRING

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
Voltage here indicates that the wiring to the circuit breaker is OK.

B1
DISCONNECT WIRE 29B FROM CIRCUIT BREAKER 2. WITH ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 29B?

NO
REPAIR 29B OR REPLACE HARNESS.

YES

B2
RECONNECT WIRE 29B. DISCONNECT WIRE 29D FROM CIRCUIT BREAKER 2. WITH ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT CIRCUIT BREAKER 2?

NO
REPLACE CIRCUIT BREAKER 2.

YES

B3
RECONNECT WIRE 29D AT CIRCUIT BREAKER 2. WITH ROTARY SWITCH IN THE RUN POSITION. CHECK FOR BATTERY VOLTAGE AT THE GAUGE WIRES 27G, 27H, 27J, AND 567A. DO YOU HAVE BATTERY VOLTAGE AT ANY OF THESE Wires?

NO
REPAIR 29D OR 27P OR REPLACE HARNESS.

YES
SEE NOTE AT RIGHT.

DIAGNOSTIC FLOWCHART
The easiest way to reach the circuit breaker and gauge wiring is to remove the gauge panel screws and pull the panel out far enough to work with the wiring.

Replace harness or repair wiring (para. 4-80).

Replace circuit breaker (para. 4-12).

You have checked all the common power wiring to all the gauges and warning lamps. Reconnect wires and return to step 3, (page 2-308) and continue testing.

<table>
<thead>
<tr>
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</tr>
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</tr>
<tr>
<td>3. Be sure to read the correct scale.</td>
</tr>
</tbody>
</table>
INSTRUMENTS CIRCUIT

C1

DISCONNECT WIRE 27F AT THE WAIT-TO-START LAMP. WITH THE ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27F?

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
You know power is available at the wire junction. Now you need to know if it is reaching the gauge.

POSSIBLE PROBLEMS
WAIT-TO-START LAMP PCB GLOW PLUG CONTROLLER WIRING

C2

DISCONNECT PCB ENGINE CONNECTOR, BODY CONNECTOR & WIRE 571A AT THE WAIT-TO-START LAMP. DO YOU HAVE CONTINUITY BETWEEN WIRE 571A & SOCKET E ON THE BODY CONNECTOR HARNESS?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
The ground circuit for the lamp goes through this wire and the PCB.

POSSIBLE PROBLEMS
WAIT-TO-START LAMP PCB GLOW PLUG CONTROLLER WIRING

C3

CONNECT RED LEAD OF STE/ICE-R OR MULTIMETER TO LEAD WIRE 27 OF THE WAIT-TO-START LAMP AND CONNECT THE BLACK LEAD TO WIRE 571 LEAD OF THE LAMP. DOES THE LAMP GLOW DIMLY?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-506)
2. MULTIMETER (RESISTANCE)

REASON FOR QUESTION
You need to make sure the lamp can light.

POSSIBLE PROBLEMS
WAIT-TO-START LAMP PCB GLOW PLUG CONTROLLER WIRING

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-506)
2. MULTIMETER (RESISTANCE)

REASON FOR QUESTION
You need to make sure the lamp can light.
REFERENCE INFORMATION

INSTRUMENTS CIRCUIT

BATTERY VOLTAGE MULTIMETER
1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

RESISTANCE AND CONTINUITY 0-4,500 OHMS STE/ICE-R TEST 91
1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Repair harness (para. 4-80).

It is important to connect the leads as indicated because you are checking continuity across a diode. The lamp will glow dimly because you are supplying a small amount of power through STE/ICE-R. You may have to shade the lamp with your hand to see if it glows.

A multimeter may not supply enough power to light the lamp. In this case, look for a much greater resistance when measuring with the leads connected in one direction than when they are connected in reverse.

Replace lamp (para. 4-20).

DC VOLTAGE 0-45 VOLTS STE/ICE-R TEST 89
1. Connect RED clip to the indicated test point. BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

CONTINUITY (RESISTANCE) MULTIMETER
1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

FROM C3, Page 2-318

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

DISCONNECT GLOW PLUG CONTROLLER. DO YOU HAVE CONTINUITY BETWEEN SOCKET 6 IN THE CONTROLLER HARNESS & SOCKET A IN THE ENGINE CONNECTOR HARNESS?

REPAIR 569A, 569 OR REPLACE HARNESS.

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

DO YOU HAVE CONTINUITY BETWEEN SOCKET 3 IN THE CONTROLLER HARNESS & SOCKET B IN THE ENGINE CONNECTOR HARNESS?

REPAIR 459B OR REPLACE HARNESS.

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

RECONNECT GLOW PLUG CONTROLLER. DO YOU HAVE CONTINUITY BETWEEN SOCKET A & SOCKET B IN THE ENGINE CONNECTOR HARNESS?

REPLACE GLOW PLUG CONTROLLER.

REASON FOR QUESTION
This wire provides power to the controller.

This wire returns power for the lamp.

If you don't have continuity here, you know that the controller is bad.

GO TO C7, Page 2-322
REFERENCE INFORMATION

WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

Repair/replace harness (para. 4-80).

Engine temperature must be below 120°F (49°C) in order to make this test. Otherwise, normal operation of the glow plug controller will cause the circuit to be open.

Replace glow plug controller (para. 4-33).

INSTRUMENTS CIRCUIT

GLOW PLUG CONTROLLER HARNESS

PCB ENGINE CONNECTOR

NO STEP
INSTRUMENTS CIRCUIT

KNOWN INFO
- GLOW PLUG CONTROLLER OK

POSSIBLE PROBLEMS
- PCB

TEST OPTIONS
- RECONNECT ALL WIRING (RECONNECT ENGINE CONNECTOR LAST) AND RECHECK WAIT-TO-START LAMP OPERATION. WITH THE ROTARY SWITCH IN THE RUN POSITION, DOES THE WAIT-TO-START LAMP COME ON?

CONNECT THE WIRES.

REASON FOR QUESTION
You may have fixed a loose or dirty connection without knowing it.

YES
- REPLACE PCB.

NO
- NO FAULTS.

FROM C6, Page 2-320

C7

NO FAULTS.
REFERENCE INFORMATION

WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

WARNING
There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

Engine temperature must be below 120°F (49°C) or the lamp may not come on.

Replace PCB (para. 4-4).
DISCONNECT WIRE 27L AT THE BRAKE WARNING LAMP. WITH THE ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27L?

REPAIR 27L OR REPLACE HARNESS.

DISCONNECT WIRE 67D AT BRAKE LAMP. CONNECT RED LEAD OF STE/ICE-R OR MULTIMETER TO WIRE 67. CONNECT THE BLACK LEAD TO WIRE 27.

DOES THE LAMP GLOW DIMLY?

REPLACE BRAKE WARNING LAMP.

DISCONNECT WIRE 67C AT PARKING BRAKE SWITCH.

DO YOU HAVE CONTINUITY BETWEEN WIRE 67C AT THE SWITCH & WIRE 67D AT THE LAMP?

REPAIR 67C,D, OR REPLACE HARNESS.

GO TO D4, Page 2-326
It is important to connect the leads as indicated because you are checking continuity across a diode. The lamp will glow dimly because you are supplying a small amount of power through STE/ICE-R. You may have to shade the lamp with your hand to see if it glows.

A multimeter may not supply enough power to light the lamp. In this case, look for a much greater resistance when measuring with the leads connected in one direction than when they are connected in reverse.

Replace harness or repair wiring (para: 4-80).

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89
1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

BATTERY VOLTAGE
MULTIMETER
1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91
1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER
1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left)
INSTRUMENTS CIRCUIT

D4

DISCONNECT WIRE 67E AT THE PARK BRAKE SWITCH. WITH THE PARK BRAKE APPLIED, DO YOU HAVE CONTINUITY ACROSS THE SWITCH LEADS?

TEST OPTIONS
1. STE/ICE-R TEST 91
   [Page 2-508]
2. MULTIMETER

REASON FOR QUESTION
This wire provides power for the lamp.

D5

DO YOU HAVE CONTINUITY FROM WIRE 67E TO BODY (OR ENGINE) GROUND?

TEST OPTIONS
1. STE/ICE-R TEST 91
   [Page 2-508]
2. MULTIMETER

REASON FOR QUESTION
You need to know that the lamp will light.

NO

REPLACE PARKING BRAKE SWITCH.

YES

REPAIR 67E, 79A OR REPLACE HARNESS.

NO FAULTS.
1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.

Replace parking brake switch (para. 4-23).

Replace harness or repair wiring (para. 4-80).

Reconnect all wiring. Connect glow plug controller last.
INSTRUMENTS CIRCUIT

TEST OPTIONS

1. BLEED BRAKE SYSTEM. DOES THE LIGHT STAY ON?

POSSIBLE PROBLEMS
- PROPORTIONING VALVE
- PARKING BRAKE SWITCH BOX
- BRAKE WARNING PRESSURE SWITCH

REASON FOR QUESTION
If the lamp stays on, it could be that the hydraulic brake system has a fault and might require bleeding.

TEST OPTIONS

2. CHECK PROPORTIONING VALVE FOR PROPER OPERATION. (GO TO B-7 PAGE 2-428). IS PROPORTIONING VALVE OPERATING PROPERLY?

POSSIBLE PROBLEMS
- PROPORTIONING VALVE
- PARKING BRAKE SWITCH BOX
- BRAKE WARNING PRESSURE SWITCH

REASON FOR QUESTION
If the lamp stays on after bleeding the brake system, the proportioning valve could be malfunctioning.

TEST OPTIONS

3. DISCONNECT WIRE 67A AND 67B FROM BRAKE WARNING PRESSURE SWITCH, AND WIRE 67C FROM PARKING BRAKE SWITCH. DISCONNECT THE PCB BODY HARNESS CONNECTOR. CONNECT A JUMPER WIRE BETWEEN WIRES 67A AND 67B. DOES THE LIGHT GO OUT?

POSSIBLE PROBLEMS
- WIRING
- PARKING BRAKE SWITCH BOX
- BRAKE WARNING PRESSURE SWITCH

REASON FOR QUESTION
If the lamp stays on with the PCB, valve switch, and park brake switch disconnected, the problem is in the wiring.

TEST OPTIONS

GO TO 4
Page 2-330
REFERENCE INFORMATION

- Bleed brake system (para. 7-2).
- Replace proportioning valve (para. 7-10).
- Replace harness or repair wiring (para. 4-60).
INSTRUMENTS CIRCUIT

FROM 3, Page 2-328

DIAGNOSTIC FLOWCHART

4

CONNECT PCB BODY HARNESS. DOES THE LIGHT STAY OFF?

TEST OPTIONS

VISUAL

YES

REPLACE PCB.

NO

REPLACE PCB BODY HARNESS.

5

CONNECT PARKING BRAKE SWITCH. MAKE SURE THE PARKING BRAKE IS DISENGAGED. DOES THE LIGHT STAY OFF?

TEST OPTIONS

VISUAL

YES

REPLACE PARKING BRAKE SWITCH.

NO

REPLACE PCB BODY HARNESS.

6

REMOVE JUMPER WIRE. CONNECT BRAKE WARNING PRESSURE SWITCH. DOES LIGHT STAY OFF?

TEST OPTIONS

VISUAL

YES

REPLACE PROPORIONING VALVE.

NO

REPLACE PCB BODY HARNESS.

END OF TEST.

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2-330
Replace PCB (para. 4-4).

Replace parking brake switch (para. 4-23).

When the brake warning pressure switch is defective, the proportioning valve must be replaced (para. 7-11).
Known Info

Power Available to Gauges
Voltmeter Doesn't Work

Possible Problems
Voltmeter Wiring

Test Options

1. STE/ICE-R Test 90
   (Page 2-508)
2. Multimeter

Reason for Question
The voltmeter reads voltage on this wire.

E1

Disconnect Wire 567A at the voltmeter. With the rotary switch in the run position, do you have battery voltage at wire 567A?

No
Repair 567A or replace harness.

Yes

E2

Is there continuity between wire 58F and engine (or body) ground?

No
Repair 58F, D, B, A or replace harness.

Yes

Replace voltmeter. Rerun instrument tests to verify no other faults.
REFERENCE INFORMATION

Replace harness or repair wiring (para. 4-80).

Be sure the charging system is functioning properly before replacing the voltmeter. Run the alternator tests, page 2-199, if you're not sure. Replace voltmeter (para. 4-16).

INSTRUMENTS CIRCUIT

**DC VOLTAGE 0-45 VOLTS STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

**BATTERY VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

**RESISTANCE AND CONTINUITY 0-4,500 OHMS STE/ICE-R TEST 91**

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUITS

F1

DISCONNECT WIRE 27 AT WIPER MOTOR CONNECTOR. WITH ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT THE MOTOR CONNECTOR?

NO

GO TO M, Page 2-356

YES

F2

DO YOU HAVE CONTINUITY FROM WIRE 57 AT THE CONNECTOR-TO-BODY (OR ENGINE) GROUND?

NO

GO TO N, Page 2-358

YES

REPLACE WIPER MOTOR OR GO TO F3.

TEST OPTIONS

1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
This wire provides power to the wipers.

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
This wire provides ground for the wipers.
REFERENCE INFORMATION

INSTRUMENTS CIRCUIT

Replace wiper motor (para. 10-53).

<table>
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<td>3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).</td>
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INSTRUMENTS CIRCUIT

F3

DISCONNECT SWITCH WIRING FROM MOTOR ASSEMBLY. WITH SWITCH IN THE OFF POSITION, DO YOU HAVE CONTINUITY FROM INPUT CONNECTOR (BATTERY) AND SOCKET 4? YOU SHOULD ALSO HAVE CONTINUITY BETWEEN PIN 2 AND SOCKET 3.

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
This will determine if switch is defective.

YES

NO

REPLACE WIPER SWITCH.

F4

WITH SWITCH IN THE LOW SPEED POSITION, DO YOU HAVE CONTINUITY FROM INPUT CONNECTOR (BATTERY) TO PIN 2? WITH THE SWITCH IN THE HIGH SPEED POSITION, CONTINUITY SHOULD EXIST BETWEEN INPUT CONNECTOR (BATTERY) AND PIN 1.

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
This will determine if switch is defective.

YES

NO

REPLACE WIPER SWITCH.

F5

WITH SWITCH DEPRESSED FOR THE PUSH-TO-WASH OPERATION, CONTINUITY SHOULD EXIST BETWEEN THE INPUT CONNECTOR (BATTERY) AND WASH TERMINAL.

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
This will determine if switch is defective.

YES

NO

REPLACE WIPER SWITCH.

REPLACE WIPER MOTOR.
1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

G1
DISCONNECT WIRE 27J FROM FUEL GAUGE. WITH THE ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27J?

TEST OPTIONS
1. STE/ICE-R TESTS 89 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
This wire provides power for the gauge.

POSSIBLE PROBLEMS
GAUGE WIRING
SENDING UNIT

G2
IS THERE CONTINUITY BETWEEN WIRE 58H AT THE FUEL GAUGE AND GROUND?

TEST OPTIONS
1. STE/ICE-R TESTS 91 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
If there is continuity, then the ground is OK

POSSIBLE PROBLEMS
GAUGE WIRING
SENDING UNIT

G3
RECONNECT WIRE 27J & DISCONNECT WIRE 28A AT THE GAUGE. IS THE RESISTANCE BETWEEN WIRE 28A AT FUEL GAUGE AND CHASSIS GROUND WITHIN 0 TO 35 OHMS?

TEST OPTIONS
1. STE/ICE-R TESTS 91 (Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
If the resistance is OK, the sense line is OK

POSSIBLE PROBLEMS
GAUGE WIRING
SENDING UNIT

G4

GO TO G4, Page 2-340

GO TO 1, Page 2-352

REPAIR 27J OR REPLACE HARNESS.

REPAIR 58H OR REPLACE HARNESS.

KNOWN INFO
FUEL GAUGE DOESN'T WORK

KNOWN INFO
POWER AVAILABLE TO THE GAUGE

KNOWN INFO
GAUGE GROUND OK
Replace harness or repair wiring (para. 4-80).

**DC VOLTAGE 0-45 VOLTS**

STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

**BATTERY VOLTAGE**

**MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

**RESISTANCE AND CONTINUITY 0-4,500 OHMS**

STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

**CONTINUITY (RESISTANCE)**

**MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUIT

G4

WITH THE ROTARY SWITCH IN THE RUN POSITION, SHORT THE SOCKET FOR WIRE 28A TO GROUND. DOES THE FUEL GAUGE READ AT OR BELOW EMPTY?

G5

WITH THE ROTARY SWITCH IN THE ON POSITION AND WIRE 28A OPEN, DOES THE FUEL GAUGE READ OFF SCALE TO ABOVE FULL?

NO

REPLACE FUEL GAUGE.

YES

REPLACE FUEL GAUGE.

NO FAULTS.
Replace fuel gauge (para. 4-16).
INSTRUMENTS CIRCUIT

H1
DISCONNECT WIRE 27H AT THE OIL PRESSURE GAUGE. WITH THE ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27H?

TEST OPTIONS

1. STE/ICE-R TEST 89
   [Page 2-503]
2. MULTIMETER

REASON FOR QUESTION
1. This is the power wire for the gauge.

H2
WITH THE ROTARY SWITCH IN THE OFF POSITION, DO YOU HAVE CONTINUITY BETWEEN WIRE 58G AT THE GAUGE AND ENGINE (OR BODY) GROUND?

TEST OPTIONS

1. STE/ICE-R TEST 91
   [Page 2-509]
2. MULTIMETER

REASON FOR QUESTION
1. This is the ground wire for the gauge.

H3
DISCONNECT WIRE 36A AT THE GAUGE AND AT THE OIL PRESSURE SENDING UNIT. DO YOU HAVE CONTINUITY THROUGH WIRE 36A? RECONNECT WIRE 36A AFTER MAKING THE MEASUREMENT.

TEST OPTIONS

1. STE/ICE-R TEST 91
   [Page 2-509]
2. MULTIMETER

REASON FOR QUESTION
1. If this wire is open, the gauge will always read offscale to the left.

KNOWN INFO

POWER AVAILABLE TO THE GAUGES
OIL PRESSURE GAUGE DOESN'T WORK

POSSIBLE PROBLEMS

GAUGE SENDING UNIT WIRING

KNOWN INFO

OIL PRESSURE GAUGE HAS POWER

POSSIBLE PROBLEMS

GAUGE SENDING UNIT WIRING

KNOWN INFO

GAUGE GROUND OK

POSSIBLE PROBLEMS

OIL PRESSURE GAUGE SENDING UNIT WIRING

REPAIR 27H OR REPLACE HARNESS.

REPAIR 58G OR REPLACE HARNESS.

REPAIR 36A OR REPLACE HARNESS.

GO TO H4, Page 2-344
REFERENCE INFORMATION

Replace harness or repair wiring (para. 4-80).

INSTRUMENTS CIRCUIT

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 99

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 99, DC Volts.
3. Displayed reading is in volts.

BATTERY VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

RESISTANCE AND CONTINUITY 0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms indicates continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays 9.9.9.

Replace harness or repair wiring (para. 4-80).
INSTRUMENTS CIRCUIT

KNOWN INFO
WIRING OK
POSSIBLE PROBLEMS
GAUGE SENDING UNIT

POSSIBLE PROBLEMS
GAUGE SENDING UNIT

TEST OPTIONS
TRY IT.

REASON FOR QUESTION
This will determine if the gauge can respond to an input signal.

H4

RECONNECT WIRE 27H AT THE OIL PRESSURE GAUGE. DISCONNECT WIRE 36A AT THE OIL PRESSURE SENDING UNIT. WITH THE ROTARY SWITCH IN THE RUN POSITION, DOES THE GAUGE READ OFF SCALE ABOVE 120 PSI (827 kPa)?

YES

REPLACE OIL PRESSURE GAUGE.

NO

H5

WITH THE ROTARY SWITCH IN THE RUN POSITION, SHORT WIRE 36A TO ENGINE GROUND AT THE OIL PRESSURE SENDING UNIT. DOES THE GAUGE READ AT OR BELOW ZERO?

YES

REPLACE OIL PRESSURE GAUGE.

NO

REPLACE OIL PRESSURE SENDING UNIT.
Make sure wire 36A is not connected to the sending unit and is not touching anything metal that could cause the wire to be grounded.
Replace oil pressure gauge (para. 4-16).

Wire 36A must be connected at the gauge. Short the wire at the sending unit to ground.
Replace oil pressure gauge (para. 4-16).
Replace oil pressure sending unit (para. 4-29).
### INSTRUMENTS CIRCUIT

**KNOWN INFO**
- Power available to the gauges temperature gauge doesn't work

**POSSIBLE PROBLEMS**
- Gauge sending unit wiring

### DIAGNOSTIC FLOWCHART

**TEST OPTIONS**
1. STE/ICE-R TEST 90  
   (Page 2-506)
2. MULTIMETER

**REASON FOR QUESTION**
This is the power wire for the gauge.

**DISCONNECT WIRE 27G AT THE TEMPERATURE GAUGE. WITH THE ROTARY SWITCH IN THE RUN POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27G?**

**YES**
- REPAIR 27G OR REPLACE HARNESS.

**NO**
- REPAIR 27G OR REPLACE HARNESS.

**TEST OPTIONS**
1. STE/ICE-R TEST 91  
   (Page 2-550)
2. MULTIMETER

**REASON FOR QUESTION**
This is the ground wire for the gauge.

**WITH THE ROTARY SWITCH IN THE OFF POSITION, DO YOU HAVE CONTINUITY BETWEEN WIRE 58E AT THE GAUGE AND ENGINE (OR BODY) GROUND?**

**YES**
- REPAIR 58E OR REPLACE HARNESS.

**NO**
- REPAIR 58E OR REPLACE HARNESS.

**TEST OPTIONS**
1. STE/ICE-R TEST 91  
   (Page 2-550)
2. MULTIMETER

**REASON FOR QUESTION**
If either of these wires are open, the gauge will always read off scale to the left.

**DISCONNECT WIRE 33A AT THE GAUGE AND AT THE WIRE 33B AT THE TEMPERATURE SENDING UNIT. DO YOU HAVE CONTINUITY FROM WIRE 33A TO WIRE 33B?**

**YES**
- REPAIR 33A, 33B OR REPLACE HARNESS.

**NO**
- REPAIR 33A, 33B OR REPLACE HARNESS.

**GO TO 14, Page 2-348**
**REFERENCE INFORMATION**

Replace harness or repair wiring (para. 4-80).

**INSTRUMENTS CIRCUIT**

### DC VOLTAGE 0-45 VOLTS

**STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

### RESISTANCE AND CONTINUITY 0-4,500 OHMS

**STE/ICE-R TEST 91**

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays -9.9.9.

### BATTERY VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
WITH THE ROTARY SWITCH IN THE RUN POSITION, SHORT WIRE 33B TO ENGINE GROUND. DOES THE GAUGE READ OFF SCALE ABOVE 250°F (120°C)?

REPLACE TEMPERATURE GAUGE.

REASON FOR QUESTION
This will determine if the gauge can respond to an input signal.

WITH THE ROTARY SWITCH IN THE RUN POSITION, SHORT WIRE 33B TO ENGINE GROUND. DOES THE GAUGE READ OFF SCALE ABOVE 250°F (120°C)?

REPLACE TEMPERATURE GAUGE.

REASON FOR QUESTION
This will determine if the gauge can respond to an input signal.

REPLACE TEMPERATURE SENDING UNIT.
Make sure wire 33B is not connected to the sending unit and is not touching anything metal that could cause the wire to be grounded.

Replace temperature gauge (para. 4-16).

Replace temperature sending unit (para. 4-26).
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INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

J FROM A1, Page 2-314

J1

DISCONNECT WIRE 11A AT THE ROTARY SWITCH. DO YOU HAVE 0 VOLTAGE AT WIRE 29B?

KNOWN INFO
POWER TO GAUGES WITH ROTARY SWITCH OFF

POSSIBLE PROBLEMS
ROTARY SWITCH WIRING

TEST OPTIONS
1. STF/ICE-R TEST 89 (Page 2-508)
2. MULTIMETER

REPAIR 29B OR REPLACE HARNESS.

NO

J2

WITH THE ROTARY SWITCH IN THE OFF POSITION, DO YOU HAVE CONTINUITY BETWEEN THE RUN AND START TERMINALS ON THE ROTARY SWITCH?

KNOWN INFO
WIRING OK

POSSIBLE PROBLEMS
ROTARY SWITCH

TEST OPTIONS
1. STF/ICE-R TEST 91 (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
Continuity with the switch off indicates a shorted switch.

NO FAULTS.

NO

REPLACE ROTARY SWITCH.

YES
REFERENCE INFORMATION

Replace harness or repair wiring (para. 4-80).

INSTRUMENTS CIRCUIT

Replace rotary switch (para. 4-10).

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89
1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

BATTERY VOLTAGE MULTIMETER
1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91
1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER
1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUIT

L1

DISCONNECT WIRE 28A AT THE FUEL SENDING UNIT HARNESS. IS THERE CONTINUITY BETWEEN THE ENDS OF WIRE 28A AT THE FUEL GAUGE AND AT THE FUEL SENDING UNIT HARNESS?

NO

REPAIR WIRE 28A.

YES

L2

IS THERE CONTINUITY BETWEEN WIRE 58C AT THE FUEL SENDING UNIT HARNESS AND BODY (OR ENGINE) GROUND?

NO

REPAIR WIRE 58C.

YES

L3

CHECK RESISTANCE ACROSS WIRE 28B & WIRE 58J AT THE FUEL SENDING UNIT HARNESS. IS THE RESISTANCE LESS THAN 50 OHMS?

NO

GO TO L4, Page 2-354

YES

GO TO L4, Page 2-354

NO FAULTS.
REFERENCE INFORMATION

The connector is located above the driveshaft toward the rear of the vehicle. Repair wiring (para. 4-80).

INSTRUMENTS CIRCUIT

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

<table>
<thead>
<tr>
<th>GAUGE READING</th>
<th>OHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL</td>
<td>35</td>
</tr>
<tr>
<td>HALF</td>
<td>16</td>
</tr>
<tr>
<td>EMPTY</td>
<td>0</td>
</tr>
</tbody>
</table>

INSTRUMENTS CIRCUIT

FUEL GAUGE

FUEL LEVEL SENDING UNIT

REAR OF LEFT CYLINDER HEAD

2-353
INSTRUMENTS CIRCUIT

FROM L3, Page 2-352

L4

DISCONNECT WIRES 28B & 58J
FROM SENDING UNIT IN TANK. IS
THERE CONTINUITY THROUGH
EACH WIRE?

TEST OPTIONS
1. STE/ICE-R TEST 91
   (Page 2-508)
2. MULTIMETER

REASON FOR QUESTION
If these wires are not open,
the fuel sending unit is bad.

KNOWLED GE

CAUGE HAS POWER &
GROUND
GAUGE OK

POSSIBLE PROBLEMS
WIRING
SENDING UNIT

NO

REPAIR WIRES
28B, 58J.

YES

REPLACE
FUEL LEVEL
SENDING UNIT.
In order to reach these wires and the sending unit, you have to remove the fuel tank (para. 3-25). You may want to recheck the previous steps to be sure you didn’t miss anything before you proceed with this step.

Replace fuel level sending unit and repair wiring (paras. 4-32 and 4-80).

**INSTRUMENTS CIRCUIT**

**RESISTANCE AND CONTINUITY**

0-4,500 OHMS

STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUIT

M1

REMOVE CLEVIS PINS AND TILT WINDSHIELD FORWARD. WITH ROTARY SWITCH IN THE RUN POSITION, IS THERE BATTERY VOLTAGE AT CONTACT P ON THE BODY?

TEST OPTIONS
1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
These contacts provide power and ground connections to the wiper motor.

M2

DO YOU HAVE CONTINUITY FROM CONTACT P ON THE WINDSHIELD FRAME TO WIRE 27 AT THE CONNECTOR?

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION
These contacts provide power and ground connections to the wiper motor.

KNOWN INFO
POWER AVAILABLE TO GAUGES
NO POWER AT WIPER MOTOR

POSSIBLE PROBLEMS
WIRING

KNOWN INFO
POWER TO CONTACT

POSSIBLE PROBLEMS
WIRING

REPAIR 27K OR REPLACE HARNESS.

NO FAULT.
REFERENCE INFORMATION

Make sure these contacts are clean. Otherwise, the wiper motor may not have power or ground. Replace harness or repair wiring (para. 4-80).

INSTRUMENTS CIRCUIT

**DC VOLTAGE 0-45 VOLTS**

STE/ICE-R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

**BATTERY VOLTAGE**

MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

**RESISTANCE AND CONTINUITY 0-4,500 OHMS**

STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms indicates continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

**CONTINUITY (RESISTANCE)**

MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
**TM 9-2320-387-24-1**

**INSTRUMENTS CIRCUIT**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**

NO WIPER MOTOR GROUND

POSSIBLE PROBLEMS

WIRING

**TEST OPTIONS**

1. STE/CE-R TEST 91
   (Page 2-508)
2. MULTIMETER

**REASON FOR QUESTION**

These contacts provide power and ground connections to the wiper motor.

---

**N1**

**TEST OPTIONS**

1. STE/CE-R TEST 91
   (Page 2-508)
2. MULTIMETER

**REASON FOR QUESTION**

These contacts provide power and ground connections to the wiper motor.

---

**N2**

**TEST OPTIONS**

1. STE/CE-R TEST 91
   (Page 2-508)
2. MULTIMETER

**REASON FOR QUESTION**

These contacts provide power and ground connections to the wiper motor.

---

**REPAIR 57F OR REPLACE HARNESS.**

**NO FAULT.**
REFERENCE INFORMATION

Make sure these contacts are clean. Otherwise, the wiper motor may not have power or ground. Replace harness or repair wiring (para. 4-80).

INSTRUMENTS CIRCUIT

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays 9.9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

FRONT OF VEHICLE

WINDSHIELD CONNECTOR
AS VIEWED FROM ABOVE
INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

O
FROM 10,
Page 2-312

TEST OPTIONS
VISUAL

KNOWLED INFO
ELECTRICAL GAUGES OK

POSSIBLE PROBLEMS
AIR RESTRICTION GAUGE
VACUUM HOSE

TEST OPTIONS
APPLY VACUUM TO HOSE
(YOU CAN JUST SUCK ON
THE HOSE TO TEST IT).

DIAGNOSTIC FLOWCHART

O1

INSPECT VACUUM HOSE FROM
AIR FILTER HOUSING TO
RESTRICTION GAUGE. IS THE
LINE INTACT?

REPLACE HOSE.

NO

REPLACE GAUGE.

YES

REASON FOR QUESTION
If the line leaks, any pressure
differential won't be seen by the
gauge.

NO

YES

NO FAULT.

O2

DOES THE GAUGE READ YELLOW
WHEN VACUUM IS APPLIED TO
THE HOSE AND DOES IT HOLD
THE READING?

KNOWLED INFO
VACUUM HOSE OK

POSSIBLE PROBLEMS
AIR RESTRICTION GAUGE

REASON FOR QUESTION
This will check gauge operation.

KNOWLED INFO
VACUUM HOSE OK

POSSIBLE PROBLEMS
AIR RESTRICTION GAUGE
REFERENCE INFORMATION

You can provide enough vacuum to operate the gauge by sucking on the hose. Replace vacuum hose (para. 3-20).

Replace air restriction gauge (para. 3-17).
INSTRUMENTS CIRCUIT

**KNOWN INFO**
- Air Filter Restriction
  - Gauge OK
  - Vacuum Tube OK

**POSSIBLE PROBLEMS**
- Wiring
- Switch
- Motor
- Circuit Breaker 1
- PCB

---

**P1**

**TEST OPTIONS**
1. SteiICE-R Test 89
2. Multimeter

**REASON FOR QUESTION**
Voltage here indicates that wiring to the circuit breaker is OK.

---

**P2**

**TEST OPTIONS**
1. SteiICE-R Test 89
2. Multimeter

**REASON FOR QUESTION**
If you have voltage here, the circuit breaker and wiring to the switch is OK.

---

**P3**

**TEST OPTIONS**
1. SteiICE-R Test 89
2. Multimeter

**REASON FOR QUESTION**
Voltage here indicates that wiring to the heater fan motor is OK.
The easiest way to reach the circuit breaker is to remove the gauge panel screws and pull the panel out far enough to work with the wiring.

**DC VOLTAGE 0-45 VOLTS**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

**BATTERY VOLTAGE MULTIMETER**

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

The heater motor is located directly in front of the passenger seat under the instrument panel, connected to the heating ducts.
INSTRUMENTS CIRCUIT

KNOWN INFO
WIRE 27C OK
WIRE 27D OK
CIRCUIT BREAKER 1 OK
WIRE 400U OK
SWITCH OK

POSSIBLE PROBLEMS
WIRING
MOTOR
PCB

TEST OPTIONS
1. STFACER TEST 91
2. MULTIMETER

REASON FOR QUESTION
This wire provides the motor's connection to ground.

DIAGNOSTIC FLOWCHART

FROM P3,
Page 2-362

P4

IS THERE CONTINUITY FROM
WIRE 57E AT THE HEATER FAN
MOTOR-TO-BODY GROUND?

NO

GO TO T,
Page 2-372

YES

P5

IF THE PROBLEM CONTINUES,
REPLACE THE HEATER MOTOR.
RETURN TO THE INSTRUMENTS
TEST, PAGE 2-305.
### Resistance and Continuity

**0-4,500 Ohms**

**STE/ICE-R TEST 91**

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.

---

### Continuity (Resistance) Multimeter

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUIT

KNOWN INFO
NONE

POSSIBLE PROBLEMS
WIRE 27C
PCB BODY
CONNECTOR

Q FROM P1,
Page 2-362

REPAIR/REPLACE WIRE 27C.
WITH THE ROTARY SWITCH IN
THE RUN POSITION, DO YOU
HAVE BATTERY VOLTAGE AT
WIRE 27C AT CIRCUIT
BREAKER 1?

TEST OPTIONS
1. STE/ICE-R TEST 89
(Page 2-506)
2. MULTIMETER

REASON FOR QUESTION
Voltage here indicates that the
wiring was bad, and the problem
was solved.

RETURN TO P2, PAGE 2-362.
**REFERENCE INFORMATION**

Replace harness or repair wiring (para. 4-80).

---

**INSTRUMENTS CIRCUIT**

### DC VOLTAGE 0-45 VOLTS

**STE/ICE-R TEST 89**

1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

### BATTERY VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
INSTRUMENTS CIRCUIT

KNOWN INFO
WIRE 27C OK

POSSIBLE PROBLEMS
WIRE 27D CIRCUIT BREAKER 1

DIAGNOSTIC FLOWCHART

R1

IS THERE CONTINUITY FROM WIRE 27D AT THE HEATER FAN SWITCH TO WIRE 27D AT CIRCUIT BREAKER 1?

R FROM P2, Page 2-362

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-503)
2. MULTIMETER

REASON FOR QUESTION
Continuity indicates that the wire is OK, and the circuit breaker must be the problem.

REPAIR/REPLACE WIRE 27D. RETURN TO P3, Page 2-362

YES

NO

R2

REPLACE CIRCUIT BREAKER 1. RETURN TO P3, Page 2-362.
INSTRUMENTS CIRCUIT

REFERENCE INFORMATION

Replace harness or repair wiring (para. 4-80).

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
INSTRUMENTS CIRCUIT

KNOWN INFO
- WIRE 27C OK
- WIRE 27D OK
- CIRCUIT BREAKER 1 OK

POSSIBLE PROBLEMS
- WIRE 400D SWITCH

S1

IS THERE CONTINUITY FROM WIRE 400D AT THE HEATER MOTOR TO WIRE 400D AT THE HEATER FAN SWITCH?

S2

REPAIR/REPLACE WIRE 400D. RETURN TO P4, Page 2-364

TEST OPTIONS
- 1. STERO-R TEST (Page 2-508)
- 2. MULTIMETER

REASON FOR QUESTION
Continuity indicates that the wiring is OK, and the switch must be the problem.

REPLACE THE HEATER FAN SWITCH. RECONNECT ALL WIRES. RETURN TO P4. PAGE 2-364.
REFERENCE INFORMATION

1. Repair wire or replace harness (para. 4-80).

2. Replace heater fan switch (para. 10-73).

INSTRUMENTS CIRCUIT

<table>
<thead>
<tr>
<th>RESISTANCE AND CONTINUITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4,500 OHMS</td>
</tr>
<tr>
<td>STE/ICE-R TEST 91</td>
</tr>
</tbody>
</table>

1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.

2. Start Test 91, 0-4,500 Ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

<table>
<thead>
<tr>
<th>CONTINUITY (RESISTANCE) MULTIMETER</th>
</tr>
</thead>
</table>

1. Set the voltmeter to an ohms scale of about 1,000 ohms.

2. Connect the RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
**INSTRUMENTS CIRCUIT**

**KNOWN INFO**
- WIRE 27C OK
- WIRE 27D OK
- CIRCUIT BREAKER 1 OK
- WIRE 400D OK
- SWITCH OK

**POSSIBLE PROBLEMS**
- WIRE 57E
- PCB BODY CONNECTOR

**DIAGNOSTIC FLOWCHART**

**T1**
**DISCONNECT THE PCB BODY CONNECTOR. IS THERE CONTINUITY FROM WIRE 57E AT THE HEATER MOTOR TO SOCKET D OF THE PCB BODY CONNECTOR HARNESS?**

**TEST OPTIONS**
1. STE/HCE-R TEST 91 (Page 2-508)
2. MULTIMETER

**REASON FOR QUESTION**
If there is continuity, the wiring is OK, and the PCB must be the problem.

**T2**
**REPAIR 57E OR REPLACE HARNESS. RETURN TO P5, PAGE 2-364**

**REPLACE THE PCB. RETURN TO P5, PAGE 2-364.**
REFERENCE INFORMATION

WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.
Replace harness or repair wiring (para. 4-80).

WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.
Replace the PCB (para. 4-4).

INSTRUMENTS CIRCUIT

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question. RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
The lights tests have almost no flow chart to guide you through a problem. This is because there aren't very many problems that can occur. The most common problems are burned-out bulbs and loose or corroded connections. Aside from bulbs and wiring, the only components are the Protective Control Box and the lights switch. If either of these is found to be faulty, you just replace the bad unit. On the following pages you will find diagrams of the major portions of the lights circuit. These are designed to help you isolate a problem without wasting too much time.
DO ANY LIGHTS WORK AT ALL?

TEST OPTIONS:
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

NO

YES

IS THERE BATTERY VOLTAGE AT SOCKET F OF LIGHTS SWITCH CONNECTOR HARNESS?

TEST OPTIONS:
1. STE/ICE-R TEST 89 (Page 2-506)
2. MULTIMETER

NO

YES

FAULTY LIGHTS SWITCH

The following steps are not diagnostics. They are supposed to give you some simple checks before you try to change a wiring harness that may be good.

1. Make sure that what you want to be on is supposed to be on. Check the switches (lights, high-low beam, etc.).

2. Check the socket and connection(s) for corrosion, cracks, or loose parts. Repair or replace any damaged components.

3. Try replacing the bulb that doesn't work with a bulb that you know works.

4. If the connections look good and a known good bulb doesn't work, you have to start checking voltage and continuity.
   a) Check for battery voltage (STE/ICE-R TEST 89, Page 2-506) at the light socket; there may be a fault in the wiring harness.
   b) Check for continuity to ground (STE/ICE-R TEST 91, Page 2-506) from the light socket; there may be a missing connection to ground.
   c) Go to the wiring diagram(s) for more help.

NO

YES

REPLACE PROTECTIVE CONTROL BOX,

REPAIR/REPLACE WIRE 15A IN BODY CONNECTOR WIRING HARNESS.

For repair/replace instructions, refer to para. 4-4.

For repair/replace instructions, notify DS maintenance (chapter 18).
WARNING
Disconnect negative battery cable before disconnecting and reconnecting PCB harness.

There is battery voltage at the PCB at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

PCB BODY CONNECTOR
LIGHT SWITCH CONNECTOR HARNESS

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89

1. Connect RED clip to positive, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

NOTE:
TO MOVE SELECTOR SWITCH LEVER FROM OFF TO ANY ON POSITION EXCEPT B.O. MARKER, UNLOCK SWITCH MUST BE LIFTED TO UNLOCK.
LIGHTS

CHECK FOR BATTERY VOLTAGE AT
THESE POINTS
(STEICE-R TEST 89 OR MULTIMETER)

CHECK FOR CONTINUITY TO
BATTERY NEGATIVE
CABLE FROM THE
STUDS AND STRAP.
(STEICE-R TEST 91
OR MULTIMETER)

CHECK FOR CONTINUITY TO
BATTERY NEGATIVE
CABLE FROM THE
STUDS AND STRAP.
(STEICE-R TEST 91
OR MULTIMETER)

TO BODY GROUND

1. WHEN CHECKING FOR VOLTAGE, MAKE SURE THAT THE LAMP YOU
   ARE CHECKING IS SUPPOSED TO BE ON (CHECK THE LIGHTS
   SWITCH, TURN SIGNAL SWITCH, TRANSMISSION, ETC.).

   CAUTION
   Disconnect negative battery cable prior to
   making continuity measurements.

2. CHECK CONTINUITY TO BODY GROUND.
BACKUP LAMPS AND REAR SIDE MARKERS

CHECK FOR BATTERY VOLTAGE AT THESE POINTS
(STE/ICE-R TEST 89 OR MULTIMETER)

CHECK FOR CONTINUITY TO BATTERY NEGATIVE CABLE FROM THE STUDS AND STRAP. (STE/ICE-R TEST 91 OR MULTIMETER)

TO BODY GROUND

1. WHEN CHECKING FOR VOLTAGE, MAKE SURE THAT THE LAMP YOU ARE CHECKING IS SUPPOSED TO BE ON (CHECK THE LIGHTS SWITCH, TURN SIGNAL SWITCH, TRANSMISSION, ETC.).

CAUTION
Disconnect negative battery cable prior to making continuity measurements.

2. CHECK CONTINUITY TO BODY GROUND.
1. WHEN CHECKING FOR VOLTAGE, MAKE SURE THAT THE LAMP YOU ARE CHECKING IS SUPPOSED TO BE ON (CHECK THE LIGHTS SWITCH, TURN SIGNAL SWITCH, TRANSMISSION, ETC.).

   **CAUTION**
   Disconnect negative battery cable prior to making continuity measurements.

2. CHECK CONTINUITY TO BODY GROUND.
1. WHEN CHECKING FOR VOLTAGE, MAKE SURE THAT THE LAMP YOU ARE CHECKING IS SUPPOSED TO BE ON (CHECK THE LIGHTS SWITCH, TURN SIGNAL SWITCH, TRANSMISSION, ETC.).

CAUTION
Disconnect negative battery cable prior to making continuity measurements.

2. CHECK CONTINUITY TO BODY GROUND.
SUMMARY OF CONNECTIONS:

<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>CONNECTION</th>
<th>WIRE NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>RIGHT FRONT TURN SIGNAL</td>
<td>460A</td>
</tr>
<tr>
<td>B</td>
<td>LEFT FRONT TURN SIGNAL</td>
<td>461A</td>
</tr>
<tr>
<td>C</td>
<td>LEFT REAR TURN SIGNAL/STOP LAMP</td>
<td>22-461A</td>
</tr>
<tr>
<td>D</td>
<td>LIGHT SWITCH TERMINAL C</td>
<td>22A</td>
</tr>
<tr>
<td>E</td>
<td>RIGHT REAR TURN SIGNAL</td>
<td>22-460A</td>
</tr>
<tr>
<td>F</td>
<td>HAZARD/TURN SIGNAL FLASHER TERM. B</td>
<td>325B</td>
</tr>
<tr>
<td>G</td>
<td>LIGHT SWITCH TERMINAL J (24 VOLTS)</td>
<td>467B</td>
</tr>
<tr>
<td>H</td>
<td>HAZARD/TURN SIGNAL FLASHER TERM. A</td>
<td>325A</td>
</tr>
</tbody>
</table>

CAUTION

Disconnect negative battery cable prior to making continuity measurements.
1. With the switch in the left position, you should have continuity from pin H to pins B and C, pin D to E, and pin F to G.
2. With the switch in the right position, you should have continuity from pin H to pins A and E, pin C to D, and pin F to G.

NOTE
- If vehicle is equipped with brake light override directional signal control assembly (P/N 12339312), refer to step 3.
- If vehicle is equipped with directional signal control assembly (P/N 12339312), refer to step 4.

3. With switch in hazard position, you should have continuity from pin H to pins A, B, C, D, and E, and pin F to G.
4. With switch in hazard position, you should have continuity from pin H to pins A, B, C, and E, and pin F to G.
2-40. TRANSMISSION SYSTEM TESTS

NOTE

When checking fault codes, note that low battery voltage can cause false fault codes to be set in TCM.

The transmission system is equipped with a computer called the Transmission Control Module (TCM) (located left rear seat compartment) which interprets, analyzes and records electronic signals from sensors and switches located on the engine, brake pedal, and transmission. The recorded codes stored in the TCM are known as TROUBLE CODES which are retrieved using the diagnostic switch cable on the J2 connector of the TCM. The TCM can protect the transmission from damage by locking it in second gear, with maximum fluid pressure, until the problem has been corrected. The following procedures will detail diagnostic testing, troubleshooting, and corrective action for any existing faults. These transmission system tests may be run any time you think there is a transmission problem or if you were sent here by another test chain. This paragraph has a different kind of flow chart to guide you through testing because of the many problems that can occur. The most common problems are loose or corroded wiring connections. To troubleshoot the transmission, you will need a diagnostic switch cable (appendix B, item 81), digital multimeter (appendix B, item 155) and a throttle position (TP) sensor test cable (appendix B, item 80).

CAUTION

Do not disconnect battery without recording trouble codes. Failure to do so will result in loss of diagnostic test codes.

The Diagnostic Test Codes (DTC) are transmitted from the TCM to transmission lamp located next to the shift lever. When diagnostic switch cable is connected to the J2 connector, the system is placed in the diagnostic mode, which causes the transmission lamp to flash. The transmission lamp will flash once, pause, flash twice (meaning code 12), pause, flash once, pause, flash twice (code 12 again), and do this one more time for a total of three times, which means the system is operational.

NOTE

Diagnostic test code 63 will be set at all times.

For example, if the TCM is sending the trouble code 74, the lamp will flash 12 three times, flash 63 three times, which is set all the time and is to be disregarded, flash code 7 and 4, 7 and 4, 7 and 4 for code 74, and then 12, 12, 12, which ends the diagnostic check. These codes will repeat again if not taken out of diagnostic mode.

The TCM J1 connector will be used to diagnose and troubleshoot wiring, sensor connectors, pins, solenoids, and brake switch to ensure all external problems are checked and corrected prior to TCM and transmission faults.

On the following pages you will find diagrams and charts of the major portions of the transmission circuits. These are designed to help you isolate a problem and correct it.
TRANSMISSION SYSTEM

START

1

CHECK THE TRANSMISSION FLUID. IS IT OK?

TEST OPTIONS

VISUAL - SEE NOTE AT RIGHT.

REASON FOR QUESTION
Transmission fluid level and appearance give a good indication of the system's condition.

KNOWLEDGE INFO

NOTHING

POSSIBLE PROBLEMS

FLUID
SHIFTING
TP SENSOR
COOLING SYSTEM
TRANSMISSION

NO

SEE NOTE AT RIGHT.

YES

2

PERFORM THE ROAD TEST PROCEDURE AT RIGHT. DID THE VEHICLE PASS THE ROAD TEST?

TEST OPTIONS

SEE PROCEDURE AT RIGHT.

REASON FOR QUESTION
Road testing the transmission is the easiest way to check the system.

KNOWLEDGE INFO

FLUID OK

POSSIBLE PROBLEMS

SHIFTER
TP SENSOR
COOLING SYSTEM
TRANSMISSION

NO

GO TO A, Page 2-386

YES

3

WITH THE VEHICLE COASTING IN 4TH GEAR, FLOOR THE ACCELERATOR. DOES THE TRANSMISSION DOWNSHIFT?

TEST OPTIONS

TRY IT (BE SURE NOT TO EXCEED ANY POSTED SPEED LIMITS).

REASON FOR QUESTION
You want to check out the TP sensor.

KNOWLEDGE INFO

FLUID OK
BANDS AND CLUTCHES OK
SHIFTER OK

POSSIBLE PROBLEMS

COOLING SYSTEM
TP SENSOR
TRANSMISSION

NO

GO TO B, Page 2-382

YES

GO TO 4, Page 2-388
REFERENCE INFORMATION

Procedure for checking transmission fluid

1. Start engine.
2. Hold down brake pedal and move transmission shift lever through all ranges including reverse. Leave the lever in each range for 2 seconds.
3. Engage parking brake and place shift lever in neutral. Check fluid level on dipstick.
4. Proper level is between FULL and ADD marks on dipstick.

NOTE
Check fluid for a burnt smell, grit, discoloration, air bubbles, or a milky appearance.

- Burnt smell, discoloration, or grit indicates worn or damaged internal components. Notify DS maintenance (chapter 14).
- Bubbles indicate an overfilled system or air leaks in the system. Drain the fluid and refill to proper level (para. 5-2).
- Milky appearance is due to water in the system. Change the fluid and filter (para. 5-2).
- Check fill tube for indications of fluid being blown out. If fluid is being blown out, check vent line for obstructions, and refill transmission to proper level (para. 5-2).

ROAD TEST PROCEDURE

1. Position shift lever in D (overdrive) and accelerate vehicle from 0 mph. A 1-2, 2-3, and 3-4 shift should occur at all throttle openings. Allow vehicle to coast down to about 0 mph; 4-3, 3-2, and 2-1 shifts should occur.
2. Position transmission shift lever in D (drive) and accelerate vehicle from 0 mph. A 1-2 and 2-3 shift should occur at all throttle openings. Allow vehicle to coast down to about 0 mph; 3-2 and 2-1 shifts should occur.
3. Position transmission shift lever in 2 (low two) and accelerate vehicle from 0 mph. A 1-2 shift should occur at all throttle openings. No 2-3 shift can be obtained in this range. A 1-2 shift in 2 is somewhat firmer than in D. This is normal.
4. Position shift lever in 1 and accelerate the vehicle from 0 mph. No upshifts should occur in this range.
5. Position shift lever in 2, and with the vehicle speed at approximately 45 mph, close throttle and move lever to 3. Transmission should downshift to 3rd gear. An increase in engine rpm and engine braking effect should be noticed.
6. Position shift lever in 2, and with the vehicle speed at approximately 35 mph, close throttle and move lever to 2. Transmission should downshift to 2nd gear. An increase in engine rpm and engine braking effect should be noticed.
7. Position shift lever 2 and, with the vehicle speed at approximately 25 mph, close the throttle and move lever to 1. Transmission should downshift to 1st gear. An increase in engine rpm and engine braking effect should be noticed.
8. Position shift lever in R and check for reverse operation.
9. Hard shifting may be indicative of an underfilled or clogged system.

The TP sensor is used to shift the transmission to a lower gear under heavy acceleration.
SHUT THE ENGINE OFF. DOES THE TP SENSOR ROD MOVE AS YOU STEP ON THE ACCELERATOR?

REPAIR OR REPLACE AS NECESSARY.

INSPECT THE TRANSMISSION SYSTEM FOR LEAKS. IS EVERYTHING OK?

REPAIR OR REPLACE AS NECESSARY.

GO TO B, Page 2-392
Repair or replace TP sensor (para. 4-46).
TRANSMISSION SYSTEM

DIAGNOSTIC FLOWCHART

A FROM 2, Page 2-386

A1

DID THE VEHICLE MOVE AT ALL DURING THE ROAD TEST?

TEST OPTIONS

VISUAL

REASON FOR QUESTION

The failure could be in the drivetrain or in the
transmission if the vehicle doesn't move.

RUN THE DRIVE-TRAIN TESTS,
(Para. 2-44), RETURN TO A2.

A2

WITH THE VEHICLE OFF, MOVE
THE GEARSHIFT. IS THE SHIFTER
WORKING PROPERLY?

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Make sure the shifter is
connected to and moving
the transmission linkages.

ADJUST OR
REPAIR AS NEEDED.
CONTINUE WITH A3.

A3

WITH THE VEHICLE OFF, STEP
ON THE THROTTLE. DOES THE
TP SENSOR ROD MOVE AS YOU
STEP ON THE THROTTLE?

TEST OPTIONS

VISUAL

REASON FOR QUESTION

The TP sensor tells the
transmission when to shift.

REPAIR OR
REPLACE AS
NECESSARY.

NO

YES

NO

YES

SEE NOTE AT RIGHT.
If the drivetrain system checks out OK, the problem is either the transmission itself, the shifter, or the modulator. The DRIVETRAIN tests are located in para. 2-43 of this manual.

Make sure that the detents in the shifter correspond to the shift positions shown on the plate. Have an assistant move the shifter and look to see that the linkage is moving at the transmission. Linkage repair and adjustment procedures are located in para. 5-9.

Look for a TP sensor problem if the vehicle was not shifting, or was not shifting as well as it should be.

Run the BRAKES and DRIVETRAIN tests in this manual. If you don't find any faults, notify DG maintenance (chapter 14).
TRANSMISSION SYSTEM

Diagnosis Flowchart

**Known Info**
- NO LEAKS
- FLUID OK
- SHIFTER OK

**Possible Problems**
- TRANSMISSION

**Test Options**
- VISUAL

**Reason for Question**
Transmission check lamp may be faulty.

---

**B1**
CONNECT DIAGNOSTIC SWITCH CABLE TO THE TRANSMISSION CONTROL MODULE (TCM) J2 CONNECTOR. DISCONNECT GLOW PLUG CONTROLLER. TURN VEHICLE IGNITION TO THE RUN POSITION. DOES TRANSMISSION CHECK LAMP STEADILY ILLUMINATE?

**Known Info**
- NO LEAKS
- FLUID OK
- SHIFTER OK

**Possible Problems**
- TRANSMISSION

**Test Options**
- MULTIMETER

**Reason for Question**
Transmission check lamp or harness leads may be faulty.

---

**B2**
CHECK VOLTAGE ON HARNESS LEADS TO TRANSMISSION CHECK LAMP. DID YOU GET: 
>12 V ON PIN 1 (CKT 657B)?
0 V ON PIN 2 (CKT 657A)?

**Known Info**
- NO LEAKS
- FLUID OK
- SHIFTER OK

**Possible Problems**
- TRANSMISSION

**Reason for Question**
Transmission check lamp or harness leads may be faulty.

---

**B3**
POSITION SWITCH TO ON. DOES THE TRANSMISSION CHECK LAMP FLASH THREE CODE 12s INDICATING THE TCM IS CAPABLE OF DIAGNOSTICS?

**Known Info**
- NO LEAKS
- FLUID OK
- SHIFTER OK

**Possible Problems**
- TRANSMISSION

**Test Options**
- SEE FLOWCHART AT RIGHT.

**Reason for Question**
Transmission check lamp must flash three code 12s indicating the TCM is capable of diagnostics.

---

**Step B3**
REFER TO CHART AT RIGHT.

**Go To**
B4, Page 2-394
### Will Not Display DTC Code 12, or Check Transmission ON Steady

**NOTE:** TRANSMISSION CHECK LAMP IS THE LAMP NEXT TO THE SHIFT LEVER MARKED "TRANS-ONLY".

<table>
<thead>
<tr>
<th>Action</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IGNITION ON, ENGINE OFF, AND GLOW PLUG CONTROLLER DISCONNECTED</strong></td>
<td>(Para. 4-33)</td>
</tr>
<tr>
<td><strong>REMOVE DIAGNOSTIC SWITCH CABLE. INSTALL JUMPER CABLE BETWEEN PINS A AND E OF J2 ON TCM ASSY.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>NO DTC 12</strong></td>
<td><strong>DTC 12 FLASHES</strong></td>
</tr>
<tr>
<td><strong>IGNITION OFF.</strong></td>
<td><strong>CHECK DIAGNOSTIC CABLE FOR OPEN AND REPAIR.</strong></td>
</tr>
<tr>
<td><strong>DISCONNECT TCM CONNECTOR.</strong></td>
<td><strong>READ CODES AND REMOVE JUMPER.</strong></td>
</tr>
<tr>
<td><strong>IGNITION ON.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>TRANS CHECK LAMP OFF</strong></td>
<td><strong>TRANS CHECK LAMP ON</strong></td>
</tr>
<tr>
<td><strong>IGNITION OFF.</strong></td>
<td><strong>REPAIR SHORT TO GROUND IN CKT 957A (Para. 4-80).</strong></td>
</tr>
<tr>
<td><strong>DIAGNOSTIC TERMINAL NOT GROUNDED.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>RECONNECT TCM CONNECTOR.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>IGNITION ON AND ENGINE OFF.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CONNECT PROBE PINE ON J2 TO GROUND.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>NO DTC 12</strong></td>
<td><strong>DTC 12 FLASHES</strong></td>
</tr>
<tr>
<td><strong>REPLACE DEFECTIVE TCM (Para. 4-33)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>OPEN CKT PIN A-J2. REPLACE TCM (Para. 4-33)</strong></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** AFTER TROUBLESHOOTING, RECONNECT GLOW PLUG CONTROLLER. VEHICLE WILL HAVE TO BE OPERATED IN ORDER FOR TCM TO RECEIVE TROUBLE CODES. AFTER REPAIRS, CHECK TRANS LAMP OPERATION.
TRANSMISSION FOLLOWING THE CODE 12 DISPLAYS, EACH STORED CODE WILL BE FLASHED THREE TIMES IN NUMERIC ORDER FROM LOWEST TO HIGHEST. WHEN ALL CODES HAVE BEEN DISPLAYED, THREE CODE 12s WILL FLASH AGAIN. TURN THE SWITCH OFF IF YOU DO NOT WISH TO REPEAT THE SEQUENCE.

RECORD THE CODES AND REFER TO THE J1 CABLE DIAGNOSTICS CHART ON PAGES 2-402 THROUGH 2-417 AND COMPLETE THE DIAGNOSTICS. REFER TO PAGE 2-395 FOR DESCRIPTION OF TROUBLE CODES.

IF CODE 51 SHOWS, REPLACE TCM (PARA. 4-45).

END OF TESTING.
The following chart will help you find the code you need. The J1 cable diagnostics checks (page 2-402) must be performed. Always correct the lower code number first. If code 51 shows up, replace TCM (para. 4-45), operate vehicle, and recheck for trouble codes.

<table>
<thead>
<tr>
<th>TROUBLE CODE</th>
<th>CIRCUIT</th>
<th>PAGE NO.</th>
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<td>2-396</td>
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<td>Throttle Position (TP) Low</td>
<td>2-396</td>
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<tr>
<td>24</td>
<td>Transmission Output Speed Sensor (TOSS)</td>
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<td>28</td>
<td>Transmission Range Pressure (TR) Switch</td>
<td>2-396</td>
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<td>Torque Converter Clutch (TCC) Brake Switch Stuck ON</td>
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<tr>
<td>38</td>
<td>TCC Brake Switch Stuck OFF</td>
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<tr>
<td>39</td>
<td>TCC Stuck OFF</td>
<td>2-397</td>
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<tr>
<td>51</td>
<td>Transmission Control Module (TCM)</td>
<td>2-397</td>
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<tr>
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<td>System Voltage High</td>
<td>2-397</td>
</tr>
<tr>
<td>53</td>
<td>System Voltage High</td>
<td>2-397</td>
</tr>
<tr>
<td>58</td>
<td>Transmission Temperature High</td>
<td>2-397</td>
</tr>
<tr>
<td>59</td>
<td>Transmission Temperature Low</td>
<td>2-397</td>
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<td>68</td>
<td>Transmission Component Slipping</td>
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<td>69</td>
<td>Torque Converter Clutch (TCC) Stuck ON</td>
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<td>71</td>
<td>Engine Speed Sensor Circuit Low</td>
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<td>Pressure Control Solenoid (PCS) Current</td>
<td>2-399</td>
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<td>Transmission Input Speed Sensor (TISS) Circuit</td>
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<td>75</td>
<td>System Voltage Low</td>
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<td>2-400</td>
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<td>82</td>
<td>1-2 Shift Solenoid Circuit Fault</td>
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<td>83</td>
<td>TCC Solenoid (PWM) Circuit Fault</td>
<td>2-400</td>
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<td>Undefined Ratio Error</td>
<td>2-401</td>
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<td>86</td>
<td>Low Ratio Error</td>
<td>2-401</td>
</tr>
<tr>
<td>87</td>
<td>High Ratio Error</td>
<td>2-401</td>
</tr>
</tbody>
</table>
**TRANSMISSION SYSTEM**

**DTC 21/22**
Throttle Position (TP) Sensor Circuit High/
Throttle Position Sensor Circuit Low

*Circuit Description:*
The TP sensor contains a resistor strip with one end connected to a 5-volt supply and the other to ground. The signal is connected to a movable contact within the TP sensor. As the accelerator pedal is applied and the throttle shaft rotates, the voltage signal will increase from approximately 0.5 to 4.5 volts.

**DTC 21 Will Set When:**
- Engine is operating.
- TP sensor signal voltage is greater than 4.9 volts.
- Conditions are met for 1 second.

**DTC 22 Will Set When:**
- Engine is operating.
- TP sensor signal voltage is less than 0.2 volt.
- Conditions are met for 1 second.

**DTC 24**
Output Speed Sensor Signal

*Circuit Description:*
The output speed sensor is a magnetic induction-type sensor. Gear teeth pressed onto the output shaft induce an alternating voltage into the sensor.

**DTC 24 Will Set When:**
- Not in P/N.
- Circuit voltage is constant.
- Engine speed is greater than 3,000 rpm.
- Output speed is less than 200 rpm.
- TP is between 10% and 100%.
- All conditions are met for 3 seconds.

**DTC 28**
Transmission Range (TR) Pressure Switch Assembly (PSA) Fault

*Circuit Description:*
The Transmission Range (TR) Pressure Switch Assembly consists of five normally open pressure switches mounted on the valve body. The TCM supplies battery voltage to each range signal. By grounding one or more of these circuits through various combinations of the pressure switches, the TCM assembly detects what transmission range has been selected by the vehicle operator. When the transmission electrical connector is disconnected, the ground potential for the three range signals to the TCM will be removed and D2 gear will be indicated.

**DTC 28 Will Set When:**
- Range signals A and C are both zero volt.
- Condition is met for 2 seconds.

**REFERENCE INFORMATION**

**DTC 28**
Transmission Range (TR) Pressure Switch Assembly (PSA) Fault

*Circuit Description:*
The Transmission Range (TR) Pressure Switch Assembly consists of five normally open pressure switches mounted on the valve body. The TCM supplies battery voltage to each range signal. By grounding one or more of these circuits through various combinations of the pressure switches, the TCM assembly detects what transmission range has been selected by the vehicle operator. When the transmission electrical connector is disconnected, the ground potential for the three range signals to the TCM will be removed and D2 gear will be indicated.

**DTC 28 Will Set When:**
- Range signals A and C are both zero volt.
- Condition is met for 2 seconds.

**DTC 37/38**
Torque Converter Clutch (TCC) Brake Switch Stuck ON/
TCC Brake Switch Stuck OFF

*Circuit Description:*
The normally closed brake switch supplies a B+ signal volt when the TCC brake switch is closed (brake pedal not applied).

**DTC 37 Will Set When:**
- Circuit 810B is open.
  - Then vehicle speed is between 5 mph (8 kph) and 20 mph (32 kph) for greater than 6 seconds.
  - Then vehicle speed is greater than 20 mph (32 kph) for greater than 6 seconds.
  - For a complete total of 7 times.

**DTC 38 Will Set When:**
TCC brake switch feed CKT 810R has constant voltage.
- Vehicle speed is greater than 20 mph (32 kph) for greater than 6 seconds.
- Then vehicle speed is between 5 mph (8 kph) and 20 mph (32 kph) for greater than 6 seconds.
- For a complete total of 7 times.
DTC 39
TCC Stuck OFF

Circuit Description:
The TCM commands the TCC PWM solenoid ON by modulating TCC signal fluid acting on the converter clutch shift valve. Then TCC fluid applies the torque converter clutch.

DTC 39 Will Set When:
- TCC is commanded ON.
- TCC slip speed greater than 65 rpm.
- Trans range in D3 or D4.
- 2nd or 3rd gear.
- All conditions are met for 2 seconds.

DTC 51
Transmission Control Module (TCM)
Faulty or Incorrect

Circuit Description:
The Transmission Control Module (TCM), an on-board computer, receives and processes input signals from sensors on the vehicle and delivers output signals to the solenoids located on the control valve assembly. These solenoids control the transmission operating pressures, upshift and downshift patterns and Torque Converter Clutch (TCC) operation.

DTC 51 Will Set When:
- There is an uncorrectable computational error, or an input is in error intermittently.

DTC 52/53
System Voltage High Long/
System Voltage High

Circuit Description:
Ignition voltage is supplied to the control module to indicate the status of the ignition switch. Battery voltage is supplied to the control module to, in part, maintain memory of learned functions and parameters.

DTC 52 Will Set When:
- The ignition is ON and the system voltage is greater than 16 volts.
- Condition is met for 109 minutes.

DTC 53 Will Set When:
- The ignition is ON and the system voltage is greater than 19.5 volts.
- Condition is met for 2 minutes.

DTC 58
Transmission Fluid Temperature (TFT)
Sensor Circuit Low
(High Temperature Indicated)

Circuit Description:
The TFT sensor is a thermistor that controls the signal voltage to the TCM. The TCM supplies a 5-volt reference signal to the sensor on TWC pin L. When the transmission fluid is cold, the sensor resistance is high and the TCM will sense high signal voltage.

As the transmission fluid temperature warms to normal transmission operating temperature 212°F (100°C), the sensor resistance becomes less and the voltage decreases to approximately 1.5 to 2.0 volts. With DTC 79 also set, check the transmission cooling system.

DTC 58 Will Set When:
- Signal voltage indicates TFT greater than 304°F (151°C).
- Condition is met for 1 second.
TRANSMISSION SYSTEM

DTC 59
Transmission Fluid Temperature (TFT) Sensor Circuit High
(Low Temperature Indicated)

Circuit Description:
The TFT sensor is a thermistor that controls the signal voltage to the TCM. The TCM supplies a 5 volt reference signal to the sensor on TWC pin L. When the transmission fluid is cold, the sensor resistance is high and the TCM will sense high signal voltage.

As the transmission fluid temperature warms to normal transmission operating temperature 212°F (100°C), the sensor resistance becomes less and the voltage decreases to approximately 1.5 to 2.0 volts.

DTC 59 Will Set When:
- Signal voltage indicates TFT less than -34°F (-37°C).
- Condition is met for 1 second.

DTC 68
Transmission Component Slipping

Circuit Description:
The TCM monitors the difference in engine speed and input speed.

DTC 68 Will Set When:
- TCC slip speed is greater than 200 rpm.
- Fourth gear is indicated.
- TCC is locked.
- Not in park/neutral.
- All conditions are met for 2 seconds.
- Transmission range switch indicates D3 or D4.
- Commanded gear indicates 2nd or 3rd gear.
- All conditions are met for 2 seconds.

DTC 69
Torque Converter Clutch (TCC) Stuck ON

Circuit Description:
The TCM commands the TCC PWM solenoid ON by modulating TCC signal fluid acting on the converter clutch shift valve. Then TCC fluid applies the torque converter clutch.

DTC 69 Will Set When:
- TCC slip speed rpm indicates between -5 and +10 rpm.
- TCC solenoid is commanded OFF.
- TP sensor signal is greater than 25%.

DTC 71
Engine Speed Sensor Circuit Low

Circuit Description:
The Camshaft Position Sensor (CPS) detects the rotational speed of the camshaft. As the camshaft rotates, an AC signal is generated in the circuit. This signal provides the input to determine engine speed for use in various calculations including TCC slip speed and overdrive ratio.

DTC 71 Will Set When:
- Engine speed is less than 50 rpm.
- Transmission range indicates R, D4, D3, or D1.
- Conditions are met for 2 seconds.
DTC 73
Pressure Control Solenoid (PCS) Circuit
Current Error (Force Motor Circuit)

Circuit Description:
The Pressure Control Solenoid (PCS) is a TCM-controlled device used to regulate transmission line pressure. The TCM compares TP voltage, engine rpm, and other inputs to determine the appropriate line pressure of a given load. The TCM will regulate the pressure by applying a varying amperage to the PCS. The applied amperage can vary from 0.1 to 1.1 amp. The TCM then monitors the amperage at the return line.

DTC 73 Will Set When:
- The return amperage varies greater than 0.16 amp from the commanded amperage.
- All conditions are met for 1 second.

DTC 74
Transmission Input Speed Sensor (TISS) Circuit

Circuit Description:
The Transmission Input Speed Sensor (TISS) consists of a permanent magnet surrounded by a coil of wire. As the forward clutch housing rotates, an AC voltage is induced in the circuit. The signal voltage and frequency vary directly with the forward clutch rotational speed.

DTC 74 Will Set When:
- Transmission range is not in park or neutral.
- Engine speed is greater than 300 rpm.
- Transmission output speed is greater than 200 rpm.
- Transmission input speed less than 50 rpm.
- All conditions are met for 2 seconds.

DTC 75
System Voltage Low

Circuit Description:
Ignition voltage is supplied to the control module to indicate the status of the ignition switch. Battery voltage is supplied to the control module to, in part, maintain memory of learned functions and parameters.

DTC 75 Will Set When:
- The ignition is ON.
- Ignition feed voltage to the control module is less than the graduated scale of:
  - 40°F (-40°C) = 7.3 volts.
  - 194°F (-90°C) = 10.3 volts.
  - 302°F (-150°C) = 11.7 volts.
- Engine speed is greater than 1,000 rpm.
- All conditions are met for 4 seconds.

DTC 79
Transmission Fluid Overtemp

Circuit Description:
The Transmission Fluid Temperature (TFT) sensor is a thermistor that controls the signal voltage to the TCM. The TCM supplies a 5-volt reference signal to the sensor on Circuit 923A. When the transmission fluid is cold, the sensor resistance is high and the TCM will sense high signal voltage.

As the transmission fluid temperature warms to normal transmission operating temperature 212°F (100°C), the sensor resistance becomes less and the voltage decreases to approximately 1.5 to 2.0 volts.

DTC 79 Will Set When:
- Transmission fluid temperature is greater than 295°F (146°C).
- All conditions are met for 30 minutes.
TRANSMISSION SYSTEM

DTC 81
2-3 Shift Solenoid Circuit Fault

Circuit Description:
Ignition voltage is supplied directly to the 2-3 shift solenoid. The TCM controls the solenoid by providing the ground path through Circuit 315A to TCM.

DTC 81 Will Set When:
- The TCM commands the solenoid ON and voltage remains high.
- The TCM commands the solenoid OFF and voltage remains low.
- All conditions are met for 2 seconds.

DTC 82
1-2 Shift Solenoid Circuit Fault

Circuit Description:
Ignition voltage is supplied directly to the 1-2 shift solenoid. The TCM controls the solenoid by providing the ground path through Circuit 237A to TCM.

DTC 82 Will Set When:
- The TCM commands the solenoid ON and voltage remains high.
- The TCM commands the solenoid OFF and voltage remains low.
- All conditions are met for 2 seconds.

DTC 83
TCC Solenoid (PWM) Circuit Fault

Circuit Description:
The control module supplies a ground through an internal Quad-Module (QDM), allowing current to flow through the solenoid coil according to the duty cycle (percentage of ON and OFF time). This current flow through the solenoid coil creates a magnetic field that magnetizes the solenoid core. The magnetized core attracts the checkball to seat against spring pressure. This blocks the exhaust for the TCC signal fluid and allows 2-3 drive fluid to feed the TCC signal circuit. The TCC signal fluid pressure acts on the TCC regulator valve to regulate line pressure and to apply fluid pressure to the TCC shift valve. When the TCC shift valve is in the apply position, regulated applied fluid pressure is directed through the TCC valve to apply the torque converter clutch.

DTC 83 Will Set When:
- The TCM commands the solenoid ON and voltage remains high.
- The TCM commands the solenoid OFF and voltage remains low.
- All conditions are met for 2 seconds.
REFERENCE INFORMATION

DTC 85
Undefined Ratio Error

Circuit Description:
The control module calculates ratio based on the transmission input speed and output speed sensor reading. The control module compares the known transmission ratio to the calculated ratio for the particular gear range selected.

DTC 85 Will Set When:
- Throttle position is greater than 25%.
- Not in park, neutral, or 4th gear.
- Engine speed is greater than 300 rpm.
- Vehicle speed is greater than 7 mph (11 kph).

<table>
<thead>
<tr>
<th>COMMANDED GEAR</th>
<th>IF CALCULATED RATIO IS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LESS THAN</td>
</tr>
<tr>
<td>1st</td>
<td>2.38</td>
</tr>
<tr>
<td>2nd</td>
<td>1.43</td>
</tr>
<tr>
<td>3rd</td>
<td>0.95</td>
</tr>
<tr>
<td>REV</td>
<td>1.97</td>
</tr>
</tbody>
</table>
- All conditions are met for 2 seconds.

DTC 86
Low Ratio Error

Circuit Description:
The control module calculates ratio based on the TISS and TOSS readings. The control module compares the known transmission ratio to the calculated ratio for the particular gear range selected.

DTC 86 Will Set When:
- Throttle position is greater than 25%.
- Not in park, reverse, or neutral.
- Engine speed greater than 300 rpm.
- Vehicle speed is greater than 7 mph (11 kph).
- Transmission gear ratio is less than 1.06 in 1st or 2nd gear.
- All conditions are met for 2 seconds.

DTC 87
High Ratio Error

Circuit Description:
The control module calculates ratio based on the TISS and TOSS readings. The control module compares the known transmission ratio to the calculated ratio for the particular gear range selected.

DTC 87 Will Set When:
- Throttle position is greater than 25%.
- Not in park, reverse, or neutral.
- Engine speed greater than 300 rpm.
- Vehicle speed is greater than 7 mph (11 kph).
- Transmission temperature is greater than 68°F (20°C).
- All conditions are met for 2 seconds.
NOTE

- The following diagnostics will help isolate and repair problem circuits, wires, pins, connectors, sensors, circuit breakers, and solenoids.
- For repair of all wiring, refer to [para. 4-80].
- Check connector pins before inserting probes.

**J1 CABLE DIAGNOSTICS CHART**

J1 Voltage Measurements With Ignition ON, Engine OFF, and Glow Plug Controller Disconnected. Refer to [para. 4-33].

<table>
<thead>
<tr>
<th>CKT NOM.</th>
<th>CKT #</th>
<th>PIN</th>
<th>TO</th>
<th>PIN</th>
<th>EXP READ</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGN PWR</td>
<td>291D</td>
<td>j</td>
<td>a or b</td>
<td></td>
<td>12VDC</td>
</tr>
<tr>
<td>Battery Pos</td>
<td>537D</td>
<td>Z</td>
<td>a or b</td>
<td></td>
<td>12VDC</td>
</tr>
<tr>
<td>Trans Lp</td>
<td>657A</td>
<td>U*</td>
<td>a or b</td>
<td></td>
<td>LED Lights</td>
</tr>
<tr>
<td>Brake Sw</td>
<td>810B</td>
<td>W</td>
<td>a or b</td>
<td></td>
<td>12V (Brake OFF)</td>
</tr>
<tr>
<td>Brake Sw</td>
<td>810B</td>
<td>W</td>
<td>a or b</td>
<td></td>
<td>0 (Brake ON)</td>
</tr>
</tbody>
</table>

* Jumper wire from U to a or b.

Reconnect Glow Plug Controller. Refer to [para. 4-33]. J1 Voltage Measurement With Ignition ON, Engine ON, Transmission in PARK.

<table>
<thead>
<tr>
<th>CKT NOM.</th>
<th>CKT #</th>
<th>PIN</th>
<th>TO</th>
<th>PIN</th>
<th>EXP READ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine rpm</td>
<td>349A</td>
<td>h</td>
<td>c or p</td>
<td></td>
<td>0.3 volt min @ idle</td>
</tr>
<tr>
<td>Press SW A</td>
<td>765A</td>
<td>A</td>
<td>a or b</td>
<td></td>
<td>Open wire</td>
</tr>
<tr>
<td>Press SW B</td>
<td>763A</td>
<td>B</td>
<td>a or b</td>
<td></td>
<td>0 TO 1 ohm</td>
</tr>
<tr>
<td>Press SW C</td>
<td>764A</td>
<td>C</td>
<td>a or b</td>
<td></td>
<td>Open wire</td>
</tr>
</tbody>
</table>

Go to pg 2-402

Go to pg 2-404

Go to pg 2-405

Go to pg 2-406

Go to pg 2-407

Go to pg 2-407

Go to pg 2-408

Go to pg 2-416

Go to pg 2-416

Go to pg 2-416
DIAGNOSTIC FLOWCHART

NOTE
Check connector pins before inserting probes.

_J1 CABLE DIAGNOSTICS CHART (Cont'd)_

J1 Resistance Measurements With Ignition OFF

<table>
<thead>
<tr>
<th>CKT NOM.</th>
<th>CKT #</th>
<th>PIN</th>
<th>TO PIN</th>
<th>EXP READ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Neg</td>
<td>599A</td>
<td>a</td>
<td>Shunt</td>
<td>0 ohm</td>
</tr>
<tr>
<td>Battery Neg</td>
<td>599B</td>
<td>b</td>
<td>Shunt</td>
<td>0 ohm</td>
</tr>
<tr>
<td>TPS</td>
<td>355A</td>
<td>s</td>
<td>c or p</td>
<td>~ 1 to 2 Kohms</td>
</tr>
<tr>
<td>TPS</td>
<td>350A</td>
<td>d</td>
<td>c or p</td>
<td>4 to 6 Kohms</td>
</tr>
<tr>
<td>TISS</td>
<td>495A</td>
<td>m</td>
<td>n</td>
<td>1 to 2 Kohms</td>
</tr>
<tr>
<td>TISS</td>
<td>496A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOSS</td>
<td>497A</td>
<td>s</td>
<td>R</td>
<td>1 to 2 Kohms</td>
</tr>
<tr>
<td>TCC SOL</td>
<td>924A</td>
<td>X</td>
<td>j</td>
<td>~ 8-12 ohms</td>
</tr>
<tr>
<td>SHIFT SOL A</td>
<td>237A</td>
<td>E</td>
<td>j</td>
<td>~18 to 24 ohms</td>
</tr>
<tr>
<td>SHIFT SOL B</td>
<td>375A</td>
<td>D</td>
<td>j</td>
<td>~18 to 24 ohms</td>
</tr>
<tr>
<td>FORCE MTR</td>
<td>264A</td>
<td>g</td>
<td>k</td>
<td>3.5 to 5.2 ohms</td>
</tr>
<tr>
<td>Trans Temp Sensor</td>
<td>923A</td>
<td>e</td>
<td>c or p</td>
<td>40 ohm to 5 Kohm (High Temp. → Low Resist.)</td>
</tr>
</tbody>
</table>

Upon completion of J1 cable diagnostics, operate the vehicle and recheck for codes to ensure codes have cleared. If codes have not cleared, refer to DS maintenance (chapter 14).
TRANSMISSION SYSTEM

IGNITION POWER

**291D**

- **Reset trans pwr CB and recheck voltage >12V?**
  - **YES** → **END**
  - **NO** → **Check for >12V on trans relay pin 3 (wire 290C/291C).**
    - **YES** → Repair wire 290C/291C.
    - **NO** → GO
      - **Repair wire 290D/291T.**
      - **YES** → Check run pwr CB for >24V (wire 29D).
      - **NO** → Troubleshoot vehicle wiring.

- **Check for >12V on trans relay pin 4 (wire 290B/291B).**
  - **YES** → Check trans pwr CB out for >12V (wire 290A/291A/537A).
    - **YES** → Repair wire 290A/291A/537A.
    - **NO** → Replace CB (para. 4-43).
  - **NO** → Check trans pwr CB in for >12V (wire 290/291/537).
    - **YES** → Check for zero V (gnd) on wire 57T at trans relay (pin 1).
      - **YES** → Replace relay (para. 4-44).
      - **NO** → Repair wire 290/291/537 (para. 4-80).
DIAGNOSTIC FLOWCHART

BATTERY CIRCUIT

537D

- Reset trans pwr CB and recheck voltage >12V.
- NO
- Check trans pwr CB out for >12V (wire 290A/291A/537A).
  - NO
  - Check trans pwr CB In for >12V (wire 290/291/537).
    - NO
    - Repair wire 290/291/537 (para. 4-80).
    - YES
    - Repair wire 290A/291A/537A (para. 4-80).
- YES
- END

VEHICLE GROUND CIRCUIT

599A

- NO
- Repair wire 599A/599C.
- YES
- END

599B

- NO
- Repair wire 599B/599C.
- YES
- END
Check for >12V on pin 1 (wire 657B) of harness connector at trans check lamp.

NO

Check pin j of J1 (wire 291D) for >12V.

NO

Follow diagnostic procedure for pin j of J1 to obtain >12V on wire 291D.

Go to page 2-402.

YES

Check for continuity on wire 657A from J1 pin U to pin 2 of harness connector at trans check lamp.

YES

Repair wire 657A (para. 4-80).

NO

Repair wire 657B (para. 4-80).

NO

Replace transmission check lamp (para. 4-41).

YES

Replace transmission check lamp (para. 4-41).

NO

Does transmission check lamp light?

YES

Faulty TCM ground. Replace TCM (para. 4-45).

Go to page 2-403.

NO
DIAGNOSTIC FLOWCHART

BRAKE SWITCH CIRCUIT

810B

Check for following resistance across brake switch leads pins 1 and 2 (wires 810A and 810B):
0 Ω - Brakes Off
∞ Ω - Brakes On.

Check for >12V on harness connector pin 1 (wire 810A) at brake switch.

Check for actuation of brake switch.

Repair wire 810B in harness (para. 4-80).

Replace stoplight switch (para. 4-60).

Follow diagnostic procedure for pin j of J1 to obtain >12V on wire 291D.

Go to page 2-402.
TRANSMISSION SYSTEM

DIAGNOSTIC FLOWCHART

ENGINE RPM SENSOR

Check resistance across pins 1 and 2 of engine rpm sensor leads, approximately 150 ohms.

349A

YES

Check for continuity from pin h wire 349A of J1 to pin 1 wire 349B and check for continuity from p wire 359B of J1 to pin 2 wire 359F on engine harness connector to rpm sensor.

NO

Replace engine rpm sensor (para. 4-37).

YES

Replace engine rpm sensor (para. 4-37).

NO

Repair wire 349A/349B, and/or wire 359B/359F (para. 4-80).
THROTTLE POSITION SENSOR CIRCUIT

Check for continuity from pin s wire 355A of J1 to pin B wire 355B of engine harness connector to TPS.

- YES: Repair wire 355A/355B (para. 4-80).
- NO:
  - NO: Vehicle wiring is ok. Proceed to the TP sensor adjustment procedure in para. 4-46 to determine whether the TP sensor or the adjustment is faulty.
  - YES: Repair wire 350A/350C (para. 4-80).

Check for continuity from pin c wire 359A of J1 to pin C wire 359H of engine harness connector to TPS.

- YES: Repair wire 359A/359H (para. 4-80).
- NO:
  - NO: Vehicle wiring is ok. Proceed to the TP sensor adjustment procedure in para. 4-46 to determine whether the TP sensor or the adjustment is faulty.
  - YES: Repair wire 350A/350C (para. 4-80).

Check for continuity from pin d wire 350A of J1 to pin A wire 350C of engine harness connector to TPS.

- YES: Repair wire 350A/350C (para. 4-80).
- NO:
  - NO: Vehicle wiring is ok. Proceed to the TP sensor adjustment procedure in para. 4-46 to determine whether the TP sensor or the adjustment is faulty.
  - YES: Repair wire 350A/350C (para. 4-80).
TRANSMISSION SYSTEM

DIAGNOSTIC FLOWCHART

TRANSMISSION INPUT SPEED SENSOR (TISS) CIRCUIT

NOTE
If reading from J1 diagnostics chart is above limit, perform high resistance - below limit, perform low resistance.

HIGH RESISTANCE

495A 496A

Check Transmission Input Speed Sensor connector and pins for continuity.

YES

Check continuity of wire 495A on J1 pin m to transmission input speed connector pin a, and check continuity of wire 496A on J1 pin n to transmission input speed connector pin b.

YES

Check resistance of Transmission Input Speed Sensor and pins A and B (TISS) 1 Kohm to 2 Kohms Ω.

NO

END

NO

Repair pin(s) or connector (para. 4-80).

Repair wire 495A, and/or wire 496A (para. 4-80).

LOW RESISTANCE

Disconnect TISS and check continuity between pins M and N at J1.

YES

Repair wire 495A/496A (para. 4-80).

NO

Replace TISS (para. 4-47).

END
NOTE
If reading from J1 diagnostics chart is above limit, perform high resistance; below limit, perform low resistance.

HIGH RESISTANCE

497A
498A

Check Transmission Output Speed Sensor connector and pins for continuity.

YES

NO

Repair pin(s) or connector (para. 4-80).

Disconnect and check continuity of wire 495A on J1 pin S to transmission output speed connector pin A, and check continuity of wire 498A on J1 pin R to transmission output speed connector pin B.

YES

NO

Repair wire 497A, and/or wire 498A (para. 4-80).

Check resistance of Transmission Output Speed Sensor and pins A and B (TOSS) 1 Kohm to 2 Kohms Ω.

YES

NO

Replace TOSS (para. 4-47).

END

LOW RESISTANCE

Disconnect TOSS and check continuity between pins M and N at J1.

YES

Repair wire 497A/498A (para. 4-80).

NO

Replace TOSS (para. 4-47).

END
TRANSMISSION SYSTEM

TORQUE CONVERTER CLUTCH
SOLENOID CIRCUIT

HIGH RESISTANCE

924A
Disconnect transmission connector from transmission. Check continuity from J1 pin X to transmission connector pin S.

YES
Check continuity from J1 pin j to transmission connector pin E.

NO
Repair wire 924A J1 pin X to transmission connector pin S (para. 4-80).

YES
Repair wire 290D/291D (para. 4-80).

Refer to DS maintenance (chapter 14).

LOW RESISTANCE

Disconnect transmission connector from transmission. Check continuity from J1 pin X to J1 pin j.

YES
Repair wires 924A, 290D, and 291D (para. 4-80).

NO
Refer to DS maintenance (chapter 14).
DIAGNOSTIC FLOWCHART

1-2 SHIFT SOLENOID CIRCUIT SHIF
SOLENOID A

HIGH RESISTANCE

237A
Check continuity from J1 pin E to transmission connector pin A.

YES

Check continuity from J1 pin j to transmission connector pin E.

YES

Repair wire 237A (para. 4-80).

NO

Repair wire 291D/290D (para. 4-80).

LOW RESISTANCE

Disconnect transmission connector from transmission. Check continuity from J1 pin E to J1 pin j.

YES

Repair wires 237A, 290D, and 291D (para. 4-80).

NO

Refer to DS maintenance (chapter 14).
TM 9-2320-387-24-1

TRANSMISSION SYSTEM  DIAGNOSTIC FLOWCHART

2-3 SHIFT SOLENOID CIRCUIT SHIFT
SOLENOID B

HIGH RESISTANCE

375A

Check continuity from J1 pin D to
transmission connector pin B.

YES

Repair wire 375A
(para. 4-80).

NO

Check continuity from J1 pin j to
transmission connector pin E.

NO

Repair wire 291D/290D
(para. 4-80).

YES

Refer to DS maintenance (chapter 14).

LOW RESISTANCE

Disconnect transmission connector
from transmission. Check continuity
from J1 pin D to J1 pin j.

YES

Repair wires 375A, 290D,
and 291D (para. 4-80).

NO

Refer to DS maintenance (chapter 14).
DIAGNOSTIC FLOWCHART

TRANSMISSION SYSTEM

PRESSURE CONTROL SOLENOID CIRCUIT
FORCE MOTOR HIGH

HIGH RESISTANCE

264A 265A

Check continuity from J1 pin g to transmission connector pin C.

YES

Repair wire 264A (para. 4-80).

NO

Check continuity from J1 pin k to transmission connector pin D.

NO

Repair wire 265A (para. 4-80).

YES

Refer to DS maintenance (chapter 14).

LOW RESISTANCE

Disconnect transmission connector from transmission. Check continuity from J1 pin g to J1 pin k.

YES

Repair short between wire 264A and wire 265A.

NO

Refer to DS maintenance (chapter 14).
TRANSMISSION SYSTEM

TRANSMISSION RANGE PRESSURE SWITCH, CIRCUIT PRESSURE SWITCH A

765A

Disconnect the transmission connector from transmission. Check continuity from J1 pin A to chassis ground at shunt.

YES

Refer to DS maintenance (chapter 14).

NO

Repair short to ground in wire 765A (para. 4-80).

TRANSMISSION RANGE PRESSURE SWITCH, CIRCUIT PRESSURE SWITCH B

763A

Disconnect the transmission connector from transmission. Check continuity from J1 pin B to chassis ground at shunt.

YES

Repair short to ground in wire 763A (para. 4-80).

NO

Refer to DS maintenance (chapter 14).

TRANSMISSION RANGE PRESSURE SWITCH, CIRCUIT PRESSURE SWITCH C

764A

Disconnect the transmission connector from transmission. Check continuity from J1 pin C to chassis ground at shunt.

YES

Repair short to ground in wire 764A (para. 4-80).

NO

Refer to DS maintenance (chapter 14).
The Transmission Temperature Sensor (TTS) is a thermistor. The resistance decreases as the temperature increases. At 68°F (20°C), the resistance should be from 2,980 to 4,020 ohms. At 248°F (120°C), the resistance should be 90 to 111 ohms.

**RESISTANCE TOO LOW**

923A

Disconnect transmission connector from transmission. Check continuity from J1 pin e to J1 pin c.

YES

Repair short from wire 923A to wire 359A/B/C/D (para. 4-80).

NO

Check continuity from J1 pin e to chassis ground.

YES

Repair wire 923A (para. 4-80).

NO

Refer to DS maintenance (chapter 14).

**RESISTANCE TOO HIGH**

Disconnect transmission connector from transmission. Check continuity from J1 pin e to transmission connector pin L.

YES

Repair break in wire 923A (para. 4-80).

NO

Check continuity from J1 pin c to transmission connector pin M.

YES

Repair break in wire 359A/B/C/D (para. 4-80).

NO

Refer to DS maintenance (chapter 14).
These brake system tests may be run any time you think you have a braking problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary.

Fold-out pages FP-22 (serial numbers 299999 and below) or fold-out page FP-23 (serial numbers 300000 and above) may be left open for reference while testing.

**NOTE**

- The brake lights and the parking brake warning lamp are not diagnosed here. If you are having trouble with these parts and you are sure the brakes are OK, go to instruments page 2-314, for the warning lamp or lights; page 2-376 for the brake lights.
- When parking brake handle is pulled, the parking brake is applied to the left and right rear brake service rotors.
BRAKE SYSTEM

DIAGNOSTIC FLOWCHART

1

START

!!

TEST OPTIONS

TEST PARKING BRAKE USING PROCEDURE AT THE RIGHT.

REASON FOR QUESTION
A working parking brake is necessary for safety.

DOES THE VEHICLE REMAIN STATIONARY USING THE PROCEDURE AT THE RIGHT? (DOES THE PARKING BRAKE WORK?)

GO TO A, Page 2-422

NO

YES

TEST OPTIONS

TEST SERVICE BRAKES USING PROCEDURE AT THE RIGHT.

REASON FOR QUESTION
It is impossible to operate a vehicle safely if the service brakes don't work well.

2

DO THE SERVICE BRAKES PASS THE ROAD TEST PROCEDURE AT THE RIGHT?

YES

Page 2-424

NO

NO FAULTS.

KNOWN INFO

NONE

POSSIBLE PROBLEMS

PARKING BRAKES
SERVICE BRAKES
HYDRAULIC SYSTEM
TIREF PRESSURE

KNOWN INFO

PARKING BRAKE OK

POSSIBLE PROBLEMS

TIREF PRESSURE
SERVICE BRAKES
HYDRAULIC SYSTEM
REFERENCE INFORMATION

WARNING

Make sure the area is clear of personnel and obstacles prior to performing this test. Failure to do so may result in serious injury.

PARKING BRAKE TEST PROCEDURE:

1. Depress service brake pedal and start engine.
2. Place transmission shift lever in D (drive) and transfer case shift lever in H (high).
3. Apply parking brake. Slowly let up on service brake pedal. Vehicle should remain stationary.

SERVICE BRAKE ROAD TEST PROCEDURE:

1. On an open, smooth, flat surface, accelerate to a steady, reasonable, safe speed (below posted limits).
2. Apply pressure on the brake pedal and bring the vehicle to a stop.
3. Repeat this procedure several times, applying a different brake pedal pressure each time. Look for the following symptoms, which may indicate a problem with the service brakes:
   1) Spongy or pulsating brake pedal.
   2) Incomplete brake pedal return.
   3) Excessive pull to one side.
   4) Unusually long braking distance.
   5) Front wheels lock up before rear wheels.
   6) Brake warning light comes on while braking.
   7) A squealing, grinding, or chattering noise while braking.
BRAKE SYSTEM

POSSIBLE PROBLEMS

PADS
CALIPER
ROTOR
CABLE
BRAKE LEVER

TEST OPTIONS

SEE TEST PROCEDURE AT RIGHT.

REASON FOR QUESTION
Parking brake may not be broken; it may just need adjustment.

HAVE YOU TRIED ADJUSTING THE PARKING BRAKE?

TRY ADJUSTING THE PARKING BRAKE.

A1

ARE THE PARKING BRAKE PADS, CALIPER, ROTOR, AND CABLE IN GOOD WORKING ORDER?

REPLACE/REPAIR BAD COMPONENTS.

A2

IS THE PARKING BRAKE SHIFTING LINKAGE IN GOOD WORKING ORDER?

REPAIR/REPLACE LINKAGE.

A3

NO FAULTS.

A FROM 1, Page 2-420

KNOWLEDGE

PARKING BRAKE INOPERATIVE

POSSIBLE PROBLEMS

PADS
CALIPER
ROTOR
CABLE
BRAKE LEVER

KNOWLEDGE

PARKING BRAKE INOPERATIVE

POSSIBLE PROBLEMS

PADS
CALIPER
ROTOR
CABLE
BRAKE LEVER

KNOWLEDGE

PARKING BRAKE INOPERATIVE

POSSIBLE PROBLEMS

PADS
CALIPER
ROTOR
CABLE
BRAKE LEVER

TEST OPTIONS

OPERATE PARKING BRAKE FOR VISUAL INSPECTION.

REASON FOR QUESTION
If the linkage is broken or binding, the parking brake will not function properly.

ARE THE PARKING BRAKE PADS, CALIPER, ROTOR, AND CABLE IN GOOD WORKING ORDER?

REPAIR/REPLACE BAD COMPONENTS.

A2

IS THE PARKING BRAKE SHIFTING LINKAGE IN GOOD WORKING ORDER?

REPAIR/REPLACE LINKAGE.

A3

NO FAULTS.

A FROM 1, Page 2-420

KNOWLEDGE

PARKING BRAKE INOPERATIVE

POSSIBLE PROBLEMS

PADS
CALIPER
ROTOR
CABLE
BRAKE LEVER

TEST OPTIONS

OPERATE PARKING BRAKE FOR VISUAL INSPECTION.

REASON FOR QUESTION
If the linkage is broken or binding, the parking brake will not function properly.

HAVE YOU TRIED ADJUSTING THE PARKING BRAKE?

TRY ADJUSTING THE PARKING BRAKE.

A1

ARE THE PARKING BRAKE PADS, CALIPER, ROTOR, AND CABLE IN GOOD WORKING ORDER?

REPLACE/REPAIR BAD COMPONENTS.

A2

IS THE PARKING BRAKE SHIFTING LINKAGE IN GOOD WORKING ORDER?

REPAIR/REPLACE LINKAGE.

A3

NO FAULTS.
REFERENCE INFORMATION

PARKING BRAKE ADJUSTMENT:
A. Chock wheels and release parking brake handle.
B. Turn adjusting knob at the tip of the brake handle clockwise as tight as possible by hand.
C. Apply parking brake handle.
D. If parking brake cannot be applied, turn adjusting knob counterclockwise until parking brake can be applied.
E. Test parking brake.

WARNING
Make sure the area is clear of personnel and obstacles prior to performing this test. Failure to do so may result in serious injury.

(1) Remove chocks.
(2) Depress service brake pedal and start engine.
(3) Place transmission shift lever in D (drive) and transfer case shift lever in H (high).
(4) Apply parking brake and slowly let up on service brake pedal. Vehicle should remain stationary.

Replace or repair parts (para. 7-1).

Repair or replace linkage (para. 7-19).
BRAKE SYSTEM

DIAGNOSTIC FLOWCHART

B1

IS THE FLUID IN THE MASTER CYLINDER FREE OF CONTAMINATION AND FILLED TO THE PROPER LEVEL?

TEST OPTIONS

VISUAL

REASON FOR QUESTION
Contaminants in fluid or low fluid level decreases braking efficiency, resulting in little or no braking action.

FILL/FLUSH SYSTEM WITH CLEAN BRAKE FLUID.

B2

IS THE MASTER CYLINDER WORKING PROPERLY AND FREE OF LEAKS?

TEST OPTIONS

1. VISUAL
2. FOLLOW TEST PROCEDURE AT THE RIGHT.

REASON FOR QUESTION
A leaky or malfunctioning master cylinder cannot produce sufficient braking forces to safely stop the vehicle.

YES

NO

REPLACE MASTER CYLINDER.

B3

ARE THE BRAKE LINES, HYDRAULIC LINES, AND CALIPER PISTON SEALS FREE OF EVIDENCE OF LEAKING AND STRUCTURAL DAMAGE?

TEST OPTIONS

VISUAL CHECK FOR LEAKS, DAMAGE, BINDING, KINKING, ETC.

REASON FOR QUESTION
If the braking system is losing fluid, stopping distances will increase until the brakes fail due to lack of fluid and fluid pressure.

YES

NO

REPLACE LEAKING LINES AND SEALS.

GO TO B4, PAGE 2-426
Flush and bleed the brake system (para. 7-2 or 7-2.1).

Master cylinder test procedure:
1. With the engine off, pump the brake pedal six or seven times, or until the pedal becomes noticeably stiffer and harder to depress.
2. Press hard on the brake pedal. If the pedal keeps going down to the floor, either the master cylinder is bad or there is a leak in the hydraulic system.

Replace master cylinder (para. 7-5 or para. 7-5.1).

Check the individual lines going to each brake. Check the supply and return lines to the hydro-booster unit. Replace brake line (para. 7-7 or para. 7-7.1).

**NOTE**
Brake hydraulic system must be bled of air whenever hydraulic lines are broken.

Bleed service brake (para. 7-2 or para. 7-2.1).
BRAKE SYSTEM

TEST OPTIONS

FROM B3, Page 2-424

B4

ARE THE BRAKE PADS FREE FROM CONTAMINATION, DIRT, DISTORTION, AND EXCESSIVE WEAR?

YES

NO

REPLACE PADS IN PAIRS (FRONT OR REAR).

TEST OPTIONS

VISUAL

POSSIBLE PROBLEMS

BRAKE PADS
CALIPERS
ROUTERS
PROPOTIONING VALVE
HYDRO-BOOSTER
MECHANICAL COMPONENTS

REASON FOR QUESTION
Dirty, bent, or thin brake pads could cause problems such as noisy brakes, erratic braking, or excessive pedal pressure.

B5

ARE THE FOUR SERVICE BRAKE ROTORS FREE FROM HEAVY SCORING, EXCESSIVE WEAR, WARING, HEAT-SPOTTING, GLAZING, AND CHIPPING?

YES

REPLACE BAD ROTORS.

NO

TEST OPTIONS

VISUAL

POSSIBLE PROBLEMS

ROUTERS
CALIPERS
PROPOTIONING VALVE
HYDRO-BOOSTER
MECHANICAL COMPONENTS

REASON FOR QUESTION
Damaged rotors reduce braking ability and speed up brake failure due to excessive heat buildup.

B6

DO THE FOUR SERVICE BRAKE ROTORS ROTATE FREELY?

YES

SEE NOTE AT RIGHT.

NO

TEST OPTIONS

TRY TO ROTATE ROTORS WHILE WHEELS ARE RAISED.

POSSIBLE PROBLEMS

ROUTERS BINDING
CALIPERS BINDING
PROPOTIONING VALVE
HYDRO-BOOSTER
MECHANICAL COMPONENTS

REASON FOR QUESTION
Sticky rotors can cause erratic braking behavior.
Replace brake pads (para. 7-3 or para. 7-3.1). The minimum brake pad thickness is 1/8 in. (3.2 mm) (serial numbers 299999 and below) 3/16 in. (4.8 mm) (serial numbers 300000 and above).

Replace service brake rotor(s) (para. 7-12 or para. 7-12.1).

The only way the rotors can be sticking is if the calipers are not releasing fully. Remove calipers, clean and lubricate guide pins with grease. Replace and clean brake caliper (para. 7-4 or para. 7-4.1).

**NOTE**
When parking brake handle is pulled the parking brake is applied to the left and right rear brake service rotors.
BRAKE SYSTEM

DIAGNOSTIC FLOWCHART

FROM B6, Page 2-426

B7

KNOW LED INFO
- PARKING BRAKE OK
- MASTER CYLINDER OK
- BRAKE PADS OK
- ROTORS OK
- CALIPERS OK

POSSIBLE PROBLEMS
- PROPORTIONING VALVE
- HYDRO-BOOSTER
- MECHANICAL COMPONENTS

DOES THE PROPORTIONING VALVE WORK PROPERLY?

TEST OPTIONS
- SEE TEST EXPLANATION AT RIGHT.

REASON FOR QUESTION
This valve regulates the flow of hydraulic fluid. If it's broken, the brakes may behave erratically.

YES

NO

REPLACE PROPORTIONING VALVE.

B8

KNOW LED INFO
- PARKING BRAKE OK
- MASTER CYLINDER OK
- BRAKE PADS OK
- ROTORS OK
- CALIPERS OK
- PROPORTIONING VALVE OK

POSSIBLE PROBLEMS
- HYDRO-BOOSTER
- MECHANICAL COMPONENTS

IS THE HYDRO-BOOSTER WORKING PROPERLY?

TEST OPTIONS
- SEE INSTRUCTIONS AT RIGHT.

REASON FOR QUESTION
The hydro-booste is an integral part of the braking system.

YES

GO TO C1 Page 2-430

NO

B9

KNOW LED INFO
- PARKING BRAKE OK
- MOST BRAKE SYSTEM COMPONENTS OK

POSSIBLE PROBLEMS
- PEDAL RETURN SPRING
- PEDAL BUSHING
- FRONT TOE-IN
- REAR TOE-OUT

LOOK AT THE BRAKE PEDAL. DOES IT MOVE THROUGH ITS FULL OPERATING RANGE?

TEST OPTIONS
- VISUAL INSPECTION - SPECIFICALLY CHECK PEDAL RETURN SPRING AND BUSHING.

REASON FOR QUESTION
A brake pedal that doesn't return to its normal position could cause the brakes to drag.

YES

REPAIR/REPLACE WORN PARTS.

NO

GO TO STEERING Page 2-452.1

2-428 Change 6
Test for faulty proportioning valve:
Drive the vehicle and have an assistant observe during the performance of this test. With vehicle at curb weight, decelerate vehicle from 45 to 40 mph (72 to 69 kph) on dry concrete road and apply sufficient pressure to lock up front brakes. If rear brakes lock up before front brakes, the proportioning valve should be replaced. Replace proportioning valve (para. 7-10).

Method for checking hydro-booster:
Depress brake pedal several times to exhaust accumulator pedal. Depress brake pedal and start engine. Brake pedal should fall, then push back against operator's foot. Replace hydro-booster (para. 7-6).

Replace service brake pedal (para. 7-9). The steering tests will check for suspension problems that will affect braking.
**BRAKE SYSTEM**

**KNOWN INFO**
- Hydro-Booster system not working properly

**POSSIBLE PROBLEMS**
- Hydro-Booster
- Power steering fluid serpentine belt
- Power steering system

**C1**
**TEST OPTIONS**
- Visual

**IS THE FLUID LEVEL IN THE POWER STEERING PUMP RESERVOIR OK?**

**FILL TO PROPER LEVEL AND BLEED IF NECESSARY.**

**YES**

**NO**

**REPLACE SERPENTINE BELT.**

**C2**
**TEST OPTIONS**
- Visual inspection of belt tensioner

**IS THE SERPENTINE BELT IN GOOD CONDITION?**

**YES**

**REPLACE SERPENTINE BELT.**

**NO**

**REASON FOR QUESTION**
- If power steering system isn't working properly, the hydro-booster may not get enough power to work properly.

**C3**
**TEST OPTIONS**
- Check components. You can run the tests in Para. 2-42 to test the steering.

**ARE ALL THE POWER STEERING HYDRAULIC COMPONENTS KNOWN TO BE OK?**

**REPLACE AS REQUIRED.**

**YES**

**NO**

**REPLACE HYDRO-BOOSTER.**

**C FROM B8, Page 2-428**

**REASON FOR QUESTION**
- The hydro-booster gets its power from the power steering pump.
Bleed power steering system (para. 8-27).

Replace serpentine belt (para. 3-81).

A defective power steering pump, gear, hoses, or control valve could affect hydro-booster operation.

2-431/(2-432 blank)
2-42. STEERING SYSTEM TESTS (SERIAL NUMBERS 299999 AND BELOW)

These steering system tests may be run any time you have a steering problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary.

The fold-out page shows the location of the major components of the steering in case you are not familiar with them. These parts are shown in a schematic manner. Illustrations of the actual components are given wherever applicable on the reference pages of the diagnostics.

Fold-out page FP-24 may be left open for reference while testing. The functional flow diagram shows the mechanical and hydraulic parts of the system and how they interact. Even if the hydraulic system fails, you will still be able to steer the vehicle, although it will require more effort.
**STEERING SYSTEM**  
(S/N 299999 AND BELOW)

**DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**

1. **DOES THE VEHICLE STEER STRAIGHT WHILE BRAKING (WHILE GOING FORWARDS AND BACKWARDS)?**
   - **YES**: Go to Brakes, Page 2-419. Return if no faults found.
   - **NO**: Drive vehicle and make several stops at moderate speeds from forward and reverse directions.
     - **REASON FOR QUESTION**: If vehicle pulls to one side or other while braking, the problem is likely to be in the brake system.

2. **DOES THE VEHICLE STEER STRAIGHT WHILE DRIVING ON A LEVEL ROAD AT A MODERATE SPEED?**
   - **NO**: Go to A, Page 2-436
   - **YES**: Try it. The vehicle should not wander, but track straight with a minimum of steering effort.
     - **REASON FOR QUESTION**: The vehicle should travel in a straight line with a minimum of steering correction.

3. **DOES THE VEHICLE STEER NORMALLY DURING TURNS (WITHOUT UNDUE EFFORT)?**
   - **NO**: Go to B, Page 2-440
   - **YES**: Drive vehicle and make turns.
     - **REASON FOR QUESTION**: Hard or noisy steering is usually due to power steering system failures.

Go to 4, Page 2-436
REFERENCE INFORMATION

STEERING SYSTEM
(S/N 299999 AND BELOW)

WARNING
Make sure that the area where you conduct these tests is free of natural and man-made obstructions. Failure to do so may result in serious injury.

PRIOR TO PERFORMING THESE TESTS:
Visually inspect steering components:
1. Check all four tires and rims for wear, inflation, damage, or warping.
   a. Adjust tire pressure (TM 9-2320-387-10).
   b. Replace any unserviceable rims (para. 8-4).
2. Check steering linkage for damage.
   a. Replace any damaged steering linkage components (para. 8-11).
   b. Lubricate steering linkage (TM 9-2320-387-10).
3. Check power steering fluid for contamination and level (TM 9-2320-387-10).
   a. Drain and replace any fluid that appears black and smells burnt.
   b. Bleed air from system where fluid appears milky white (para. 8-27).
4. Check serpentine drivebelt for fraying, cracks, or damage.
   Replace damaged serpentine drivebelt (para. 3-81).

While travelling at a moderate speed (20 mph (32 kph)), apply the brakes while applying minimal pressure to the steering wheel. If pull to one side or the other occurs, make a note of the speed and on what side of the vehicle it occurs. Repeat this procedure for different speeds and braking forces. If the vehicle seems to steer straight while braking, there probably isn't a problem with the brakes (at least not one that affects the steering). If the braking action feels strange in any way, the brake diagnostics should be run to assure vehicle safety. This test will usually reveal problems with frozen brake calipers.

If the wheels are out of alignment or if the tires are worn unevenly, vehicle may wander.

Symptoms of bad steering characteristics include hard steering, excessive play in steering, a momentary increase in steering effort when turning wheel quickly, and jerking of the steering wheel when turning.
STEERING SYSTEM
(S/N 299999 AND BELOW)

DIAGNOSTIC FLOWCHART

IS THE VEHICLE FREE FROM RATTLING NOISES AND STRANGE VIBRATIONS WHEN TURNING OR GOING OVER ROUGH TERRAIN?

KNOWN INFO

| BRAKES OK |
| STRAIGHT LINE |
| BEHAVIOR OK |
| POWER STEERING |
| SYSTEM OK |

POSSIBLE PROBLEMS

SUSPENSION

TEST OPTIONS

TEST DRIVE - LISTEN AND FEEL FOR VIBRATION AND OTHER NOISE.

REASON FOR QUESTION

If there was no noise on smooth ground and there is now, there is probably a problem with the suspension.

FROM 3, Page 2-434

GO TO C, Page 2-446

NO FAULTS.

YES

NO
Drive the vehicle until the tires warm up. If the condition goes away, it was probably caused by a burst lube pack or a flat spot on a tire. Both of these conditions are OK since the vehicle will operate normally after the tires warm up.
TM 9-2320-387-24-1

STEERING SYSTEM
(S/N 299999 AND BELOW)

DIAGNOSTIC FLOWCHART

A1

ARE THE TIRES AND WHEELS OK?

TEST OPTIONS
1. CHECK THE TIRES FOR PROPER INFLATION AND FOR UNEVEN OR EXCESSIVE WEAR.
2. CHECK THE WHEELS FOR LARGE DENTS OR WARPAGE.

REASON FOR QUESTION
You can't expect the vehicle to steer OK if the tires are not good.

NO
REPAIR OR REPLACE AS NEEDED.

YES

A2

DO THE FRONT WHEELS HAVE THE PROPER AMOUNT OF TOE-IN?

TEST OPTIONS
MEASURE TOE-IN.

REASON FOR QUESTION
Poorly adjusted toe-in could have an effect on directional stability.

NO
ADJUST TOE-IN.

YES

A3

DO THE REAR WHEELS HAVE THE PROPER AMOUNT OF TOE-OUT?

TEST OPTIONS
MEASURE TOE-OUT.

REASON FOR QUESTION
Poorly adjusted toe-out could have an effect on directional stability.

NO
ADJUST TOE-OUT.

YES

GO TO C.

Page 2-446

2-438 Change 6
Uneven tire wear can be caused by improper inflation, suspension misalignment or damage, hard service, or wheel imbalance. For wheel and tire replacement and maintenance procedures, refer to para. 8-3.

For instructions on adjusting front wheel toe-in, refer to para. 8-9.

For instructions on adjusting rear wheel toe-out, refer to para. 8-10. Part C will test out the suspension parts to see if they are OK.
DIAGNOSTIC FLOWCHART

STEERING SYSTEM
(S/N 299999 AND BELOW)

KNOWN INFO
STRAIGHT LINE BEHAVIOR OK BRAKES OK HARD STEERING

POSSIBLE PROBLEMS
POWER STEERING PUMP POWER STEERING COMPONENTS SUSPENSION

B1
IS THE SERPENTINE BELT IN GOOD CONDITION?

TEST OPTIONS
LOOK AT BELT TENSIONER POSITION.

REASON FOR QUESTION
If belt tensioner has fully retracted, the power steering unit will not work properly.

ADJUST OR REPLACE BELTS.

YES

KNOWN INFO
WHEELS AND TIRES OK BRAKES OK HARD STEERING SERPENTINE BELT OK

POSSIBLE PROBLEMS
POWER STEERING PUMP POWER STEERING COMPONENTS SUSPENSION

B2
IS THE FLUID LEVEL NORMAL IN THE POWER STEERING PUMP?

TEST OPTIONS
CHECK THE CAP/DIPSTICK FOR PROPER FLUID LEVEL.

REASON FOR QUESTION
Low fluid level may cause power steering pump to work improperly.

NO

ADD FLUID AND BLEED SYSTEM.

YES

KNOWN INFO
WHEELS AND TIRES OK BRAKES OK HARD STEERING SERPENTINE BELT OK FLUID LEVEL OK

POSSIBLE PROBLEMS
POWER STEERING PUMP POWER STEERING COMPONENTS SUSPENSION

B3
ARE THE POWER STEERING PUMP, PULLEY, AND BRACKET FIRMLY ATTACHED AND IN GOOD WORKING ORDER?

TEST OPTIONS
CHECK THEM.

REASON FOR QUESTION
Loose or broken power steering components could cause power steering assist to work improperly.

NO

REPAIR/REPLACE POWER STEERING COMPONENTS.

YES

GO TO B4, Page 2-442

2-440 Change 6
REFERENCE INFORMATION

STEERING SYSTEM
(S/N 299999 AND BELOW)

Check serpentine belt tensioner position.

CAUTION
Do not overfill hydraulic fluid.
See TM 9-2320-387-10 for fluid replacement procedure. For bleeding procedure, refer to para. 8-27.
Low fluid level could indicate a problem elsewhere in the system; either leaking hydraulic lines or a leaking or damaged power steering pump. If adding fluid seems to cure the problem, you should probably run the rest of the tests to make sure there aren't any other problems.

CAUTION
Serpentine belt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path. Inspect water pump pulley for proper installation and ease of rotation. Any wobble or misalignment will cause belt failure. Refer to para. 3-81 for pulley alignment procedures.
A loose pump, pulley, or bracket could cause excess noise, slipping belt, or other malfunctions. For appropriate repair or replacement procedures, refer to para. 8-23.
TEST OPTIONS

VISUAL

REASON FOR QUESTION
Leaking fluid from the hydraulic hoses could indicate a bad hose or a bad component.

NO

REPLACE DEFECTIVE HOSES.

YES

REPLACE DEFECTIVE HOSES.

B4

ARE THE COMPONENTS LISTED AT THE RIGHT CLEAN, TIGHT, AND FREE OF EVIDENCE OF LEAKING FLUID?

NO

B5

THE NEXT THREE QUESTIONS DON’T HAVE A NO PATH. REMEMBER THE ANSWERS UNTIL THE END OF THE TEST CHAIN.

YES

B6

GO TO B6, Page 2-442.2
Check hydraulic hoses, power steering pump, power steering cooler, hydraulic control valve, hydro-booster unit, steering gear, fan shroud, and fan clutch. See hose replacement procedures (refer to para 8-24). Check power steering cooler for bent fins or any other airflow restrictions. Straighten fins or replace power steering cooler (para. 3-8) if damaged beyond repair.

1. With engine off, disconnect pressure hose from hydro-boost and connect tube and quick-disconnect to hydro-boost.

   **NOTE**
   Have drainage container ready to catch fluid.

2. Connect adapter and quick-disconnect to pressure hose.

3. Connect hose from valve on power steering analyzer to tube and quick-disconnect on hydro-boost.

4. Connect hose from gauge side of power steering analyzer to adapter and quick-disconnect on pressure hose.

5. Loosen hose clamp and remove cooler hose from return tube on steering gearbox.

6. Plug hose with plug or bolt (3/8 in. or 10 mm dia.) and secure with hose clamp.

7. Connect bypass hose to tube on steering gearbox and secure with hose clamp.

(continued on page 2-443)
DOES THE COOLING FAN DISENGAGE PROPERLY?

YES

REMEMBER FOR END OF TEST

NO

FROM B5, Page 2-442

TEST OPTIONS

SEE NOTE AT RIGHT.

REASON FOR QUESTION

If the power steering pump can develop enough pressure to disengage the fan, the pump and gear are probably OK.

KNOWN INFO

HARD OR ABNORMAL STEERING

POSSIBLE PROBLEMS

POWER STEERING PUMP
POWER STEERING GEAR
FAN DRIVE
HYDRO-BOOSTER
POWER STEERING COOLER

GO TO B7
PAGE 2-444
8. Loosen hose clamp and remove control valve return hose from tube on power steering pump.
9. Plug return hose with plug or bolt (3/8 in. or 10 mm dia.) and secure with hose clamp.
10. Connect other end of bypass hose to tube on power steering pump and secure with hose clamp.
11. Connect STE/ICE-R to vehicle diagnostic connector and set for measuring RPM (para. 2-46).
12. Open analyzer valve to full open position.
13. Start engine (Refer to TM 9-2320-387-10).
14. Remove power steering reservoir cap and turn steering wheel all the way left, hold in place for 5 seconds, then repeat process with steering wheel all the way right. This releases air from the system.
15. Return steering wheel to center position and shut engine off (para. 3-45).
16. Check and add power steering fluid to reach FULL COLD level in reservoir (Refer to TM 9-2320-387-10).
17. Start engine (Refer to TM 9-2320-387-10) and allow engine to idle and reach operating temperature of 190° F to 230° F.
18. Check for proper engine idle speeds and adjust if necessary (para. 3-45).
   6.5L engine          700±25 RPM
   6.5L detuned engine          700±25 RPM

19. Ensure analyzer valve is in full open position and engine is at proper idle speed.
20. Initial pressure should be 150-250 psi and a flow of 2.50-3.50 gpm. If these specifications aren’t present, check installation of analyzer and check power steering system (Refer to TM 9-2320-387-10).
21. With power steering system working properly, partially close analyzer valve until pressure reaches 700 psi. If flow rate varies more than 1 gpm from the initial reading, replace power steering pump (para. 8-23).

   **CAUTION**

   Do not leave analyzer valve fully closed for more than 5 seconds. Severe damage may occur to power steering pump.

22. With engine at idle, close and open analyzer valve three times, recording pressure each time. All readings should be 1300 psi or higher, if pressure is lower, replace power steering pump (para. 8-23).
23. With analyzer valve in the open position, increase engine rpm to 1500 and record fluid flow. If fluid flow varies more than 1 gpm from initial reading, replace power steering pump (para. 8-23).
24. With engine at idle, turn steering wheel all the way left, hold in place for 5 seconds, then repeat process with steering wheel all the way right and record flow rates. If flow rate does not drop to 1 gpm or less, replace steering gearbox (para. 8-20).
25. With engine at idle, turn wheels slightly left and right and release quickly. If pressure does not increase and snap back within 2 seconds, check steering shaft and column for binding and repeat step 15. If pressure still does not increase and snap back, replace steering gearbox (para. 8-20).
26. With engine at idle, push brake pedal down and hold. Record pressure. If pressure varies more than 50 psi from step 22, replace hydro-boost (para. 7-6).
27. With engine at idle, push brake pedal down and release quickly. If pressure does not increase and snap back within 2 seconds, replace hydro-boost (para. 7-6).
28. Shut off engine. Remove power steering analyzer and restore power steering system to original configuration.
29. Bleed power steering system (para. 8-27).

   **NOTE**

   You must be certain that the engine cooling system is working ok, or this test won’t tell you anything. If the engine is cold, and everything is working ok, the fan should be disengaged. You can tell by gently revving the engine in neutral with the hood open. If the fan is engaged you will feel a breeze outside the driver’s door. If it’s disengaged, you won’t feel it. If you aren’t sure if it’s working ok, run the tests in Paragraph 2-31.

---

**REFERENCE INFORMATION**

**STEERING SYSTEM**

(S/N 299999 AND BELOW)
Diagnoistic Flowchart:

**Steering System**

(S/N 299999 and below)

**Known Info**

Hard or Abnormal Steering

**Possible Problems**

Power Steering Pump
Power Steering Gear
Fan Drive
Hydro-Booster

**B7**

Is the Hydro-Booster Working Properly?

**Test Options**

See procedures at right.

**Reason for Question**

The hydro-booster will affect the operation of the steering system.

**Remember for End of Test.**

**B8**

Turn steering wheel slightly to left or right and release wheel quickly. The steering wheel should center itself. Does this happen?

**Test Options**

Try it.

**Reason for Question**

The steering gear is working properly if this happens.

**Remember for End of Test.**

**B9**

Look at the chart to the right to determine what is wrong and repair it as directed.
Method for checking hydro-booster: Depress brake pedal several times to exhaust accumulator. Depress brake pedal and start engine. Brake pedal should fall and then push back against operator's foot.

<table>
<thead>
<tr>
<th>ANSWERS TO QUESTION</th>
<th>COMPONENT TO REPLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>B6       B7       B8</td>
<td>POWER STEERING PUMP</td>
</tr>
<tr>
<td>NO       NO       NO</td>
<td>SEE NOTE BELOW</td>
</tr>
<tr>
<td>NO       NO       YES</td>
<td>SEE NOTE BELOW</td>
</tr>
<tr>
<td>NO       YES      NO</td>
<td>RUN ENGINE COOLING TEST (PARA. 2-25)</td>
</tr>
<tr>
<td>NO       YES      YES</td>
<td>POWER STEERING PUMP</td>
</tr>
<tr>
<td>YES      NO       NO</td>
<td>HYDRO-BOOSTER</td>
</tr>
<tr>
<td>YES      YES      NO</td>
<td>DS LEVEL (CHAPTER 14) STEERING GEAR</td>
</tr>
<tr>
<td>YES      YES      YES</td>
<td>NO FAULTS</td>
</tr>
</tbody>
</table>

NOTE
To diagnose the second and third cases to one item, it is necessary to have a power steering analyzer. Additionally, for all cases, check the hoses for the particular part to make sure they are OK.
DIAGNOSTIC FLOWCHART

STEERING SYSTEM
(S/N 299999 AND BELOW)

C1

CHECK THE TIE ROD ENDS, CENTER LINK PITMAN ARM AND IDLER ARM, AND ALL OF THE MOUNTING HARDWARE FOR THESE PARTS. ARE THEY ALL OK?

NO

REPLACE AS NEEDED.

YES

TEST OPTIONS
VISUAL INSPECTION - LOOK FOR BENT PARTS, LOOSE MOUNTINGS AND BAD BUSHINGS.

REASON FOR QUESTION
These are the parts that turn the front wheels in response to the steering wheel movements.

C2

CHECK POWER STEERING DRIVEBELT PULLEY FOR GROOVES AND SCORING, AND MAKE SURE BELT TENSIONER POSITION INDICATES SERPENTINE BELT IS OK. ARE THESE OK?

NO

REPLACE DAMAGED/WORN BELT OR PULLEY.

YES

TEST OPTIONS
VISUAL INSPECTION OF PULLEY AND BELT TENSIONER.

REASON FOR QUESTION
A damaged pulley will ruin the serpentine belt. A damaged serpentine belt will slip, causing the power steering to loose power or fail.

C3

ARE THE BALL JOINTS OK (NOT WORN)?

NO

REPLACE BALL JOINTS.

YES

TEST OPTIONS
SEE PROCEDURE AT RIGHT.

REASON FOR QUESTION
Worn ball joints can result in difficult or noisy steering.

GO TO C4, Page 2-448

2-446 Change 6
REFERENCE INFORMATION

STEERING SYSTEM
(S/N 299999 AND BELOW)

Check for looseness in idler arm and pitman arm (paras. 8-17 and 8-13). For replacing center link, refer to para. 8-14. For replacing tie rods, refer to para. 8-16.

For replacing the pulley, refer to para. 8-23.

CAUTION
Do not loosen slotted nut to install cotter pin. Loosening the nut may result in damage to the equipment.

To check for proper operation of ball joints:
(1) Chock rear wheels front and back.
(2) Raise front wheels about 2 in. off the ground and support on a jack stand.
   a. For Lower Ball Joints
(3) Mark a line across the head of the top bolt holding the steering arm cover. Make sure the mark is parallel to the lower control arm.
(4) Put a prybar between the cover control arm and geared hub.
(5) Set a 6-in. ruler upright between the lower control arm and the marked screw.
(6) Push down the prybar to try to move the hub.
(7) Measure movement in the hub assembly. If movement is more than 1/8 in. (3 mm), replace lower ball joint (para. 6-24).
   b. For Upper Ball Joints
(8) Grasp top of tire and attempt to move it IN and OUT.
(9) Grasp upper control arm and attempt to move it up and down.
(10) If there is any noticeable movement between geared hub and upper control arm, replace upper ball joint (para. 6-23).
STEERING SYSTEM
(S/N 299999 AND BELOW)

DIAGNOSTIC FLOWCHART

FROM C3, Page 2-446

C4

ARE THE CONTROL ARMS AND THEIR BUSHINGS OK?

TEST OPTIONS
VISUAL INSPECTION - LOOK FOR BROKEN OR WORN BUSHINGS AND BENT CONTROL ARMS. ALSO CHECK MOUNTING HARDWARE.

REASON FOR QUESTION
Worn control arms reduce steerability of the vehicle and reduce tire life.

YES

NO

REPLACE CONTROL ARMS/BUSHINGS.

C5

ARE THE SHOCK ABSORBERS AND COIL SPRINGS OPERATING EFFECTIVELY?

TEST OPTIONS
SEE PROCEDURE AT RIGHT.

REASON FOR QUESTION
Broken or fatigued shock absorbers and coils can lead to loss of steering control on rough surfaces.

NO

YES

REPLACE SHOCKS/COIL SPRINGS.

C6

ARE THE RADIUS RODS OK (NOT WORN OUT)?

TEST OPTIONS
VISUAL INSPECTION - CHECK FOR EXCESSIVE WEAR, UNSERVICEABLE BUSHINGS.

REASON FOR QUESTION
The radius rods serve to keep the rear wheels pointed in the proper direction.

NO

YES

REPLACE RADIUS ROD.

GO TO C7, Page 2-450
REFERENCE INFORMATION

STEERING SYSTEM
(S/N 299999 AND BELOW)

For upper and lower control arm and bushing replacement instructions, refer to paras. 6-25 and 6-26.

To test the shocks and springs, drive the vehicle over a variety of terrain. If the vehicle continues to bounce after hitting a bump, the shocks may be worn. If the vehicle bottoms out on the suspension, the shocks may be worn. If the vehicle sags when loaded, the springs may be worn. If the shock absorber bodies are not warm after driving the vehicle, the shocks are no good.

For coil spring and shock absorber replacement instructions, refer to paras. 6-27 and 6-28.

For instructions on replacing the radius rod, refer to para. 6-22.
STEERING SYSTEM
(S/N 299999 AND BELOW)

DIAGNOSTIC FLOWCHART

FROM C6, Page 2-448

TEST OPTIONS
VISUAL INSPECTION - LOOK FOR BROKEN HARDWARE AND WORN SPLINES.

REASON FOR QUESTION
These parts carry the motion of the steering wheel to the steering gear.

C7

KNOWLEDGE INFO
MOST STEERING AND SUSPENSION PARTS ARE OK

POSSIBLE PROBLEMS
STEERING SHAFTS CAPSCREWS STABILIZER BAR

CHECK THE STEERING COLUMN AND THE INTERMEDIATE STEERING SHAFT. ARE THEY OK?

REPLACE AS NEEDED.

NO

YES

C8

KNOWLEDGE INFO
WHEELS, TIRES, BRAKES OK
POWER STEERING SYSTEM OK
SUSPENSION OK
MOST STEERING COMPONENTS OK

POSSIBLE PROBLEMS
STABILIZER BAR CAPSCREWS

IS THE STABILIZER BAR OK (BAR AND BAR MOUNTS)?

REPLACE STABILIZER BAR.

NO

YES

C9

KNOWLEDGE INFO
WHEELS, TIRES, BRAKES OK
POWER STEERING SYSTEM OK
BALL JOINTS OK
CONTROL ARMS OK
SHOCKS/SPRINGS OK
SERPENTINE BELT AND PULLEY OK

POSSIBLE PROBLEMS
CAPSCREWS

ARE STEERING GEAR MOUNTING CAPSCREWS ADEQUATELY TIGHT? THEY SHOULD BE TIGHTENED TO 60 FT-LB (81 N-M).

TIGHTEN CAPSCREWS IF NECESSARY.

NO

YES

GO TO C10

PAGE 2-452

TEST OPTIONS
1. VISUAL
2. CHECK WITH TORQUE WRENCH.

REASON FOR QUESTION
If the capscrews get loose or fall out, the steering gearbox could move, causing serious problems with steering.
NOTE
Inspect intermediate shaft U-joints for wear, binding, or missing/damaged grease fittings. Replace or lubricate as necessary. Refer to [para. 8-21] for replacement and TM 9-2320-387-10, Appendix G, for lubrication instructions.

Replace the steering column and intermediate shaft [paras. 8-18 and 8-19].

Replace the stabilizer bar [para. 6-20].

If you still have a problem, rerun the test chain to make sure you didn’t miss anything. If you didn’t go down the A chain, you may want to run those tests in order to check out the hydraulic parts of the steering system.
WITH VEHICLE STARTED, TURN STEERING WHEEL LEFT AND RIGHT AND OBSERVE STEERING GEAR MOUNTING AREA. IS THERE ANY MOVEMENT?

REASON FOR QUESTION
If cracks are present in the welds or inner/outer frame rails, the steering gear could move, causing serious problems with steering.

TEST OPTIONS
1. VISUAL
2. REMOVE STEERING GEAR (PARA. 8-20) AND INSPECT FOR CRACKS.

KNOWN INFO
WHEELS, TIRES, BRAKES OK
POWER STEERING SYSTEM OK
BALL JOINTS OK
CONTROL ARMS OK
SHOCKS/SPRINGS OK
SERPENTINE BELT & PULLEY OK
CAPSCREWS OK

POSSIBLE PROBLEMS
CRACKS AT BOSS WELDS OR INNER/OUTER FRAME RAILS

NOTIFY GENERAL SUPPORT MAINTENANCE.
2-42.1. STEERING SYSTEM TESTS (SERIAL NUMBERS 300000 AND ABOVE)

These steering system test may be run any time you have a steering problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary.

The fold-out page shows the location of the major components of the steering in case you are not familiar with them. These parts are shown in a schematic manner. Illustrations of the actual components are given whenever applicable on the reference pages of the diagnostics.

Fold-out page FP-25 in Appendix F may be left open for reference while testing. The functional flow diagram shows the mechanical and hydraulic parts of the system and how they interact. Even if the hydraulic system fails, you will still be able to steer the vehicle, although it will require more effort.
STEERING SYSTEM (S/N 300000 AND ABOVE)

1. DOES THE VEHICLE STEER STRAIGHT WHILE BRAKING (WHILE GOING FORWARDS AND BACKWARDS)?
   - NO: GO TO BRAKES, Page 2-419, RETURN IF NO FAULTS FOUND.
   - YES: GO TO A, Page 2-452.6

2. DOES THE VEHICLE STEER STRAIGHT WHILE DRIVING ON A LEVEL ROAD AT A MODERATE SPEED?
   - NO: GO TO A, Page 2-452.6
   - YES: GO TO 4, Page 2-452.4

3. DOES THE VEHICLE STEER NORMALLY DURING TURNS (WITHOUT UNDUE EFFORT)?
   - NO: GO TO B, Page 2-452.8
   - YES: GO TO 4, Page 2-452.4

TEST OPTIONS

DRIVE VEHICLE AND MAKE SEVERAL STOPS AT MODERATE SPEEDS FROM FORWARD AND REVERSE DIRECTIONS.

REASON FOR QUESTION
If vehicle pulls to one side or other while braking, the problem is likely to be in the brake system.

TRY IT. THE VEHICLE SHOULD NOT WANDER, BUT TRACK STRAIGHT WITH A MINIMUM OF STEERING EFFORT.

REASON FOR QUESTION
The vehicle should travel in a straight line with a minimum of steering correction.

DRIVE VEHICLE AND MAKE TURNS.

REASON FOR QUESTION
Hard or noisy steering is usually due to power steering system failures.

KNOWN INFO

NOTHING

POSSIBLE PROBLEMS
POWER STEERING PUMP
POWER STEERING COMPONENTS
STEERING LINKAGES
SUSPENSION
BRAKES

KNOWN INFO
BRAKING SYSTEM OK

POSSIBLE PROBLEMS
POWER STEERING PUMP
POWER STEERING COMPONENTS
STEERING LINKAGES
SUSPENSION

KNOWN INFO
BRAKES OK
STRAIGHT LINE BEHAVIOR OK

POSSIBLE PROBLEMS
POWER STEERING PUMP
POWER STEERING COMPONENTS
STEERING LINKAGES
SUSPENSION
WARNING

Make sure that the area where you conduct these tests is free of natural and man-made obstructions. Failure to do so may result in serious injury.

PRIOR TO PERFORMING THESE TESTS:

Visually inspect steering components:

1. Check all four tires and rims for wear, inflation, damage, or warping.
   a. Adjust tire pressure (TM 9-2320-387-10).
   b. Replace any unserviceable rims (para. 8-4.1).

2. Check steering linkage for damage.
   a. Replace any damaged steering linkage components (para. 8-20.1).
   b. Lubricate steering linkage (TM 9-2320-387-10).

3. Check power steering fluid for contamination and level (TM 9-2320-387-10).
   a. Drain and replace any fluid that appears black and smells burnt.
   b. Bleed air from system where fluid appears milky white (para. 8-27).

4. Check serpentine drivebelt for fraying, cracks, or damage.
   Replace damaged serpentine drivebelt (para. 3-81.2).

While travelling at a moderate speed (20 mph 32 kph), apply the brakes while applying minimal pressure to the steering wheel. If pull to one side or the other occurs, make a note of the speed and on what side of the vehicle it occurs. Repeat this procedure for different speeds and braking forces. If the vehicle seems to steer straight while braking, there probably isn’t a problem with the brakes (at least not one that affects the steering). If the braking action feels strange in any way, the brake diagnostics should be run to assure vehicle safety. This test will usually reveal problems with frozen brake calipers.

If the wheels are out of alignment or if the tires are worn unevenly, vehicle may wander.

Symptoms of bad steering characteristics include hard steering, excessive play in steering, a momentary increase in steering effort when turning wheel quickly, and jerking of the steering wheel when turning.
STEERING SYSTEM (S/N 300000 AND ABOVE)

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAKES OK</td>
</tr>
<tr>
<td>STRAIGHT LINE</td>
</tr>
<tr>
<td>BEHAVIOR OK</td>
</tr>
<tr>
<td>POWER STEERING</td>
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<td>SYSTEM OK</td>
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<table>
<thead>
<tr>
<th>POSSIBLE PROBLEMS</th>
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<tr>
<td>SUSPENSION</td>
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</tbody>
</table>

4

**IS THE VEHICLE FREE FROM RATTLING NOISES AND STRANGE VIBRATIONS WHEN TURNING OR GOING OVER ROUGH TERRAIN?**

- **NO**
  - GO TO C. (Page 2-452.16)
  - NO FAULTS.

- **YES**
  - FROM 3, Page 2-452.2

TEST OPTIONS

- TEST DRIVE - LISTEN AND FEEL FOR VIBRATION AND OTHER NOISE.

REASON FOR QUESTION

If there was no noise on smooth ground and there is now, there is probably a problem with the suspension.
Drive the vehicle until the tires warm up. If the condition goes away, it was probably caused by a burst lube pack or a flat spot on a tire. Both of these conditions are OK since the vehicle will operate normally after the tires warm up.
**STEEERING SYSTEM (S/N 300000 AND ABOVE)**

**DIAGNOSTIC FLOWCHART**

**A1**

**ARE THE TIRES AND WHEELS OK?**

- **KNOWN INFO**
  - Vehicle exhibits poor straight line steering

- **POSSIBLE PROBLEMS**
  - TIRES
  - ALIGNMENT
  - SUSPENSION

- **TEST OPTIONS**
  1. Check the tires for proper inflation and for uneven or excessive wear.
  2. Check the wheels for large dents or warpage.

- **REASON FOR QUESTION**
  You can't expect the vehicle to steer OK if the tires are not good.

- **YES**
  - Repair or replace as needed.

- **NO**
  - Go to C1, Page 2-452.16

**A2**

**DO THE FRONT WHEELS HAVE THE PROPER AMOUNT OF TOE-IN?**

- **KNOWN INFO**
  - Wheels and tires ok

- **POSSIBLE PROBLEMS**
  - FRONT AND REAR WHEEL ALIGNMENT SUSPENSION

- **TEST OPTIONS**
  - Measure toe-in.

- **REASON FOR QUESTION**
  Poorly adjusted toe-in could have an effect on directional stability.

- **YES**
  - Adjust toe-in.

- **NO**
  - Go to A3

**A3**

**DO THE REAR WHEELS HAVE THE PROPER AMOUNT OF TOE-OUT?**

- **KNOWN INFO**
  - Wheels and tires ok
  - Front alignment ok

- **POSSIBLE PROBLEMS**
  - SUSPENSION
  - REAR ALIGNMENT

- **TEST OPTIONS**
  - Measure toe-out.

- **REASON FOR QUESTION**
  Poorly adjusted toe-out could have an effect on directional stability.

- **YES**
  - Adjust toe-out.

- **NO**
  - Go to C1, Page 2-452.16
Uneven tire wear can be caused by improper inflation, suspension misalignment or damage, hard service, or wheel imbalance. For wheel and tire replacement and maintenance procedures (refer to para. 8-3).

For instructions on adjusting front wheel toe-in (refer to para. 8-9).

For instructions on adjusting rear wheel toe-in (refer to para. 8-10). Part C will test out the suspension parts to see if they are OK.
IS THE SERPENTINE BELT IN GOOD CONDITION?

TEST OPTIONS
LOOK AT BELT TENSIONER POSITION.

REASON FOR QUESTION
If belt tensioner has fully retracted, the power steering unit will not work properly.

B1

ADJUST OR REPLACE BELTS.

NO

YES

IS THE FLUID LEVEL NORMAL IN THE POWER STEERING RESERVOIR?

TEST OPTIONS
CHECK THE CAP/DIPSTICK FOR PROPER FLUID LEVEL.

REASON FOR QUESTION
Low fluid level may cause power steering pump to work improperly.

B2

ADD FLUID AND BLEED SYSTEM.

NO

YES

ARE THE POWER STEERING PUMP, PULLEY, AND BRACKET FIRMLY ATTACHED AND IN GOOD WORKING ORDER?

TEST OPTIONS
CHECK THEM.

REASON FOR QUESTION
Loose or broken power steering components could cause power steering assist to work improperly.

B3

REPAIR/REPLACE POWER STEERING COMPONENTS.

NO

YES

GO TO B4.

Page 2-452.10
Serpentine belt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path. Inspect water pump pulley for proper installation and ease of rotation. Any wobble or misalignment will cause belt failure. Refer to [para. 3-81.2] for pulley alignment procedures. A loose pump, pulley, or bracket could cause excess noise, slipping belt, or other malfunctions. For appropriate repair or replacement procedures (refer to [para. 8-23]).
TEST OPTIONS

VISUAL

REASON FOR QUESTION
Leaking fluid from the hydraulic hoses could indicate a bad hose or a bad component.

ARE THE COMPONENTS LISTED AT THE RIGHT CLEAN, TIGHT, AND FREE OF EVIDENCE OF LEAKING FLUID?

REPLACE DEFECTIVE HOSES.

YES

THE NEXT TWO QUESTIONS DON’T HAVE A NO PATH. REMEMBER THE ANSWERS UNTIL THE END OF THE TEST CHAIN.

TEST OPTIONS

1. THIS TEST CHAIN.
2. POWER STEERING ANALYZER (SEE PROCEDURE AT RIGHT REGARDING USE).

REASON FOR QUESTION
You can’t determine what is wrong in the hydraulics until you test everything.

GO TO B6, Page 2-452.14
1. With engine off, disconnect pressure hose from hydro-boost and connect tube and quick-disconnect to hydro-boost.

   **NOTE**
   Have drainage container ready to catch fluid.

2. Connect adapter and quick-disconnect to pressure hose.

3. Connect hose from valve on power steering analyzer to tube and quick-disconnect on hydro-boost.

4. Connect hose from gauge side of power steering analyzer to adapter and quick-disconnect on pressure hose.

5. Connect STE/ICE-R to vehicle diagnostic connector and set for measuring RPM (refer to para. 2-45).

6. Open analyzer valve to full open position.

7. Start engine (refer to TM 9-2320-387-10).

8. Remove power steering reservoir cap and turn steering wheel all the way left, hold in place for 3 seconds, then repeat process with steering wheel all the way right. This releases air from the system.

9. Return steering wheel to center position and shut engine off (refer to para. 3-45).

10. Check and add power steering fluid to reach FULL COLD level in reservoir (refer to TM 9-2320-387-10).

11. Start engine (Refer to TM 9-2320-387-10) and allow engine to idle and reach operating temperature of 190° F to 230° F.

12. Check for proper engine idle speeds and adjust if necessary (refer to para. 3-45).

6.5L engine 700±25 RPM

13. Ensure analyzer valve is in full open position and engine is at proper idle speed.

14. Initial pressure should be 250–400 psi and a flow of 4.00 gpm. If these specifications aren't present, check installation of analyzer and check power steering system (TM 9-2320-387-10).

15. With power steering system working properly, partially close analyzer valve until pressure reaches 700 psi. If flow rate varies more than 1 gpm from the initial reading, replace power steering pump (para. 8-23.1).

**CAUTION**
Do not leave analyzer valve fully closed for more than 3 seconds. Severe damage may occur to power steering pump.

16. With engine at idle, close and open analyzer valve three times, recording pressure each time. All readings should be 1600 psi or higher, if pressure is lower, replace power steering pump (para. 8-23.1).

17. With analyzer valve in the open position, increase engine rpm to 1500 and record fluid flow. If fluid flow varies more than 1 gpm from initial reading, replace power steering pump (para. 8-23.1).
18. With engine at idle, turn steering wheel all the way left, hold in place for 1–3 seconds, then repeat process with steering wheel all the way right and record flow rates. If flow rate does not drop to 1 gpm or less, replace steering gearbox (refer to para. 8-20.1).

19. With engine at idle, turn wheels slightly left and right and release quickly. If pressure does not increase and snap back within 2 seconds, check steering shaft and column for binding and repeat step 9. If pressure still does not increase and snap back, replace steering gearbox (refer to para. 8-20.1).

20. With engine at idle, push brake pedal down and hold. Record pressure. If pressure varies more than 100 psi from step 16, replace hydro-boost (refer to para. 7-6).

21. With engine at idle, push brake pedal down and release quickly. If pressure does not increase and snap back within 2 seconds, replace hydro-boost (refer to para. 7-6).

22. Shut off engine. Remove power steering analyzer and restore power steering system to original configuration.

23. Bleed power steering system (refer to para. 8-27).
**DIAGNOSTIC FLOWCHART**

**POWER STEERING PUMP**
**POWER STEERING GEAR**
**HYDRO-BOOSTER**

---

**KNOWN INFO**

**B6**

**IS THE HYDRO-BOOSTER WORKING PROPERLY?**

**REASON FOR QUESTION**
The hydro-boost will affect the operation of the steering system.

**TEST OPTIONS**

SEE PROCEDURES AT RIGHT.

---

**TEST OPTIONS**

TRY IT.

**REASON FOR QUESTION**
The steering gear is working properly if this happens.

---

**KNOWN INFO**

**B7**

**TURN STEERING WHEEL SLIGHTLY TO LEFT OR RIGHT AND RELEASE WHEEL QUICKLY. THE STEERING WHEEL SHOULD CENTER ITSELF. DOES THIS HAPPEN?**

**REASON FOR QUESTION**
The steering gear is working properly if this happens.

---

**B8**

**LOOK AT THE CHART TO THE RIGHT TO DETERMINE WHAT IS WRONG AND REPAIR IT AS DIRECTED.**
Method for checking hydro-booster: Depress brake pedal several times to exhaust accumulator. Depress brake pedal and start engine. Brake pedal should fall and then push back against operator's foot.

<table>
<thead>
<tr>
<th>ANSWERS TO QUESTION:</th>
<th>COMPONENT TO REPLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>B6</td>
<td>B7</td>
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<tr>
<td>NO</td>
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<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

**NOTE**

To diagnose the second and third cases to one item, it is necessary to have a power steering analyzer. Additionally, for all cases, check the hoses for the particular part to make sure they are OK.
DIAGNOSTIC FLOWCHART

STEERING SYSTEM
(S/N 300000 AND ABOVE)

KNOWLEDGE
WHEELS AND TIRES OK
BRAKES OK
ALIGNMENT OK

POSSIBLE PROBLEMS
STEERING COMPONENTS
SUSPENSION COMPONENTS

TEST OPTIONS
VISUAL INSPECTION - LOOK FOR BENT PARTS, LOOSE MOUNTINGS AND BAD BUSHINGS.

REASON FOR QUESTION
These are the parts that turn the front wheels in response to the steering wheel movements.

C1
CHECK THE TIE ROD ENDS, CENTER LINK PITMAN ARM AND IDLER ARM, AND ALL OF THE MOUNTING HARDWARE FOR THESE PARTS. ARE THEY ALL OK?

NO
REPLACE AS NEEDED.

YES

C2
CHECK POWER STEERING DRIVEBELT PULLEY FOR GROOVES AND SCORING, AND MAKE SURE BELT TENSIONER POSITION INDICATES SERPENTINE BELT IS OK. ARE THESE OK?

NO
REPLACE DAMAGED/WORN BELT OR PULLEY.

YES

C3
ARE THE BALL JOINTS OK (NOT WORN)?

NO
REPLACE BALL JOINTS.

YES

GO TO C4.

TEST OPTIONS
SEE PROCEDURE AT RIGHT.

REASON FOR QUESTION
Worn ball joints can result in difficult or noisy steering.

KNOWLEDGE
WHEELS AND TIRES OK
BRAKES OK
SERPENTINE BELT OK
STEERING LINKAGES OK

POSSIBLE PROBLEMS
BALL JOINTS
OTHER SUSPENSION COMPONENTS
OTHER STEERING COMPONENTS

REASON FOR QUESTION
A damaged pulley will ruin the serpentine belt. A damaged serpentine belt will slip, causing the power steering to lose power or fail.
To check for proper operation of ball joints:
(1) Chock rear wheels front and back.
(2) Raise front wheels about two inches off the ground and support on a jack stand.

NOTE
If ball joint boot is ripped or torn, ball joint is unserviceable.
(a) Lower ball joints.
(3) Mark a line across the head of the top bolt holding the steering arm cover. Make sure the mark is parallel to the lower control arm.
(4) Put a prybar between the cover control arm and gear hub.
(5) Set a 6-inch ruler upright between the lower control arm and the marked screw.
(6) Push down the prybar to try to move the hub.
(7) Measure movement in the hub assembly. If movement is more than 1/8 inch (3 mm), replace lower ball joint (refer to para. 6-27).
(b) Upper ball joints.
(8) Visually inspect ball joint boot, and replace upper ball joint if boot is ripped or torn.
(9) Grasp top of tire and attempt to move tire IN and OUT. Observe upper control arm and gear hub where upper ball joint is mounted. If lateral movement is observed, upper ball joint may be worn.
(10) Replace upper ball joint if movement is 1/8 in. (3 mm) or more (refer to para. 6-23).

For replacing center link, refer to para. 8-17. For replacing pulley (refer to para. 8-23.1).

REFERENCE INFORMATION
STEERING SYSTEM
(S/N 300000 AND ABOVE)

CAUTION
Do not loosen slotted nut to install cotter pin. Loosening the nut may result in damage to the equipment.

To check for proper operation of ball joints:
(1) Chock rear wheels front and back.
(2) Raise front wheels about two inches off the ground and support on a jack stand.

NOTE
If ball joint boot is ripped or torn, ball joint is unserviceable.
(a) Lower ball joints.
(3) Mark a line across the head of the top bolt holding the steering arm cover. Make sure the mark is parallel to the lower control arm.
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(6) Push down the prybar to try to move the hub.
(7) Measure movement in the hub assembly. If movement is more than 1/8 inch (3 mm), replace lower ball joint (refer to para. 6-27).
(b) Upper ball joints.
(8) Visually inspect ball joint boot, and replace upper ball joint if boot is ripped or torn.
(9) Grasp top of tire and attempt to move tire IN and OUT. Observe upper control arm and gear hub where upper ball joint is mounted. If lateral movement is observed, upper ball joint may be worn.
(10) Replace upper ball joint if movement is 1/8 in. (3 mm) or more (refer to para. 6-23).
STEERING SYSTEM (S/N 300000 AND ABOVE)

C4
ARE THE CONTROL ARMS AND THEIR BUSHINGS OK?

YES
REPLACE CONTROL ARMS/BUSHINGS.

NO

C5
ARE THE SHOCK ABSORBERS AND COIL SPRINGS OPERATING EFFECTIVELY?

YES
REPLACE SHOCKS/COIL SPRINGS.

NO

C6
ARE THE RADIUS RODS OK (NOT WORN OUT)?

YES
REPLACE RADIUS ROD.

NO

TEST OPTIONS
VISUAL INSPECTION - LOOK FOR BROKEN OR WORN BUSHINGS AND BENT CONTROL ARMS. ALSO CHECK MOUNTING HARDWARE.

REASON FOR QUESTION
Worn control arms reduce steerability of the vehicle and reduce tire life.

TEST OPTIONS
SEE PROCEDURE AT RIGHT.

REASON FOR QUESTION
Broken or fatigued shock absorbers and coils can lead to loss of steering control on rough surfaces.

TEST OPTIONS
VISUAL INSPECTION - CHECK FOR EXCESSIVE WEAR, UNSERVICEABLE BUSHINGS.

REASON FOR QUESTION
The radius rods serve to keep the rear wheels pointed in the proper direction.

FROM C3, Page 2-452.16

GO TO C7, Page 2-452.20
For upper and lower control arm and bushing replacement instructions (refer to para. 6-25).

To test the shocks and springs, drive the vehicle over a variety of terrain. If the vehicle continues to bounce after hitting a bump, the shocks may be worn. If the vehicle bottoms out on the suspension, the shocks may be worn. If the vehicle sags when loaded, the springs may be worn. If the shock absorber bodies are not warm after driving the vehicle, the shocks are no good. For coil spring and shock absorber replacement instructions (refer to para. 6-27 and para. 6-28).

For instructions on replacing the radius rod (refer to para. 6-22).
ARE STEERING GEAR MOUNTING CAPSCREWS ADEQUATELY TIGHT? THEY SHOULD BE TIGHTENED TO 160–195 FT-LB (217–264 N•M)

NO

TIGHTEN CAPSCREWS IF NECESSARY.

YES

GO TO C10.

TEST OPTIONS
1. VISUAL
2. CHECK WITH TORQUE WRENCH.

REASON FOR QUESTION
If the capscrews get loose or fall out, the steering gearbox could move, causing serious problems with steering.

POSSIBLE PROBLEMS
CAPSCREWS

KNOWLEDGE
WHEELS, TIRES, BRAKES OK
POWER STEERING SYSTEM OK
BALL JOINTS OK
CONTROL ARMS OK
SHOCKS/SPRINGS OK
SERPENTINE BELT AND PULLEY OK

KNOWLEDGE
WHEELS, TIRES, BRAKES OK
POWER STEERING SYSTEM OK
SUSPENSION OK
MOST STEERING COMPONENTS OK

POSSIBLE PROBLEMS
STABILIZER BAR CAPSCREWS

IS THE STABILIZER BAR OK (BAR AND BAR MOUNTS)?

NO

REPLACE STABILIZER BAR.

YES

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If the bar is broken or loose, the vehicle could be hard to control at moderate to high speeds during turns.

POSSIBLE PROBLEMS
STABILIZER BAR CAPSCREWS

KNOWLEDGE
WHEELS, TIRES, BRAKES OK
POWER STEERING SYSTEM OK

ARE STEERING GEAR MOUNTING CAPSCREWS ADEQUATELY TIGHT? THEY SHOULD BE TIGHTENED TO 160–195 FT-LB (217–264 N•M)

NO

TIGHTEN CAPSCREWS IF NECESSARY.

YES

GO TO C10.

TEST OPTIONS
VISUAL INSPECTION - LOOK FOR BROKEN HARDWARE AND WORN SPLINES.

REASON FOR QUESTION
These parts carry the motion of the steering wheel to the steering gear.

POSSIBLE PROBLEMS
STEERING SHAFTS CAPSCREWS STABILIZER BAR

KNOWLEDGE
MOST STEERING AND SUSPENSION PARTS ARE OK

CHECK THE STEERING COLUMN AND THE INTERMEDIATE STEERING SHAFT. ARE THEY OK?

NO

REPLACE AS NEEDED.

YES

GO TO C6.

FROM C6.
Page 2-452.18

DIAGNOSTIC FLOWCHART

STEERING SYSTEM (S/N 300000 AND ABOVE)
NOTE
Inspect intermediate shaft U-joints for wear, binding, or missing/damaged grease fittings. Replace or lubricate as necessary. Refer to para. 8-21 for replacement and TM 9-2320-387-10, for lubrication instructions.

Replace the steering column and intermediate shaft [para. 8-18] and [para. 8-19].

Replace the stabilizer bar [para. 6-20.1].

If you still have a problem, rerun the test chain to make sure you didn’t miss anything. If you didn’t go down the A chain, you may want to run those tests in order to check out the hydraulic parts of the steering system.
2. REMOVE STEERING GEAR (PARA. 8-20.1) AND INSPECT FOR CRACKS.

REASON FOR QUESTION
If cracks are present in the welds or inner/outer frame rails, the steering gear could move, causing serious problems with steering.

TEST OPTIONS
1. VISUAL
2. REMOVE STEERING GEAR (PARA. 8-20.1) AND INSPECT FOR CRACKS.

KNOWN INFO
- WHEELS, TIRES, BRAKES OK
- POWER STEERING SYSTEM OK
- BALL JOINTS OK
- CONTROL ARMS OK
- SHOCKS/SPRINGS OK
- SERPENTINE BELT & PULLEY OK
- CAPSCREWS OK

POSSIBLE PROBLEMS
- CRACKS AT BOSS WELDS OR INNER/OUTER FRAME RAILS

WITH VEHICLE STARTED, TURN STEERING WHEEL LEFT AND RIGHT AND OBSERVE STEERING GEAR MOUNTING AREA. IS THERE ANY MOVEMENT?

NO

NO FAULTS

YES

NOTIFY GENERAL SUPPORT MAINTENANCE.
2-43. DRIVETRAIN TESTS

These drivetrain tests may be run any time you think you have a drivetrain problem or if you were sent here by another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary.

The fold-out page shows the location of the major components of the drivetrain system in case you are not familiar with them.

Fold-out page FP-27 may be left open for reference while testing. Also, due to the design of the functional flow diagram, it is not necessary to have a location of parts diagram so it has been omitted.

**NOTE**
Problems with the transmission and drivetrain cooling system are dealt with in para. 2-40.
DRIVETRAIN

1. IS THE TRANSMISSION FLUID OK?
   - KNOWLEDGE
     NOTHING
   - POSSIBLE PROBLEMS
     TRANSFER CASE DIFFERENTIALS HALF AND PROPELLER SHAFTS CV AND U-JOINTS GEARED HUBS
   - TEST OPTIONS
     VISUAL - SEE NOTE AT RIGHT.
   - REASON FOR QUESTION
     The transfer case shares its fluid with the transmission system.
   - SEE NOTE AT RIGHT.

2. ROAD-TEST THE VEHICLE. DOES IT PASS?
   - KNOWLEDGE
     FLUID OK
   - POSSIBLE PROBLEMS
     TRANSFER CASE DIFFERENTIALS HALF AND PROPELLER SHAFTS CV AND U-JOINTS GEARED HUBS
   - TEST OPTIONS
     TRY ALL TRANSFER CASE OPTIONS AND NOTE UNUSUAL BEHAVIOR.
   - REASON FOR QUESTION
     A road test is the best way to test the drivetrain.
   - NO
     GO TO A, Page 2-460
   - YES
     GO TO A, Page 2-460

3. DOES THE SPEEDOMETER WORK?
   - KNOWLEDGE
     SHIFTER OK FLUID OK VEHICLE PASSES ROAD TEST
   - POSSIBLE PROBLEMS
     TRANSFER CASE DIFFERENTIALS HALF AND PROPELLER SHAFTS CV AND U-JOINTS GEARED HUBS
   - TEST OPTIONS
     VISUAL
   - REASON FOR QUESTION
     The speedometer is driven by the rear output shaft of the transfer case.
   - NO
     GO TO C, Page 2-468
   - YES
     GO TO D, Page 2-468

GO TO 4, Page 2-456
Procedure for checking transmission fluid

1. Start engine.
2. Hold down brake pedal and move transmission shift lever through all ranges including reverse.
3. Engage parking brake and place shift lever in neutral. Check fluid level on dipstick.
4. Proper level is between FULL and ADD marks on dipstick.

Check fluid for a burnt smell, grit, discoloration, air bubbles, or a milky appearance.

- Burnt smell, discoloration, or grit indicates worn or damaged internal components. Notify DS maintenance (chapter 14).
- Bubbles indicate an overfilled system or air leaks in the system. Drain the fluid and refill to proper level (para. 5:2).
- Milky appearance is due to water in the system. Replace fluid and filter.

If the speedometer works but the vehicle doesn't move, the transmission is OK and the problem is in the transfer case. Most likely the fault is in the splined output shafts of the transfer case. Listen for unusual noise.
DRIVETRAIN DIAGNOSTIC FLOWCHART

**KNOWN INFO**
- SHIFTER OK
- TRANSFER CASE OK
- HALFSHAFTS AND CV JOINTS OK
- GEARED HUBS

**POSSIBLE PROBLEMS**
- HALFSHAFTS
- PROPELLER SHAFTS
- CV JOINTS
- GEARED HUBS

**TEST OPTIONS**

**VISUAL**

**REASON FOR QUESTION**
- The halfshafts transmit power from the differentials to the geared hubs.

---

4

**INSPECT HALFSHAFTS AND CONSTANT VELOCITY (CV) JOINTS. ARE THEY OK?**

**YES**

**REPAIR OR REPLACE AS NEEDED.**

**NO**

**REASON FOR QUESTION**
- The halfshafts transmit power from the differentials to the geared hubs.

---

5

**INSPECT HALFSHAFT INNER JOINTS FOR BINDING. ARE THEY OK?**

**YES**

**NOTIFY DS (CHAPTER 21).**

**NO**

**REASION FOR QUESTION**
- A binding condition occurs during vehicle operation as a result of vibration feedback.

---

6

**INSPECT FRONT AND REAR PROPELLER SHAFTS AND U-JOINTS. ARE THEY OK?**

**YES**

**REPAIR OR REPLACE AS NEEDED.**

**NO**

**REASON FOR QUESTION**
- The propeller shafts transmit power from the transfer case to the differentials.

---

FROM 3. Page 2-454

GO TO 7. Page 2-458
REFERENCE INFORMATION

Check for torn boots on the CV joints, stripped splines, smooth joint operation, and proper mounting torques.

Replace halfshafts and CV joints [para. 6-7].

Lubricate in accordance with TM 9-2320-387-10.

1. Perform front wheel toe-in alignment preliminary inspection [para. 8-3 task a.]
2. Raise and support front of vehicle [para. 8-2].
3. Rotate wheel by hand.

**NOTE**
- If intermittent binding or resistance is felt during wheel rotation (six times per wheel revolution), differential alignment is required.

4. If no resistance is felt during rotation of wheel halfshaft axle and inner joint, rotate opposite wheel. If no resistance is present at either wheel, proceed to step 7.

**NOTE**
- Record position at which resistance is felt.
- If an intermittent binding or resistance is felt during rotation of wheel, halfshaft axle shaft is contacting inner joint.

5. Repeat steps 3 and 4 to determine serviceability for opposite wheel.
6. Notify DS maintenance (chapter 21) for front differential alignment.
7. Lower front of vehicle [para 8-2].

Check for smooth operation of U-joints, stripped splines, bent yokes, or other problems. Also check to see if the shaft itself is bent. Replace propeller shafts or U-joints [paras. 6-2 through 6-5].

Lubricate in accordance with TM 9-2320-387-10.
The geared hubs transmit power from the drivetrain to the wheels.

**TEST OPTIONS**

**VISUAL**

**REASON FOR QUESTION**

The geared hubs transmit power from the drivetrain to the wheels.

**KNOWN INFO**

- Shifter OK
- Transfer case OK
- Halfshafts and CV joints OK
- Propeller shafts OK
- U-joints OK
- Geared hubs OK

**POSSIBLE PROBLEMS**

- Geared hubs
- Differentials

**INSPECT THE GEARED HUBS. ARE THEY OK?**

- **NO**
  - Repair or replace as needed

- **YES**
  - No faults found.
  - If you were sent here from another test chain, return there.

**TEST OPTIONS**

**VISUAL**

**REASON FOR QUESTION**

The only thing left is the differentials.

**KNOWN INFO**

- Shifter OK
- Transfer case OK
- Halfshafts and CV joints OK
- Propeller shafts OK
- U-joints OK
- Geared hubs OK

**POSSIBLE PROBLEMS**

- Differentials

**INSPECT THE FRONT AND REAR DIFFERENTIALS. ARE THEY OK?**

- **NO**
  - Notify DS (Chapter 14), except for lubrication.

- **YES**
  - No faults found.
  - If you were sent here from another test chain, return there.
Make sure the geared hubs turn freely.
Check mounting hardware for proper installation.
Lubricate in accordance with TM 9-2320-387-10.
Replace geared hubs (para. 6-9).

Check for loose mounting and broken parts.
Check fluid in accordance with TM 9-2320-387-10.
Notify DS maintenance (chapter 14) for other faults.
DRIVETRAIN

KNOWN INFO

VEHICLE FAILS
ROAD TEST
FLUID OK

POSSIBLE PROBLEMS

SHIFTER
PROPeller SHAFTS
HALFSHAFTS
GEARED HUBS
TRANSFER CASE

TEST OPTIONS

A FROM 2,
Page 2-454

WITH THE VEHICLE OFF, HAVE AN ASSISTANT MOVE THE SELECTOR LEVER. DOES THE LINKAGE AT THE TRANSFER CASE WORK PROPERLY?

TEST OPTIONS

VISUAL

REASON FOR QUESTION
To make sure the shifter works.

YES

NO

REPAIR SHIFTER AS NEEDED.

A2

KNOWN INFO

VEHICLE FAILS
ROAD TEST
FLUID OK
SHIFTER OK

POSSIBLE PROBLEMS

SHAFTS
GEARED HUBS
TRANSFER CASE
TRANSMISSION

TEST OPTIONS

VISUAL

REASON FOR QUESTION
If the vehicle doesn't move, it means the transmission or transfer case is probably at fault.

NO

GO TO B,
Page 2-464

YES

A3

KNOWN INFO

VEHICLE FAILS
ROAD TEST
FLUID OK
SHIFTER OK
VEHICLE MOVES

POSSIBLE PROBLEMS

SHAFTS
GEARED HUBS
TRANSFER CASE
TRANSMISSION

TEST OPTIONS

TRY TO FEEL IF THE TRANSMISSION IS SHIFTING PROPERLY, OR GO TO TRANSMISSION, PAGE 2-385.

REASON FOR QUESTION
A road-test failure could be due to the transmission.

NO

YES

NO

GO TO TRANSMISSION,
Page 2-385

GO TO A4,
Page 2-462
Lubricate in accordance with Table 2-1.

Adjust and repair linkage (105A-1 or 6-9). Make sure the detents in the shifter correspond with the positions on the name plate.

If difficulty occurs when shifting transfer range with engine running, perform Engine Idle Speed Adjustment prior to troubleshooting drivetrain.

If engine was turned OFF in order to shift transfer to desired range, notify DS maintenance (chapter 14).

For the vehicle not to move, there must be a major problem in the drivetrain.

If you've already run the transmission tests and you still can't find the problem, continue down this test chain.
**DRIVETRAIN**

**DIAGNOSTIC FLOWCHART**

**FROM A3, Page 2-460**

**TEST OPTIONS**

**VISUAL**

**REASON FOR QUESTION**

The propeller shafts transmit power to the differentials.

**A4**

ARE BOTH PROPELLER SHAFTS AND U-JOINTS OK?

**NO**

REPLACE AS NEEDED.

**YES**

**TEST OPTIONS**

**VISUAL**

**REASON FOR QUESTION**

Halfshafts transmit power from the differentials to the geared hubs.

**A5**

ARE ALL 4 HALFSHAFTS AND CONSTANT VELOCITY JOINTS OK?

**NO**

REPLACE AS NEEDED.

**YES**

**TEST OPTIONS**

**VISUAL**

**REASON FOR QUESTION**

The geared hubs transmit power from the drivetrain to the wheels.

**A6**

INSPECT THE GEARED HUBS. ARE THEY OK?

**NO**

REPLACE AS NEEDED.

**YES**

SEE NOTE AT RIGHT.
Lubricate in accordance with TM 9-2320-387-10.

Check for smooth operation of U-Joints, stripped splines, bent yokes, or other problems. Also check to see if the shaft itself is bent.

Repair and replace propeller shafts and U-joints (para. 6-2 through 6-4).

Check for torn boots on the CV joints, stripped splines, smooth joint operation, and proper mounting torques.

For halfshaft maintenance procedures, refer to para. 6-7.

Lubricate in accordance with TM 9-2320-387-10.

Make sure the geared hubs turn freely. Check mounting hardware for proper installation.

Lubricate in accordance with TM 9-2320-387-10.

If you haven't found any faults, check the differential fluid in accordance with TM 9-2320-387-10. Otherwise, notify DS maintenance (chapter 14).
THE PROBLEM IS MOST LIKELY IN THE TRANSFER CASE OR TRANSMISSION. IF YOU FIND NO FAULTS IN THIS TEST CHAIN AND YOU CAME FROM TRANSMISSION, NOTIFY DS MAINTENANCE (CHAPTER 14).

INSPECT THE FRONT AND REAR PROPELLER SHAFTS AND U-JOINTS. ARE THEY OK?

INSPECT THE HALFSHAFTS AND THE CONSTANT VELOCITY JOINTS. ARE THEY OK?

GO TO B4, Page 2-466
If the vehicle doesn't work, both shafts would have to be broken.

Check for smooth operation of U-joints, stripped splines, bent yokes, or other problems.

Also check to see if the shaft itself is bent.

Replace propeller shafts (paras. 6-3 through 6-4).

Lubricate in accordance with TM 9-2320-387-10.

If the vehicle doesn't move, all four shafts may be broken.

Check for torn boots on the CV joints, stripped splines, smooth joint operation, and proper mounting torques.

For halfshaft maintenance procedures, refer to para. 6-7.

Lubricate in accordance with TM 9-2320-387-10.
DRIVETRAIN

KNOWN INFO
- Shifter OK
- Transfer Case OK
- Transmission OK
- Propeller Shafts OK
- U-Joints OK
- Halfshafts and CV Joints OK

POSSIBLE PROBLEMS
- Geared Hubs
- Differentials

INSPECT THE GEARED HUBS. ARE THEY OK?

TEST OPTIONS
- Visual

REASON FOR QUESTION
The geared hubs transmit power from the drivetrain to the wheels.

NO

REPLACE AS NEEDED.

YES

CHECK THE FLUID LEVEL AND CONDITION IN EACH DIFFERENTIAL. IS IT OK?

TEST OPTIONS
- Visual

REASON FOR QUESTION
To make sure the differentials are OK.

NO

CHANGE AS NEEDED.

YES

IF YOU STILL HAVE A PROBLEM, RUN TRANSMISSION TESTS (PARA. 2-40) IF YOU HAVEN'T ALREADY. OTHERWISE, NOTIFY DS MAINTENANCE (CHAPTER 14).

FROM B3, Page 2-464

2-466
Make sure the geared hubs turn freely. For geared hub replacement procedure, refer to para. 5-9.
Check mounting hardware for proper installation.
Lubricate in accordance with TM 9-2320-387-10.

Check for loose mounting and broken parts. Notify GS maintenance (chapter 30).
Check fluid level in accordance with TM 9-2320-387-10.
Notify DS maintenance (chapter 14) for other faults.
**Drivetrain**

**Known Info**
- Speedometer doesn't work
- Possible problems: Driven gear, cable, speedometer head

**Test Options**
- Disconnect the speedometer cable from the transfer case. Turn the cable by hand. Does the speedometer respond to the cable?

**Reason for Question**
If the speedometer moves in response to the cable, it means the driven gear or the drive gear is no good.

**Known Info**
- Speedometer doesn't work, driven gear, OK
- Possible problems: Cable, speedometer

**Test Options**
- Disconnect the speedometer cable from the speedometer. Have an assistant turn one end while you watch the other.

**Reason for Question**
This will tell you if the cable is OK.

**Diagnostic Flowchart**

- Replace cable
- Replace speedometer
A NO answer means the speedometer did move.

**NOTE**
If you answer NO, check the driven gear in the transfer case. If it's OK, the problem is the drive gear. Notify DS maintenance (chapter 14).

Replace the driven gear (para. 5-17).

---

Replace the cable (para. 4-18)

Replace speedometer (para. 4-17).
2-44. WINCH SYSTEM TESTS

These winch system tests may be run any time you think you have a winch problem or if you were sent here by another test chain. Just follow the path and answer the questions. Additional information and notes are given on the facing page when necessary.
WINCH SYSTEM

1

IS THE ELECTRIC WINCH GROUND STRAP COVERED IN DIRT OR MUD?

YES

CLEAN GROUND STRAP.

NO

2

IS WINCH CABLE BOUND?

YES

SECURE WINCH CABLE FIRMLY.

NO

3

IS WINCH CONTROL CABLE CONNECTOR FREE FROM LOOSENESS OR CORROSION?

YES

CLEAN CORRODED CONNECTOR OR SECURE LOOSE CONNECTION.

NO

KNOWN INFO

NOTHING

POSSIBLE PROBLEMS

GROUND STRAP
WINCH CABLE
WINCH CONTROL
CABLE CONNECTOR
WINCH POWER CABLES
WINCH
WINCH CONTROL

TEST OPTIONS

VISUAL

REASON FOR QUESTION

A dirty ground strap may cause the winch not to operate properly.

KNOWN INFO

GROUND STRAP OK

POSSIBLE PROBLEMS

WINCH CABLE
WINCH CONTROL
CABLE CONNECTOR
WINCH POWER CABLES
WINCH
WINCH CONTROL

TEST OPTIONS

VISUAL

REASON FOR QUESTION

A loose winch cable may cause the winch not to operate properly.

KNOWN INFO

GROUND STRAP OK
WINCH CABLE OK

POSSIBLE PROBLEMS

WINCH CONTROL
CABLE CONNECTOR
WINCH POWER CABLES
WINCH
WINCH CONTROL

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Looseness and corrosion at winch cables and connectors will interfere with the proper operation of the winch.

GO TO 4.

Page 2-474
WINCH SYSTEM DIAGNOSTIC FLOWCHART

4

ARE WINCH POWER CABLES FIRMLY SECURED AND NOT DAMAGED? IS BATTERY VOLTAGE PRESENT IN POSITIVE LEAD 6 AND NEGATIVE LEAD 7?

YES

REPAIR/REPLACE WINCH POWER CABLE.

NO

REPAIR/REPLACE WINCH POWER CABLE.

5

DISCONNECT WINCH CONTROL CABLE. IS CONTINUITY PRESENT BETWEEN COMMON TERMINAL 471 AND 472 IN AND 471 AND 473 OUT?

YES

NO

REPLACE WINCH OR WINCH CONTROL.

NO FAULTS FOUND.

TEST OPTIONS

1. STE/ICE-R TEST 89
2. MULTIMETER
3. VISUAL

REASON FOR QUESTION

When winch power cables are loose or damaged, winch will not operate properly.

KNOWN INFO

GROUND STRAP OK
WINCH CABLE OK
WINCH CONTROL CABLE CONNECTOR OK

POSSIBLE PROBLEMS

WINCH POWER CABLES
WINCH
WINCH CONTROL

TEST OPTIONS

1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION

If continuity is present in both positions, winch is inoperative. If continuity is not present in both positions, winch control is inoperative.

KNOWN INFO

GROUND STRAP OK
WINCH POWER CABLES OK
WINCH CONTROL CABLE CONNECTOR OK

POSSIBLE PROBLEMS

WINCH
WINCH CONTROL
REFERENCE INFORMATION

REPAIR/REPLACE WINCH POWER CABLES (PARA. 12-28).

WINCH SYSTEM

DC VOLTAGE 0-45 VOLTS
STE/ICE-R TEST 89
1. Connect RED clip to the indicated test point, BLACK clip to negative or ground.
2. Start Test 89, DC Volts.
3. Displayed reading is in volts.

BATTERY VOLTAGE MULTIMETER
1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE-R TEST 91
1. Connect RED clip and BLACK clip to the indicated terminals in question; RED to the first, BLACK to the second.
2. Start Test 91, 0-4,500 Ohms.
3. Displayed reading is in ohms. Less than 5 ohms indicates continuity. If the resistance is over 4,500 ohms, STE/ICE-R displays .9.9.9.9.

CONTINUITY (RESISTANCE) MULTIMETER
1. Set the voltmeter to an ohms scale of about 1,000 ohms.
2. Connect the RED and BLACK leads to the connections stated in the question.
3. Be sure to read the correct scale. Less than 5 ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).

REPLACE WINCH OR WINCH CONTROL (PARA. 12-27).
UP-ARMOR CARRIERS

START

1

DOES WEAPON STATION ROTATE PROPERLY?

TEST OPTIONS

VISUAL

REASON FOR QUESTION
If the lockpin in the turret lock assembly binds, sticks, is dented, or is out of alignment, weapon station will not rotate.

NO

REPLACE TURRET LOCK ASSEMBLY.

YES

2

IS BRAKE HANDLE IN PROPER POSITION?

TEST OPTIONS

VISUAL

REASON FOR QUESTION
Weapon station will not lock if brake handle is not in locked position.

NO

PLACE BRAKE HANDLE IN LOCKED POSITION.

YES

OTHER CAUSES; NOTIFY DS MAINTENANCE (CHAPTER 14).
Replace turret lock assembly (para. 11-56).

Place brake handle in locked position (TM 9-2320-387-10).
2-44.1. HYDRAULIC WINCH SYSTEMS TESTS

These winch system tests may be run any time you think you have a winch problem or if you were sent here by another test chain, just follow the path and answer the questions. Additional information and notes are given on the facing page when necessary.
Check all hydraulic line connectors and winch control valves. Tighten any loose connections. Fill and bleed power steering system as necessary. (Refer to para. 8-27 or 8-27.1.)

**WARNING**

Wear leather gloves when handling winch cable. Do not handle cable with bare hands. When fully extending winch cable, ensure that five wraps of winch cable remain on drum at all times. Direct all personnel to stand clear of winch cable during operation. Failure to do so may cause damage to vehicle and injury or death to personnel.

Ensure winch cable is not stacked or binding with tiebars on winch housing. If winch cable is stacked or binding, shut down vehicle and carefully remove tiebars from winch housing. Move winch control levers to FREESPOOL and attempt to pay out winch cable by hand. (Refer to TM 9-2320-387-10.)

Fill power steering fluid reservoir. (Refer to TM 9-2320-387-10.)
HYDRAULIC WINCH SYSTEM

DIAGNOSTIC FLOWCHART

KNOWN INFO
WINCH CABLE OK
WINCH HYDRAULIC LINE CONNECTORS OK
FLUID LEVEL OK

POSSIBLE PROBLEMS
WINCH CONTROLLER POWER CABLES
WINCH CONTROLLER ELECTRICAL CONNECTIONS

TEST OPTIONS
1. STE/ICE–R TEST 89
2. MULTIMETER
3. VISUAL

REASON FOR QUESTION
IS WINCH CONTROLLER POWER CABLES FREE OF DAMAGE?
DISCONNECT POSITIVE LEAD 785B FROM CIRCUIT BREAKER. IS BATTERY VOLTAGE PRESENT?

YES

CHECK/REPLACE WINCH CONTROLLER POWER CABLES

NO

5

KNOW INO
WINCH CONTROLLER POWER CABLES OK
WINCH CABLE OK
WINCH HYDRAULIC LINE CONNECTIONS

POSSIBLE PROBLEMS
WINCH CONTROLLER ELECTRICAL CONNECTIONS

TEST OPTIONS
VISUAL

REASON FOR QUESTION
ARE WINCH CONTROLLER ELECTRICAL CONNECTIONS TIGHT, FULLY SEATED, AND FREE OF CORROSION?

YES

REPLACE CONTROLLER OR CONTROLLER WIRING

NO

6

KNOWN INFO
WINCH CONTROLLER ELECTRICAL CONNECTIONS OK
WINCH CONTROLLER POWER CABLES OK
WINCH CABLE OK

POSSIBLE PROBLEMS
WINCH VALVE ASSEMBLY ELECTRICAL CONNECTIONS

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
IS BATTERY VOLTAGE PRESENT AT VALVE ASSEMBLY ELECTRICAL CONNECTIONS 785A OR 785C?

YES

REPLACE VALVE ASSEMBLY

NO

FROM 3, Page 2-478.2

GO TO 7, Page 2-478.3
Replace winch controller power cables (para. 12-36.6).

While depressing either IN or OUT button on controller, check for battery voltage at wires going to valve assembly. If battery voltage is present, ensure electrical connections are tight and fully seated and attempt winch operations.

If winch fails to operate, replace valve assembly (para. 25-13.2 M1113) (para. 12-36.5 M1114).

### DC VOLTAGE 0-45 VOLTS
STE/ICE–R TEST 89

1. Connect RED clip to the indicated test point, BLACK clip to the negative or ground.
2. Start test 89, DC Volts.
3. Displayed reading is in volts.

### BATTERY VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volts scale of at least 40 volts.
2. Connect the RED lead to positive and the BLACK lead to negative.
3. Be sure to read the correct scale.
**HYDRAULIC WINCH SYSTEM**

**DIAGNOSTIC FLOWCHART**

---

**KNOWN INFO**

<table>
<thead>
<tr>
<th>WINCH VALVE ASSEMBLY</th>
<th>ELECTRICAL CONNECTIONS OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>WINCH CONTROLLER</td>
<td>ELECTRICAL CONNECTIONS OK</td>
</tr>
<tr>
<td>WINCH POWER CABLES</td>
<td></td>
</tr>
</tbody>
</table>

**POSSIBLE PROBLEMS**

- WINCH
- WINCH CONTROLLER

---

**NO FAULTS FOUND**

---

**TEST OPTIONS**

1. STE/ICE-R TEST 91
2. MULTIMETER

---

**REASON FOR QUESTION**

IF CONTINUITY IS PRESENT IN BOTH POSITIONS AND WINCH IS INOPERATIVE, WINCH IS FAULTY. IF NO CONTINUITY IS PRESENT IN BOTH POSITIONS, WINCH CONTROLLER IS FAULTY.

---

**FROM 6, Page 2-478.4**

**DISCONNECT WINCH CONTROL CABLE. IS CONTINUITY PRESENT BETWEEN TERMINALS 785B AND 785C: IN? IS CONTINUITY PRESENT BETWEEN TERMINALS 785A AND 785B: OUT?**

---

**NO**

---

**REPLACE WINCH/WINCH CONTROLLER**

---

**YES**

---

**NO FAULTS FOUND**

---

**PAGE 2-478.4**
REFERENCE INFORMATION

Replace winch (para. 12-27.1) or winch controller (para. 12-32.1).

HYDRAULIC WINCH SYSTEM

RESISTANCE AND CONTINUITY
0-4,500 OHMS
STE/ICE–R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in question; RED to the first, BLACK to the second.

2. START TEST 91, 0-4,500 Ohms.

3. Displayed reading is in Ohms. Less than 5 Ohms is continuity. If the resistance is over 4,500 Ohms, STE/ICE–R displays .9.9.9.9.

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an Ohms scale of about 1,000 Ohms.

2. Connect RED and BLACK leads to the connections stated in the question.

3. Be sure to read the correct scale. Less than 5 Ohms indicates continuity. For an open circuit, the meter should peg full scale (needle all the way to the left).
These diagnostic connector assembly tests can be run any time you think there is a problem with the vehicle's DCA or its on-board transducers. Do not use this paragraph to test the STE/ICE-R and its cables and transducers. Refer to TM 9-4910-571-12&P to test the STE/ICE-R. This paragraph will also supply instructions on how to use the STE/ICE-R in the TK mode to substitute for tests run through the DCA.

The HMMWV is equipped with three transducers – the pulse tachometer, the fuel pressure transducer, and the current shunt. A power test (12, 13) or rpm test (10) use the pulse tachometer. The fuel pressure test (24) uses the pressure transducer. All of the starting circuit tests and battery tests done through the DCA use the shunt. Check to see that the wires are connected to the transducer for the test you're trying to run. There is a four-wire connector for the fuel pressure transducer, a two-wire connector for the pulse tachometer, and there are four wires connected to the shunt in addition to the battery cables.

The fold-out page FP-29 gives a cross reference between DCA tests and Transducer Kit tests. Use this cross reference to find out how to substitute TK tests for DCA tests if you have a bad DCA. The Location of Parts page has a schematic of the HMMWV DCA.
DCA TROUBLESHOOTING

1.

WERE YOU RUNNING A FUEL PRESSURE, RPM, OR POWER TEST?

TEST OPTIONS

SEE NOTE TO RIGHT ABOUT THIS PARAGRAPH.

REASON FOR QUESTION
You need to know which transducer is causing the problem.

NO

GO TO A, Page 2-484

YES

2.

WERE YOU RUNNING STE/ICE-R TEST 24, FUEL PRESSURE?

TEST OPTIONS

NONE

REASON FOR QUESTION
You need to know which transducer is causing the problem.

NO

GO TO B, Page 2-466

YES

3.

DISCONNECT CONNECTOR DIRECTLY BEFORE FUEL PRESSURE TRANSDUCER. INSPECT FOR BENT PINS. DOES EVERYTHING LOOK OK?

TEST OPTIONS

VISUAL

REASON FOR QUESTION
If the transducer pins are bent or broken, you will get bad measurements.

NO

REPAIR OR REPLACE WIRING/TRANSDUCER AS NEEDED.

YES

GO TO 4, Page 2-482
NOTE
The diagnostics in this chapter assume you have already run a test through the DCA. If you haven't run a test and are here to test the entire DCA, run Tests 10 (RPM), 24 (Fuel Pressure), and 80 (Battery Current). Make note of the results for later.

If you want to test the entire DCA harness, answer YES here and then return and answer NO when you've finished the test chain. Answer NO here to test the shunt.

Answer NO here to test the pulse tachometer.

Repair wiring (para. 4-60) or replace transducer (para. 3-51).
DCA TROUBLESHOOTING

FROM 3, Page 2-480

TEST OPTIONS
STE/ICE-R TEST 49

REASON FOR QUESTION
This will tell if you have a fuel system problem or a DCA problem.

4

KNOWLEDGE

STUICE-R OK
WI OK
RUNNING TEST 24
WIRING LOOKS OK

POSSIBLE PROBLEMS
TRANSDUCER
DCA
FUEL SYSTEM

REMOVE THE FUEL PRESSURE TRANSDUCER FROM THE TOP OF THE FUEL FILTER. USE THE STE/ICE-R IN THE TK MODE TO MEASURE THE FUEL PRESSURE WITH THE 25 PSI (172 kPa) (RED) TRANSDUCER. IS THE FUEL PRESSURE OK?

VWECIABLE PROBLEM. IF YOU CAME FROM ANOTHER PARAGRAPH, RETURN THERE AND FOLLOW THE PATH CORRESPONDING TO A FAILURE OF THE TEST YOU WERE RUNNING.

YES

5

TEST OPTIONS
NONE

REASON FOR QUESTION
If Test 24 gave the same result as Test 49, then everything is OK.

KNOWLEDGE

STUICE-R OK
WI OK
RUNNING TEST 24
WIRING LOOKS OK
FUEL SYSTEM OK

POSSIBLE PROBLEMS
TRANSDUCER
DCA

DID TEST 24 GIVE A CORRECT RESULT?

SEE NOTE AT RIGHT.

NO FAULTS.
The fuel pressure should always be greater than 3 psi (21 kPa). If you get about the same pressure with the 2 transducers, then you have a fuel system problem. Remove fuel pressure transducer (para. 4-30). Make sure the STE/ICE-R is powered by a W5 cable.

You will have to decide if Test 24 gave the wrong result. If Test 24 gave a substantially different result than Test 49, answer NO to this question.

**NOTE**

VEHICLE DCA FAULTY. Use the STE/ICE-R in the TK mode for the rest of your testing. See the chart on the foldout page for a way to run the rest of the DCA tests in the TK mode. Have DS maintenance repair the DCA when you're finished.

---

**DCA TROUBLESHOOTING**

<table>
<thead>
<tr>
<th>0 TO 25 PSIG PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 49</td>
</tr>
<tr>
<td>1. CONNECT RED TRANSUDER TO FUEL FILTER.</td>
</tr>
<tr>
<td>2. CONNECT TRANSUDER TO A W4 CABLE. MAKE SURE THE SYSTEM UNDER TEST IS NOT PRESSURIZED. CONNECT OTHER END OF W4 TO J2 OR J3. PERFORM OFFSET TEST.</td>
</tr>
<tr>
<td>3. TURN ON SYSTEM AND READ PRESSURE</td>
</tr>
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---

TM 9-2320-387-24-1
DCA TROUBLESHOOTING

KNOWN INFO
STEICE-R OK
CABLES OK
TK OK
MEASURING THROUGH SHUNT OR ACROSS BATTERIES

POSSIBLE PROBLEMS
SHUNT WIRING
BATTERY WIRING
VEHICLE SYSTEMS
DCA

TEST OPTIONS
NO

A1

SEE THE CHART ON THE FOLDOUT PAGE AND PERFORM THE TK MODE TEST FOR THE DCA TEST YOU WERE RUNNING. DOES THE VEHICLE PASS THE TEST?

YES

DIAGNOSTIC FLOWCHART

TEST OPTIONS
TK MODE TEST THAT CORRESPONDS TO DCA TEST AS SHOWN ON THE FOLDOUT PAGE.

REASON FOR QUESTION
If the TK test tells you that the vehicle is OK, the problem is in the DCA. Otherwise, the vehicle itself has a fault.

A2

DID THE ORIGINAL DCA TEST GIVE A CORRECT RESULT?

NO

VEHICLE PROBLEM. IF YOU CAME FROM ANOTHER PARAGRAPH, RETURN THERE AND FOLLOW THE PATH CORRESPONDING TO A FAILURE OF THE TEST YOU WERE RUNNING.

YES

SEE NOTE AT RIGHT.

NO FAULTS.

KNOWN INFO
VEHICLE OK
STEICE-R OK
CABLES OK
TK OK

POSSIBLE PROBLEMS
SHUNT WIRING
BATTERY WIRING
DCA

TEST OPTIONS
NONE

REASON FOR QUESTION
If you got a substantially different test result through the DCA, then you have a DCA problem.
Make sure the STE/ICE-R is powered by a W5 cable.

If the TK mode test tells you that the vehicle has a fault, return to the paragraph you came from. If the vehicle tests OK, continue here.

You will have to decide if the DCA test result is wrong. If the TK test gave a substantially different result than the DCA test, answer NO to this question.

NOTE

VEHICLE DCA FAULTY. Use the STE/ICE-R in the TK mode for the rest of your testing. See the chart on the foldout page for a way to run the rest of the DCA tests in the TK mode. Have DS maintenance repair the DCA when you're finished.

You can check the connections at the shunt and the power stud to see if they are OK. Look at the schematic for help.
**DCA TROUBLESHOOTING**

**B1**

**KNOWN INFO**
- **STATE-RE OK**
- **CABLES OK**
- **TK OK USING PULSE TACHOMETER**

**POSSIBLE PROBLEMS**
- **TACHOMETER**
- **VEHICLE SYSTEMS**
- **DCA**

**TEST OPTIONS**
- **REMOVE THE TACHOMETER FROM THE ENGINE AND INSPECT IT. IS IT OK?**
- **REPLACE TACHOMETER**

**YES**

**NO**

**B2**

**KNOWN INFO**
- **VEHICLE TACHOMETER OK**
- **STATE-RE OK**

**POSSIBLE PROBLEMS**
- **VEHICLE SYSTEMS**
- **DCA**

**TEST OPTIONS**
- **INSTALL THE TACHOMETER FROM THE TK KIT. RUN THE ORIGINAL TEST WITH THE VEHICLE TEST METER IN THE TK MODE. IS THE VEHICLE OK?**
- **SEE THE CHART ON THE FOLDOUT PAGE TO RUN THE TK VERSION OF THE TEST YOU WANT.**

**YES**

**NO**

**B3**

**KNOWN INFO**
- **VEHICLE OK**
- **STATE-RE OK**
- **CABLES OK**
- **TK OK**

**POSSIBLE PROBLEMS**
- **DCA**

**TEST OPTIONS**
- **DID THE ORIGINAL DCA TEST GIVE A CORRECT RESULT?**
- **SEE NOTE TO RIGHT**
- **NO FAULTS.**

**REASON FOR QUESTION**
- If you came from another paragraph, return there and follow the path corresponding to a failure of the test you were running.
- If you got a substantially different test result through the DCA, then you have a DCA problem.
- If the tachometer is not good, you can't expect good test results.
Remove tachometer (para. 4-16). If you find the tachometer defective, replace it and return to where you came from and rerun the original DCA test. If it fails again, return to this question and answer YES.

Make sure the STEACE-R is powered by the W5 cable.

If you don't find any faults in the vehicle, the slot in the oil pump drive could be too worn to drive the tachometer. If you see this, notify DS maintenance (chapter 14).

You will have to decide if the DCA test result is wrong. If the TK test gave a substantially different result than the DCA test, answer NO to this question.

NOTE

VEHICLE DCA FAULTY. Use the STEACE-R in the TK mode for the rest of your testing. See the chart on the foldout page for a way to run the rest of the DCA tests in the TK mode. Have DS maintenance repair the DCA when you're finished.
2-45.1. ELECTRONIC SPEEDOMETER SYSTEM TEST

These electronic speedometer system tests may be run any time you think you have an electronic speedometer problem or if you were sent here by another test chain, just follow the path and answer the questions. Additional information and notes are given on the facing page when necessary.

Fold-out page FP-31 contains a schematic of the electronic speedometer. This page may be left open for reference while testing.
**ELECTRONIC SPEEDOMETER SYSTEM DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**
- MULTIMETER

**REASON FOR QUESTION**
- No voltage at terminal indicates an open in the speedometer wiring harness.

1. **IS BATTERY VOLTAGE DISPLAYED ON MULTIMETER?**
   - **NO**
     - REPLACE SPEEDOMETER WIRING HARNESS
   - **YES**
     - REPLACE SPEEDOMETER SENDER (Para. 4-18.1)

2. **IS BATTERY VOLTAGE DISPLAYED ON MULTIMETER?**
   - **NO**
     - REPLACE SPEEDOMETER WIRING HARNESS
   - **YES**
     - REPLACE SPEEDOMETER SENDER (Para. 4-18.1)

**KNOWN INFO**
- SPEEDOMETER INOPERATIVE
- OTHER GAUGES OPERATE NORMALLY
- SPEEDOMETER HAS POWER

**POSSIBLE PROBLEMS**
- OPEN
- SHORT
- SPEEDOMETER SENDER GENERATOR
- SPEEDOMETER DRIVEN GEAR

**KNOWN INFO**
- SPEEDOMETER INOPERATIVE
- OTHER GAUGES OPERATE NORMALLY
- SPEEDOMETER HAS POWER

**POSSIBLE PROBLEMS**
- OPEN
- SHORT
- SPEEDOMETER SENDER GENERATOR
- SPEEDOMETER DRIVEN GEAR

**GO TO 3,**
*Page 2-488.4*
Remove instrument cluster from instrument panel [para. 4-14.1].

**Battery Voltage Multimeter**

1. Set the multimeter to DC scale of at least 40 volts.
2. Connect red lead to speedometer harness pin A and the black lead to good ground.
3. Turn rotary switch to run position.

**Battery Voltage Multimeter**

Connect the red lead to the speedometer harness terminal A and the black lead to terminal D.
ELECTRONIC SPEEDOMETER SYSTEM

DIAGNOSTIC FLOWCHART

3

DOES SENDER GENERATOR CIRCUIT HAVE CONTINUITY?

FROM 2
Page 2-488.2

YES

NO

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
No resistance indicates an open wiring harness or sender generator.
High resistance indicates a short.
Less than 5 ohms indicates continuity.

POSSIBLE PROBLEMS
OPEN
SHORT
SPEEDOMETER
SENDER GENERATOR
SPEEDOMETER
DRIVEN GEAR

4

ARE SPEEDOMETER DRIVE GEARS GOOD?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Stripped or broken speedometer driven gear will cause sender generator to be inoperative.

POSSIBLE PROBLEMS
SPEEDOMETER
SPEEDOMETER
DRIVEN GEAR

NO

YES

REPLACE SENDER GENERATOR
[Para. 5-17.1] or REPLACE SPEEDOMETER WIRING HARNESS [Para. 4-18.1].

REPLACE SENDER GENERATOR [Para. 5-17.1] or REPLACE SPEEDOMETER WIRING HARNESS [Para. 4-18.1].

REPLACE SPEEDOMETER DRIVEN GEAR [Para. 5-17.2].

REPLACE SPEEDOMETER [Para. 4-17.1].

END OF TEST

KNOWN INFO
SPEEDOMETER INOPERATIVE
OTHER GAUGES OPERATE NORMALLY
SPEEDOMETER HAS POWER
SPEEDOMETER HAS GROUND

KNOWN INFO
SPEEDOMETER INOPERATIVE
OTHER GAUGES OPERATE NORMALLY
SPEEDOMETER HAS POWER
SPEEDOMETER HAS GROUND
NO OPEN CIRCUIT

POSSIBLE PROBLEMS
OPEN
SHORT
SPEEDOMETER
SENDER GENERATOR
SPEEDOMETER
DRIVEN GEAR

POSSIBLE PROBLEMS
SPEEDOMETER
SPEEDOMETER
DRIVEN GEAR
REFERENCE INFORMATION

ELECTRONIC SPEEDOMETER SYSTEM

RESISTANCE AND CONTINUITY

1. Turn rotary switch to the OFF position.
2. Set multimeter to ohm scale of approximately 1,000 ohms.
3. Connect multimeter leads to speedometer harness terminal B and C.

Remove and inspect speedometer driven gear (Para. 5-17.2).
## 2-46. STE/ICE-R TEST PROCEDURES

This paragraph will be helpful when using the STE/ICE-R to answer diagnostic questions. Use this paragraph as a reference if you need additional information about a specific test. This paragraph contains information such as possible errors, test procedures, control codes, and additional notes as necessary. The following chart will help you find the test you need. The STE/ICE-R setup and internal checks (Test No. G01, page 2-51) must be performed prior to performing tests. A complete description and operation of the STE/ICE-R is found on page 2-509. See TM 9-4910-571-12&P for additional information.

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ENGINE RPM (AVERAGE) TEST #10

Description:
This procedure measures engine speed in the range 50 to 5,000 rpm. At speeds below 50 rpm, the VTM will display 0. At speeds above 5,000 rpm, the display may give a false reading. Test requires DCA hookup only.

Typical Applications:
Check engine speed.

Pre-Test Procedures:
Run confidence test.

Possible Error Messages:
E014 Incorrect number of cylinders entered.

Test Procedure:
1. Set TEST SELECT switches to 10.
2. Press and release TEST button.
4. Observe displayed value (RPM).
POWER TEST (RPM/SEC) TEST #12

Description:
This procedure measures an engine's power-producing potential in units of RPM/SEC. Test requires DCA hookup only.

Typical Applications:
Check engine power in units of RPM/SEC.

Test Procedure:
1. Start and idle engine.
2. Set TEST SELECT switches to 10.
3. Press and release TEST button.
4. Observe displayed value (RPM) to adjust idle speed, if necessary.
5. Press down sharply on accelerator and observe displayed value (RPM) to adjust governor speed, if necessary.
6. Set TEST SELECT switches to 12.
7. Press and release TEST button.
9. When CIP appears on display, press down sharply on engine accelerator and hold it to the floor. When VIM displays a number, release accelerator.
10. Observe displayed value (RPM/SEC).

Pre-Test Procedures:
Run confidence test. Warm up engine to operating temperature.

Possible Error Messages:
E009 Engine not running at start of test.
E011 Throttle control operated incorrectly.
E012 Ignition adapter/pulse tachometer missing.
E014 Incorrect number of cylinder entries.
E033 Error in entry of power test constants.

NOTES:
Engine idle speed must be checked before performing power test. Idle speed must be approximately 675 rpm to run test.
Engine governor no-load speed must be checked before performing power test. Governor no-load speed must be within the 3,600 - 3,800 rpm range to run test.
POWER TEST (PERCENT) TEST #13

Description:
This procedure measures the percentage of engine's power-producing potential as compared to a good engine. Test requires DCA hookup only.

Test Procedure:
1. Start and idle engine.
2. Set TEST SELECT switches to 10.
3. Press and release TEST button.
4. Observe displayed value (RPM) to adjust idle speed, if necessary.
5. Press down sharply on engine accelerator and observe displayed value (RPM) to adjust governor speed, if necessary.
7. Press and release TEST button.
9. When CIP appears on display, press down sharply on engine accelerator and hold it to the floor. When VTM displays OFF, release accelerator.
10. A number will be displayed after the engine has returned to idle speed. This number is the test result in units of percent of nominal-rated power.

Pre-Test Procedures:
Run confidence test. Warm up engine to operating temperature.

Typical Applications:
Check engine power.

Possible Error Messages:
- E009 Engine not running at start of test.
- E011 Throttle control operated incorrectly.
- E012 Ignition adapter/pulse tachometer missing.
- E024 Test not valid for VID entered.

NOTE:
Engine idle speed must be checked before performing power test. Idle speed must be approximately 675 rpm to run test. Engine governor no-load speed must be checked before performing power test. Governor no-load speed must be within the 3,900 - 4,100 rpm range to run test.
COMPRESSION UNBALANCE TEST #14

Description:
This procedure compares the compression between the highest and lowest cylinders and displays the unbalance in percent. Test requires DCA hookup only.

Typical Applications:
Check compression unbalance of engine with VTM powered from battery of vehicle being tested.

Pre-Test Procedures:
Run confidence test. Warm up engine to operating temperature.
Run first-peak series tests 72, 73, 74, 75.

Test Procedure:
1. Set up engine to prevent starting by disconnecting wire 54A. Stop engine. Shut off fuel before cranking. Crank engine without fuel for 5 seconds to clear fuel from cylinders.
2. Set TEST SELECT switches to 14.
3. Press and release TEST button.
4. Wait until GO appears on display before proceeding.
5. When GO appears, crank engine. Display will change to ---- while engine is turning.
6. When OFF or E013 appears, stop cranking.
7. If OFF appears, wait for message to appear.
   (A) The number displayed will be the percent unbalance between the highest and lowest cylinders. A number above 25 is a failure.
   (B) If GO appears, repeat from step 2.
   (C) A FAIL message usually means compression is too far unbalanced to measure with STE/ICE.

Possible Error Messages:
E008 VTM doesn't detect battery voltage.
E013 VTM cannot use data received.
E027 Error in entry of compression unbalance constants.
E032 Vehicle's cranking speed is varying too much for a compression unbalance measurement.

NOTE:
If E013 appears, test data cannot be analyzed because of weak batteries or interrupted cranking during test. Correct problem and repeat from step 2.
FUEL SUPPLY PRESSURE (PSI) TEST #24

Description:
This procedure measures the return pressure in order to detect line blockage, leaks, or insufficient restrictor back-pressure. Test requires DCA hookup only.

Typical Applications:
Fuel supply pressure

Pre-Test Procedures:
Run confidence test. Wait for 1 minute after turning engine off to run this test.

Control Functions:
01, 02, 03, 04, 06

Test Procedure:
1. Turn off vehicle.
2. Set TEST SELECT switch to 24.
3. Press and hold TEST button until CAL appears on display.
4. Release TEST button and wait for offset value to appear on display. If offset is within -15 to 15, proceed. If not, go to DCA Troubleshooting Procedure.
5. Press and release TEST button
7. Observe displayed value.

Possible Error Messages:
E005 Offset not performed.
PRESSURE (PSI) 0 TO 1,000 TEST #50

Description:
This procedure measures pressure in the 0 to 1,000 PSIG range. Test requires the use of the TK adapters and transducers.

Pre-Test Procedures:
Run confidence test.

Typical Applications:
Oil pressure

Control Functions:
01, 02, 03, 04, 06

Test Procedure:
1. Attach connector P1 of cable W4 to J2 TK or J3 TK.
2. Install blue-striped pressure transducer where pressure is to be measured. Attach connector P2 of cable W4 to transducer.
3. Set TEST SELECT switch to 50. Press and hold TEST button until CAL appears on display.
4. Release TEST button and wait for offset value to appear on display. If offset is within -150 to 150, proceed. If not, go to DCA Troubleshooting Procedure.
5. Energize system.
6. Press and release TEST button.
7. Observe displayed value.

Possible Error Messages:
E005 Offset not performed.
E002 Transducer not connected.
BATTERY VOLTAGE TEST #67

Description:
This procedure measures battery voltage in the 9 to 32 volts range. The voltage is measured directly at the power source of the VTM, and may be done with the vehicle operating or shut down. Test requires DCA hookup only.

Typical Applications:
Check battery voltage.

Pre-Test Procedures:
Run confidence test.

Test Procedure:
1. Set TEST SELECT switch to 67.
2. Press and release TEST button.
3. If .9.9.9.9 is displayed, voltage is not within the test range.
4. Observe displayed value (volts).

Possible Error Messages:
None.
STARTER MOTOR VOLTAGE TEST #68

Description:
This procedure measures the voltage present at the starter motor positive terminal in the 0 - 32 volts range. Test requires DCA hookup only.

Pre-Test Procedures:
Run confidence test.

Typical Applications:
Check starter motor voltage.

Control Functions:
01, 02, 03, 04, 06

Test Procedure:
1. Disconnect fuel solenoid wire 54A to prevent starting.
2. Set TEST SELECT switch to 68.
3. Press and release TEST button.
4. Crank the engine and observe the displayed voltage.

Possible Error Messages:
None.
STASTER NEGATIVE CABLE VOLTAGE DROP TEST #69

Description:
This procedure measures the voltage drop on the starter path. A high voltage (>2V) indicates excessive ground path resistance. Test requires DCA hookup only.

Pre-Test Procedures:
Run confidence test.

Typical Applications:
Check starter negative cable voltage drop.

Control Functions:
01, 02, 03, 04, 06

Test Procedure:
1. Disconnect fuel solenoid wire 54A to prevent starting.
2. Set TEST SELECT switch to 69.
3. Press and release TEST button.
4. Crank the engine and observe the displayed voltage.

Possible Error Messages:
None.
STARTER SOLENOID VOLTS TEST #70

Description:
This procedure measures the voltage present at the starter solenoids positive terminal. Test requires DCA hookup only.

Pre-Test Procedures:
Run confidence test.

Typical Applications:
Check starter solenoid volts.

Control Functions:
01, 02, 03, 04, 06

Test Procedure:
1. Disconnect fuel solenoid wire 54A to prevent starting.
2. Set TEST SELECT switch to 70.
3. Press and release TEST button.
4. Crank the engine and observe the displayed voltage.

Possible Error Messages:
None.
2-46. STE/ICE-R TEST PROCEDURES (Cont'd)

**STARTER CURRENT AVERAGE TEST #71**

**Description:**
This procedure measures the average starter current in the 0 - 1,000 amps range. Test requires DCA hookup only.

**Pre-Test Procedures:**
Run confidence test.

**Typical Applications:**
Check starter current.

**Control Functions:**
01, 02, 03, 04, 05

**Test Procedure:**
1. Disconnect fuel solenoid wire 54A to prevent starting.
2. Set TEST SELECT switch to 71.
3. Press and hold TEST button until CAL appears on display.
4. Release TEST button and wait for offset value to appear on display. If offset is within -150 to 150, proceed. If not, go to DCA Troubleshooting Procedure.
5. Press and release TEST button.
6. Crank engine.
7. Observe the displayed starter current.

**Possible Error Messages:**
E005 Offset not performed.
CURRENT FIRST PEAK TEST #72

Description:
This procedure measures the overall condition of the complete starting system. Test requires DCA hookup only.

Pre-Test Procedures:
Run confidence test. Warm up engine to operating temperature. Turn off all electrical accessories.

Typical Applications:
Check condition of starting system on CI engines with VTM being powered from battery of vehicle tested.

Possible Error Messages:
E002 Transducer not connected.
E005 Offset not performed.
E008 VTM does not detect battery voltage.
E013 VTM cannot use data received.
E020 No first-peak information was detected by the VTM.
E021 VTM cannot calculate result because current is over current probe's range.

Test Procedure:
1. Disconnect fuel solenoid wire 54A to prevent starting.
2. Make sure all vehicle accessories are off.
3. Set TEST SELECT switches to 72.
4. Press and hold TEST button until CAL appears on display.
5. Release TEST button and wait for offset value to appear on display. If offset is within the range -150 to 150, proceed. If not, go to DCA Troubleshooting Procedure.
6. Press and release TEST button.
7. When GO appears on display, crank engine for 2 seconds or until one of the following appears on the display: OFF .9.9.9.9 A number An error message
8. Observe displayed value (amps).

NOTES:
If .9.9.9.9 is displayed, current first-peak was too high and cannot be measured with VTM.
If E013 is displayed, check battery connections and correct as necessary. Repeat step 6. If E013 persists after 3 tests, VTM cannot perform test.
BATTERY INTERNAL RESISTANCE TEST #73

Description:
This procedure measures the internal battery resistance. Internal battery resistance is a measure of the state of the batteries. Test requires DCA hookup only.

Typical Applications:
Evaluate batteries on CI engines with VTM being powered from battery of vehicle tested.

Test Procedure:
1. Disconnect fuel solenoid wire 54A from the injector pump to prevent starting.
2. Make sure all vehicle accessories are off.
3. Set TEST SELECT switches to 73.
4. Press and hold TEST button until CAL appears on display.
5. Release TEST button and wait for offset value to appear on display. If offset is within the -150 to 150 range, proceed. If not, go to DCA Troubleshooting Procedure.
6. Press and release TEST button.
7. When GO appears on display, crank engine for 2 seconds or until one of the following appears on the display: OFF .9.9.9.9 A number An error message
8. Observe displayed value (milliohms). The limit is 25 milliohms per battery pair.
9. Test 75 is Battery Resistance Change. You can run that test after this one if desired.

Pre-Test Procedures:
Run confidence test. Turn off all electrical accessories.

Possible Error Messages:
E002 Transducer not connected.
E005 Offset not performed.
E008 VTM does not detect battery voltage.
E013 VTM cannot use data received.
E020 No first-peak information was detected by the VTM.
E021 VTM cannot calculate result because current is over current probe’s range.

NOTES:
If .9.9.9.9 is displayed, battery internal resistance was too high and cannot be measured with VTM.

If E013 is displayed, check battery connections and correct as necessary. Repeat Step 6. If E013 persists after 3 tests, VTM cannot perform test.
STARTER CIRCUIT RESISTANCE TEST #74

Description:

This procedure measures starter circuit resistance. Test requires DCA hookup only.

Pre-Test Procedures:

Run confidence test. Warm up engine to operating temperature. Turn off all electrical accessories.

Typical Applications:

Check resistance of complete starting system in CI engines with VTM powered from batteries of vehicle being tested.

Possible Error Messages:

E002 Transducer not connected.
E005 Offset not performed.
E008 VTM does not detect battery voltage.
E013 VTM cannot use data received.
E020 No first-peak information was detected by the VTM.
E021 VTM cannot calculate result because current is over current probe's range.

Test Procedure:

1. Disconnect fuel solenoid wire 54A to prevent starting.
2. Make sure all vehicle accessories are off.
3. Set TEST SELECT switches to 74.
4. Press and hold TEST button until CAL appears on display.
5. Release TEST button and wait for offset value to appear on display. If offset is within the range -150 to 150, proceed. If not, go to DCA Troubleshooting Procedure.
6. Press and release TEST button.
7. When GO appears on display, crank engine for 2 seconds or until one of the following appears on the display: OFF .9.9.9.9 A number An error message
8. Observe displayed value (milliohms).

NOTES:

If .9.9.9.9 is displayed, the starter circuit resistance value was too high and cannot be measured with VTM.

If E013 is displayed, check battery connections and correct as necessary. Repeat Step 6. If E013 persists after 3 tests, VTM cannot perform test.
BATTERY RESISTANCE CHANGE TEST #75

Description:
This procedure measures the change of battery resistance. Test requires DCA hookup only.

Pre-Test Procedures:
Run confidence test. Warm up engine to operating temperature. Turn off all electrical accessories.

Typical Applications:
Evaluate batteries in CI engines with VTM powered from batteries of vehicle being tested.

Possible Error Messages:
E002 Transducer not connected.
E005 Offset not performed.
E008 VTM does not detect battery voltage.
E013 VTM cannot use data received.
E020 No first-peak information was detected by the VTM.
E021 VTM cannot calculate result because current is over current probe's range.

Test Procedure:
1. Disconnect fuel solenoid wire 54A to prevent starting.
2. Make sure all vehicle accessories are off.
3. Set TEST SELECT switches to 75.
4. Press and hold TEST button until CAL appears on display.
5. Release TEST button and wait for offset value to appear on display. If offset is within the -150 to 150 range, proceed. If not, go to DCA Troubleshooting Procedure.
6. Press and release TEST button.
7. When GO appears on display, engage starter for 2 seconds or until one of the following appears on the display: OFF
   .9.9.9.9
   A number
   An error message
8. Observe displayed value (milliohms/seconds). The limit is 50 milliohms per battery pair. A lower number is better than a higher one.

NOTES:
If .9.9.9.9 is displayed, the battery resistance change value is beyond the range of the VTM and cannot be measured with the VTM.
If E013 is displayed, check battery connections and correct as necessary. Repeat Step 6. If E013 persists after 3 tests, VTM cannot perform test.
BATTERY CURRENT TEST #80

Description:
This procedure measures current to or from the battery. Test requires DCA hookup only.

Pre-Test Procedures:
Run confidence test.

Typical Applications:
Evaluate batteries in CI engines.

Control Functions:
01, 02, 03, 04

Test Procedure:
1. Set TEST SELECT switch to 80.
2. Press and hold TEST button until CAL appears on display.
3. Release TEST button and wait for offset value to appear on display. If offset is within -150 to 150, proceed. If not, go to DCA Troubleshooting Procedure.
4. Press and release TEST button.
5. Observe displayed value (amps).

Possible Error Messages:
E005 Offset not performed.
DC VOLTAGE 0 TO 45 VOLTS  TEST #89

Description:
This procedure measures voltage in the range of -45 to 45 volts. The VTM is used as a DC voltmeter with the decimal point in the correct position. This test must be done with the component being tested turned on. Test requires the use of the TK adapters and transducers.

Typical Applications:
- Fuel solenoid
- Starter solenoid
- Alternator output
- Any DC voltage measurement

Pre-Test Procedures:
Run confidence test.

Control Functions:
01, 02, 03, 04, 06

Possible Error Messages:
E005  Offset not performed.

Test Procedure:
2. Connect the desired test leads to P2.
3. Set TEST SELECT switch to 89.
4. Short leads together. Press and hold TEST button until CAL appears on display.
5. Release TEST button and wait for offset value to appear on display.
6. If offset is within -6.8 to 6.8, proceed. If not, go to DCA Troubleshooting Procedure.
7. Press and release TEST button. Observe displayed value.
DC CURRENT 0 TO 1,500 AMPS TEST #90

Description:
This procedure measures DC current in the range of 0 to 1,500 amps. The VTM is used as an ammeter with the decimal point in the right position. This test may be done with the vehicle/equipment operating. Test requires the use of the TK adapters and transducers.

Typical Applications:
- Alterator output
- Average starter current
- Battery current
- Any DC current up to 1,500 amps

Pre-Test Procedures:
Run confidence test.

Test Procedure:
2. Attach P1 to J2 or J3. Connect the current probe to P2.
3. Set TEST SELECT switch to 90.
4. Clamp probe to de-energized wire.
5. Press and hold TEST button until CAL appears on display.
6. Release TEST button and wait for offset value to appear on display. If offset is within 225 to -225, proceed. If not, go to DCA Troubleshooting Procedure.
8. Observe displayed value. A negative reading indicates the probe is backwards. Reverse and repeat from Step 4.

Possible Error Messages:
E002 Transducer not connected.
E005 Offset not performed.

Control Functions:
01, 02, 03, 04, 06
RESISTANCE AND CONTINUITY 0 TO 4,500 OHMS TEST #91

Description:
This procedure measures resistance in the range of 0 to 4,500 ohms. The VTM is used as an ohmmeter, and test results are always displayed with the decimal point in the right position. Additionally, any voltage present in the device being tested will adversely affect test results. Make sure the circuit or component being tested is shut off. Test requires the use of the TK adapters and transducers.

Typical Applications:
• Continuity checks
• Resistance measurements
• Switch and relay functions

Pre-Test Procedures:
Run confidence test.

Test Procedure:
2. Connect the desired test leads to P2.
3. Set TEST SELECT switch to 91.
4. Short leads together. Press and hold TEST button until CAL appears on display.
5. Release TEST button and wait for offset value to appear on display.
6. If offset is within -225 to 225, proceed. If not, go to DCA Troubleshooting Procedure.
7. Press and release TEST button. Observe displayed value.

Possible Error Messages:
E005 Offset not performed.
E022 External voltage detected while measuring resistance.
a. **STE/ICE-R Description and Operation.** The following describes the operation of the Simplified Test Equipment/Internal Combustion Engines-Reprogrammable (STE/ICE-R) system and contains detailed operating procedures. It is used to test the serviceability of HMMWV vehicles and to perform primary fault detection and isolation. After the technician has identified a faulty part or subsystem, he is referred to a paragraph number for replacement or repair procedures for individual parts.

b. **Description and Operation.** STE/ICE-R is a testing system that performs tests and measurements on internal combustion engines. STE/ICE-R measures standard voltage, current, resistance, pressure, temperature, and speed. Special tests, such as compression balance tests and starter system evaluations, are performed by STE/ICE-R. Standard equipment functions, including vacuum pressure gauge, compression gauge, low-current tester and multimeter, are features of the STE/ICE-R set. STE/ICE-R is portable and operates on either 12- or 24-volt vehicle batteries or equivalent power source. The STE/ICE-R system consists of a Vehicle Test Meter (VTM), a Transducer Kit (TK), four electrical cables, a transit case, and technical publications.

c. **Vehicle Test Meter.**

1. **General.** The VTM provides a method for the technician to test vehicle electrical and mechanical components. Readings are either pass/fail indications or digital displays in units familiar to the technician (psi, rpm, volts, ohms, amps, etc.). The Diagnostic Connector Assembly (DCA) is permanently mounted in the vehicle and provides accessibility to the most frequently needed test points. The use of the VTM through the DCA is referred to as DCA mode. The VTM interfaces with the vehicle directly with a transducer(s) from the Transducer Kit (TK). The use of the VTM through the TK is referred to as TK mode. The DCA and the TK can be used at the same time. This may be necessary when the diagnostic connector assembly has a missing transducer. If a transducer is missing, a no sensor indication (E002) is displayed when a measurement is made. If this happens, the TK mode can be used to make the measurement. The use of the VTM through the DCA and TK is referred to as the combined mode. Additional tests can be done that involve manually probing and/or connecting transducers to appropriate test points. Operating power for the VTM is drawn from the vehicle batteries or some equivalent battery source. Power is routed to the VTM through the DCA connected to the battery. The STE/ICE-R general purpose testing capabilities that may be applied to the vehicle are: 0-1,000 psi pressure, 0-45 volts DC, and 0-40k ohms resistance. The following control functions can be performed in conjunction with the special tests: Interleave (displays rpm with next test), Display Maximum Value, Display Minimum Value, and Display Peak-to-Peak Value.

2. **Controls and Indicators.** The controls and readout display on the VTM are illustrated. The following paragraphs describe how the controls are used and how the display functions:

   (a) **Power Switch (PUSH ON/PULL OFF).** The power switch controls DC power to the VTM. The VTM can operate from a 12- or 24-volt battery system. When the power switch is pushed in (PUSH ON), the VTM power is on. To shut the VTM off, pull out the power switch (PULL OFF). The power switch contains a 4-amp circuit breaker. The power switch will pop out automatically if something is wrong which causes the VTM to use more power than it should. If the switch pops out, check your hookup carefully and try again before returning the VTM to direct support maintenance.

   (b) **TEST SELECT Switches.** The TEST SELECT switches are used to select the actual test to be performed. There are 10 positions on each switch numbered 0 through 9. The number dialed into these switches is read by the VTM when you press the test button. Changing the TEST SELECT switch positions has no effect until the TEST button is pushed.

   (c) **TEST Button.** Depressing and releasing the TEST button causes the test measurement to begin. Observe the measured value on the readout display. The reading will be in units normally used for the particular vehicle measurement. These units are listed on the flip cards. The TEST button must be pressed and immediately released. Depressing and holding the TEST button down initiates an offset test. Offset tests are described in TM 9-4910-571-12&P.
(d) **Readout Display.** The readout display will show different types of readouts during testing up to a maximum of four characters (for example, .8.8.8.8). The types of readouts are described in detail in paragraph 3 and are summarized as follows:

1. **Status Readout.** This type of readout keeps the technician informed of what is happening, such as power applied, failed test, etc.
2. **Numerical Readout.** This type of readout is the measured value in units of the measurement being made. If you are measuring 0-45 volts DC, the number 24 on the display indicates 24 volts.
3. **Error Readout.** This type of readout indicates that the wrong test number was selected, the transducer is not connected, or the VTM is faulty.

(e) **Flip Cards.** The flip cards list the 2-digit test number system for selecting the various tests. The cards also summarize the test and operating instructions contained herein.

(f) **Power/DCA Connector J1.** Connector J1 connects the VTM to either a vehicle diagnostic connector using the DCA cable or to the vehicle batteries using the power cable. Operating power and signals from the installed transducers are supplied to the VTM through the DCA cable.
(g) **Transducer Cable Connectors J2, J3.** Connectors J2 or J3 connect the VTM to any transducer in the transducer kit. Operating power is supplied to the transducer and signals from the transducers are supplied to the VTM through the cable. Connectors J2 and J3 are identical and can be interchanged with each other or used in combination.

(h) **Test Probe Cable Connector J4.** Connector J4 connects test leads to the VTM when doing manual voltage resistance tests.
3. Readouts. The following paragraphs describe the different types of readouts that can occur during testing.

(a) Status Readout. A status readout keeps the technician informed about what is happening. For example, 8.8.8.8 is displayed each time the power switch is pushed on. It means that power is applied, and that all elements of the display are operative. It changes to --- 1.5 seconds later, indicating that the VTM is ready to be used for testing. The status readout displays are described in table 2-2.

(b) Prompting Message. A prompting message is a technician action message. It is a signal for you to do something such as crank the engine. For example, UEH tells you to enter the vehicle type identification number into the VTM. After the technical action is performed, the test will automatically continue. Prompting messages are listed in table 2-3.

(c) Numerical Readout. A numerical readout is the measured value in units of the measurement being made. For example, if you are measuring 0-45 volts DC, 12.7 is volts DC. If you are measuring 0-25 psig pressure, 12.7 is psig. The units for each test are listed on the flip card. The numbers displayed in the VTM are always positive unless there is a minus shown to make them negative.
2-46. STE/ICE-R TEST PROCEDURES (Cont'd)

(d) Error Readout. E001 is a typical error readout. There are 15 different readouts. All error readouts start with E. An error readout is a warning that you forgot to connect the transducer, selected a wrong test number, failed to start the engine, etc. All of the error messages mean you must correct the problem before continuing testing. Error readouts are listed in Table 2-4. If the error message does not go away after corrective action, refer to TM 9-4910-571-12&P.

(e) Confidence Error Readouts. C004 is a typical error readout resulting from the detection of a faulty VTM during confidence test. For detailed information concerning confidence error readouts, refer to TM 9-4910-571-12&P.

<table>
<thead>
<tr>
<th>VTM Readout</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>.8.8.8.8</td>
<td>A readout of .8.8.8.8 appears for 1 to 2 seconds each time the power is applied to the VTM. It means that there is power to the VTM, and that all elements of the readout display are operative.</td>
</tr>
<tr>
<td>---</td>
<td>A readout of --- indicates the following:</td>
</tr>
<tr>
<td></td>
<td>(1) After power turn-on, it signifies that the VTM is ready for testing.</td>
</tr>
<tr>
<td></td>
<td>(2) During a compression unbalance test, it signifies testing is in progress.</td>
</tr>
<tr>
<td>.9.9.9.9</td>
<td>A readout of .9.9.9.9 indicates that the VTM is reading a test value beyond the range of its measurement capability. Either (1) the wrong test number is selected for the parameter being measured, or (2) there is a fault in the vehicle.</td>
</tr>
<tr>
<td>PASS</td>
<td>A PASS or FAIL readout is the result of a test that checks the condition of a component being measured. A PASS/FAIL readout means just that — the component either passes or fails the test.</td>
</tr>
<tr>
<td>FAIL</td>
<td></td>
</tr>
</tbody>
</table>

Table 2-2. Status Readouts.
### Table 2-3. Prompting Messages.

<table>
<thead>
<tr>
<th>VTM Readout</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>UEH</td>
<td>Signal to ECT switches. Vehicle Identification (VID) numbers are found under TEST DATA on the flip card on the vehicle test cards.</td>
</tr>
<tr>
<td>GO</td>
<td>Signal to technician to crank engine in compression balance or first-peak tests.</td>
</tr>
<tr>
<td>OFF</td>
<td>Signal to technician to stop cranking in compression balance test or to release the accelerator in the CI power test.</td>
</tr>
<tr>
<td>CAL</td>
<td>Signal to the technician to release the TEST button during an offset test.</td>
</tr>
<tr>
<td>66</td>
<td>Numbers are used for prompting messages in several tests. In confidence test, a readout of 66 signals the technician to enter 99. In test no. 12, the first numerical readout signals the technician to shut off fuel.</td>
</tr>
</tbody>
</table>

### Table 2-4. Error Readouts.

<table>
<thead>
<tr>
<th>VTM Readout</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E000</td>
<td>Occurs if you request the VTM for information it does not have. For example, if you request the VID and it has not been entered.</td>
</tr>
<tr>
<td>E001</td>
<td>Occurs in either the DCA or TK mode of operation. It indicates that a non-existent test number has been dialed into the TEST SELECT switches.</td>
</tr>
<tr>
<td>E002</td>
<td>Indicates that the required transducer is not connected.</td>
</tr>
<tr>
<td>E003</td>
<td>Indicates that a test number has been dialed which does not apply to the vehicle under test. It can only occur in the DCA mode.</td>
</tr>
<tr>
<td>E004</td>
<td>Indicates that a VID number or number of cylinders information has not been entered.</td>
</tr>
<tr>
<td>E005</td>
<td>Indicates that the transducer offset test was not performed.</td>
</tr>
<tr>
<td>E007</td>
<td>Indicates a conflict between the VID number dialed in and the number of cylinders dialed in. It may occur in response to either VID entry or number-of-cylinders entry.</td>
</tr>
<tr>
<td>E008</td>
<td>Indicates the VTM is not receiving the required voltage signal for the test selected. This error code is related only to starter and compression balance tests.</td>
</tr>
<tr>
<td>E009</td>
<td>Indicates that the engine was not running at the start of the test.</td>
</tr>
<tr>
<td>E010</td>
<td>Indicates that a wrong VID was dialed into the VTM.</td>
</tr>
<tr>
<td>E011</td>
<td>Indicates that throttle control was operated incorrectly during power test, taking too much time to either accelerate or decelerate.</td>
</tr>
<tr>
<td>E013</td>
<td>Indicates bad data were taken for the test in progress. Repeat the test once.</td>
</tr>
<tr>
<td>E014</td>
<td>Indicates that a wrong number of cylinders was dialed into the VTM.</td>
</tr>
<tr>
<td>E018</td>
<td>Indicates that an engine rpm or AC frequency test was terminated automatically to protect the VTM. Termination is only after several minutes of no-signal operation. Most likely the VTM was left on the vehicle and the engine stalled.</td>
</tr>
</tbody>
</table>
2-46. **STE/ICE-R TEST PROCEDURES (Cont’d)**

d. Cable Assemblies.

1. **General.** The cable assemblies are shown below and are referred to by the cable number and by a name which describes how the cable is used. If necessary, the two transducer cables (W4) can be joined with the adapter supplied in the transducer kit to make one long cable.

![Diagram of cable assemblies]

2. **Installation.** When cables are connected, large key on the cable connector mates with a keyway on the transducer connector or the VTM connector for proper installation. If you experience any difficulty during testing and suspect that a cable is bad, refer to TM 9-4910-571-12&P for checking cable continuity.

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>TK NO.</th>
<th>PART NO.</th>
<th>QTY</th>
<th>ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>11669227</td>
<td>1</td>
<td>Hose and fitting assy (spark plug adapter)</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>12258878</td>
<td>1</td>
<td>Current probe</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>12258853-1</td>
<td>1</td>
<td>Pipe thread reducer, 3/4 MPT to 1/4 FPT</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>12258853-3</td>
<td>1</td>
<td>Pipe thread reducer, 1/2 MPT to 1/4 FPT</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>12258853-2</td>
<td>2</td>
<td>Pipe thread reducer, 3/8 MPT to 1/4 FPT</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>444620</td>
<td>1</td>
<td>Hex-head plug, 1/4 MPT</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>5327970</td>
<td>1</td>
<td>Hex-head plug, 1/8 MPT</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>12258876</td>
<td>1</td>
<td>Pressure transducer, 0-1000 psig</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>12258881</td>
<td>1</td>
<td>Snubber</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>234X5</td>
<td>1</td>
<td>Male connector, 5/16 tube to 1/4 MPT</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>3204X2</td>
<td>1</td>
<td>Coupling reducer, 1/8 FPT to 1/4 FPT</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>223X5</td>
<td>1</td>
<td>Pressure transducer, -30 in. Hg to 25 psig</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>12258877</td>
<td>1</td>
<td>Street tee, 1/2 pipe thread</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>444152</td>
<td>1</td>
<td>Street tee, 1/4 pipe thread</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>3750X4</td>
<td>1</td>
<td>Street tee, 1/8 pipe thread</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>547002</td>
<td>1</td>
<td>Street tee, 1/8 pipe thread</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>12258879-2</td>
<td>1</td>
<td>Street elbow, 1/4 pipe thread</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>12258879-1</td>
<td>1</td>
<td>Street elbow, 1/8 pipe thread</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>12258875</td>
<td>1</td>
<td>Pulse tachometer</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>12258880</td>
<td>1</td>
<td>Fuel line adapter</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>MS3119E14-19</td>
<td>1</td>
<td>Tachometer drive adapter</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>MS3119E14-20</td>
<td>1</td>
<td>Ignition adapter</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>8840543</td>
<td>1</td>
<td>Adapter (connector-to-connector)</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>11669236</td>
<td>1</td>
<td>Hose assembly, 1/8 MPT</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>12258852</td>
<td>1</td>
<td>Pipe nipple, 1/8 MPT</td>
</tr>
</tbody>
</table>
1. **General.** The transducer kit contains a pulse tachometer transducer, a pressure and a vacuum transducer, and the necessary adapters (bushing, plugs, tees, etc.). Also included in the kit is a current probe for measuring current and a test probe cable for measuring voltage and resistance.

Not all fittings have part number markings. The legend will help to identify the items.

Before installing any transducer kit item on the vehicle, be sure to clean the mounting surfaces. This is particularly important if you are going to open fuel lines or tap into manifolds. Dirt particles entering the engine can cause damage to both the engine and the transducer kit item.

The transducers should be kept clean, free of dirt and grease, and handled with reasonable care.

2. **Pressure Transducer.** The pressure transducers have a small breather hole on the side of the housing which should be kept unplugged. Do not use high pressure.

3. **Pulse Tachometer.** Make sure that the slotted hole in the engine tachometer driveshaft is clear and not hard-packed before installing the pulse tachometer.

4. **Threaded Adapters.** Observe threaded fittings carefully to avoid engaging straight threads with pipe threads. Each measurement device (transducer) in the transducer kit has its own identification resistor. The VTM uses this identification resistor to check that the correct transducer is connected for the measurement being made. If the correct transducer is not connected, error code E002 will be displayed.
2-47. VEHICLE TESTING

a. General. To troubleshoot a vehicle problem, the technician can use the STE/ICE-R (vehicle test meter and transducers) and the vehicle test card.

b. Data Entry Tests. For information regarding Data Entry, Cylinder Entry, VID Entry, and Data Display Tests, refer to TM 9-4910-571-12&P.

c. Offset Tests. The STE/ICE-R VTM performs a test by setting the TEST select switches to the test number and pressing the TEST button. For some tests, an offset test is required before the test itself can be performed. This is done by selecting the number of the desired test and holding the TEST button down for several seconds.

The offset test nullifies characteristic differences in the VTM, test leads, and transducers. It zeros the meter. Once the offset is performed, the VTM automatically corrects for the offset before displaying measured values. The displayed offset value should be checked against limits on the vehicle test card. If the displayed value is outside these limits, either the transducer or the test cable is faulty and must be replaced. This is another form of self-test. The offset is performed when each transducer is connected. All tests requiring offset are identified by an asterisk (*) on the flip cards and by OFFSET LIMITS on the vehicle test cards. The offset test is performed with the test probe cable or transducer connected to the VTM. Care should be taken to see that no stimulus is applied to the transducer. Test probe cable leads should be shorted together. To perform an offset test, dial the test number into the TEST SELECT switches. Press and hold the TEST button until the prompting message CAL appears on the display. A few seconds after release of the TEST button, a number will appear. This is the measured offset value associated with the test probe cable or transducer and cable.

d. Control Tests. These tests are used to change (or control) the way a vehicle test is displayed or the way it is run. There are four control tests:

01 Interleave (displays rpm with next test).
02 Display Minimum Value for next test.
03 Display Maximum Value for next test.
04 Display Peak-to-Peak Value for next test.

Control tests 01, 02, 03, and 04 specify the action to be taken by the next test only. A subsequent test will reset the control.

1. Interleave (Test 01). This test alternately measures engine speed and a second parameter such as fuel pressure or alternator voltage. To initiate interleave, dial 01 into the TEST SELECT switches and press and release the TEST button. The prompting message PASS will signal the technician to dial in the second test number and again press and release the TEST button.

2. Minimum Value (Test 02). This test displays the minimum value measured during a test. To initiate a minimum value display, dial 02 into the TEST SELECT switches and press and release the TEST button. The prompting message PASS will signal the technician to dial in the desired test number and again press and release the TEST button. The minimum value is displayed and updated whenever a lower minimum value is measured. Entering 02 and the test number again will reset the process and a new minimum value will be displayed.
3. Maximum Value (Test 03). This test displays the maximum value measured during a test. To initiate a maximum value display, dial 03 into the TEST SELECT switches and press and release the TEST button. The prompting message PASS will signal the technician to dial in the desired test number and again press and release the TEST button. The maximum value is displayed and updated whenever a higher maximum value is measured. Entering 03 and the test number again will reset the process and a new maximum value will be displayed.

4. Peak-to-Peak Value (Test 04). This test displays the peak-to-peak value of 0-45 volts DC (89), 0-1,500 amps DC (90), and battery volts (67). To start a peak-to-peak measurement, dial 04 into the TEST SELECT switches and press the TEST button. The prompting message PASS will signal the operator to dial in one of the three numbers (89, 90, 67) and again press the TEST button.
Table 2-6. STE/ICE-R GO-Chain Tests.

**INDICATES VTM IS PROPERLY CONNECTED AND READY FOR TESTS**

**INDICATES GO CONDITION AFTER CONFIDENCE TESTS**

**NOTE**

Perform all GO steps until a NO-GO condition exists, then perform the NO-GO step indicated.

**CAUTION**

- Do not connect or disconnect the VTM while the vehicle is running.
- Connect DCA cable to the VTM before connecting to the diagnostic connector.

1. **CONNECT VTM TO VEHICLE DIAGNOSTIC CONNECTOR:**
   - PULL OFF the VTM power switch.
   - Connect DCA cable to the VTM.
   - Connect DCA cable to the vehicle.
   - PUSH ON the VTM power switch.
   - Verify that the display indicates .8.8.8.8 for approximately 2 seconds and then changes to - - - -.
   - Does the VTM display .8.8.8.8 and then change to - - - -?

**YES**

- Proceed to step 3.

**NO**

- Proceed to following page.

**NOTE**

*PULL OFF* the VTM power switch.

**DCA MODE**
Table 2-6. STE/ICE-R GO-Chain Tests (Cont’d).

1. **Does display light up?**
   - **NO**
   - **YES**
     - If only a portion of .8.8.8.8 or ---- is displayed, a display module may be burned out. Refer to TM 9-4910-571-12&P for module replacement.
     - Return to step 1.

2. **PROCEED AS FOLLOWS:**
   - PULL OFF power switch.
   - Check and clean all battery connections and interconnecting cables.
   - PUSH ON the power switch.
   - **NO**
     - Does the VTM display .8.8.8.8 and then change to ----?
       - **NO**
         - No power for VTM. Connect to a known good battery to see if problem is the vehicle or the VTM.
         - Proceed to step 3.
       - **YES**
         - PULL OFF the power switch.
         - Use power cable W5 to connect to a known good battery.
         - PUSH ON the power switch.
         - Does the VTM display .8.8.8.8 and then change to ----?

3. **YES**
   - Proceed to step 3.
   - **NO**
     - Proceed to TM 9-4910-571-12&P for fault isolation of cable W1.
     - If cable is bad, replace cable.
     - If cable is good, replace STE/ICE-R.

- Check the vehicle battery electrolyte level.
- Clean vehicle battery terminals.
- Check vehicle battery specific gravity (para. d-7A).
- Charge vehicle battery (TM 9-6140-200-14).
- Return to step 1.
- If problem repeats, look for broken or loose connections in DCA wiring from battery or in cable W1.
**Table 2-6. STE/ICE-R GO-Chain Tests (Cont’d).**

- **Dial 66 into TEST SELECT and press TEST.**
  - *Does the VTM display and hold 0066?*

  **Yes**
  - **RUN CONFIDENCE TEST:**
    - Dial 66 into TEST SELECT and press TEST.
    - Does the VTM display and hold 0066?

  **No**
  - PULL OFF the power switch.
  - PUSH ON the VTM power switch.
  - Verify that the display indicates .8.8.8.8 for approximately 2 seconds and then changes to ****.
  - Redial 66 and press TEST.
  - Does the VTM display and hold 0066?

  **Yes**
  - STE/ICE-R is bad. Replace.

  **No**
  - STE/ICE-R is bad. Replace.

- **NOTE**
  At this point in the test, several numbers will appear on the display. Wait for readout display of PASS.

- Proceed to following page.
Table 2-6. STE/ICE-R GO-Chain Tests (Cont'd).

**NOTE**
The VTM can fail Confidence Test if a bad transducer is connected to it. If the VTM fails Confidence Test when powered by W1 (DCA mode), remove all cable from the VTM and connect only W5, then clip W5 to the vehicle batteries. If it passes Confidence Test this way, there is a bad transducer in the vehicle's DCA. If it fails, the VTM has failed internally. Repeat TM 9-4910-571-12&P.

**NOTE**
If message E010 appears, either wrong number is entered or VTM is connected to wrong DCA connector.

**4 ENTER VEHICLE IDENTIFICATION NUMBER (VIN):**
- Dial 60 into TEST SELECT and press TEST.
- When UEH appears, dial vehicle identification number (21) into TEST SELECT and press TEST.
- VIN entered should appear on the display.

*Does the VTM display the number 21?*

**UEH**
PROMPTING MESSAGE

- Repeat step 4.
  - Does the VTM display the number 21?

**YES**

- STE/ICE-R is bad. Replace.

**NO**

- Proceed to troubleshooting procedures.
### CHAPTER 3
ENGINE SYSTEMS (UNIT) MAINTENANCE

#### Section I. LUBRICATION SYSTEM MAINTENANCE

#### 3-1. LUBRICATION SYSTEM MAINTENANCE TASK SUMMARY

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3-2. ENGINE OIL DIPSTICK TUBE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts

- O-ring (Appendix G, Item 216)
- Nut and lockwasher assembly (Appendix G, Item 197)
- Silicone compound (Appendix C, Item 74)

Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition

- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level

- Unit

a. Removal

1. Remove oil dipstick (7) from oil dipstick tube (6).
2. Remove nut and lockwasher assembly (5) and capscrew (2) from harness clamp (3) and upper dipstick tube bracket (8). Discard nut and lockwasher assembly (5).
3. Remove two screw-assembled washers (4) from upper dipstick tube bracket (8) and fuel line bracket (1).
4. Remove oil dipstick tube (6) from engine oil pan (10).
5. Remove and discard O-ring (9).

b. Installation

1. Apply RTV silicone compound to O-ring (9) and install O-ring (9) on oil dipstick tube (6).
2. Install oil dipstick tube (6) in engine oil pan (10).
3. Install upper dipstick tube bracket (8) on fuel line bracket (1) with two screw-assembled washers (4). Tighten screw-assembled washers (4) to 3-4 lb-ft (4-5 N-m).
4. Secure harness clamp (3) to upper dipstick tube bracket (8) with capscrew (2) and nut and lockwasher assembly (5).
5. Install oil dipstick (7) into oil dipstick tube (6).
3-2. ENGINE OIL DIPSTICK TUBE REPLACEMENT (Cont’d)

FOLLOW-ON TASKS:
- Start engine (TM 9-2320-387-10) and check for oil leaks.
- Lower and secure hood (TM 9-2320-387-10).
This task covers:
   a. Removal
   b. Inspection
   c. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
   automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
   automotive (Appendix B, Item 2)

Materials/Parts
   Lubricating oil (Appendix C, Item 44)

Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

Equipment Condition
   Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
   Unit

---

a. Removal

1. Loosen clamp (2) and disconnect CDR valve hose (1) from engine oil filler tube (3).
2. Remove two nuts (4), washers (5), and engine oil filler tube (3) from timing chain cover (7) and studs (8).

b. Inspection

Inspect grommet (6) for breaks or cracks. Replace if defective.

c. Installation

1. Coat grommet (6) with lubricating oil.
2. Install engine oil filler tube (3) on timing chain cover (7) and studs (8) with two washers (5) and nuts (4). Tighten nuts (4) to 13-20 lb-ft (18-27 N·m).
3. Connect CDR valve hose (1) to engine oil filler tube (3) and tighten clamp (2).

---

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-4. ENGINE OIL FILTER ADAPTER MAINTENANCE

This task covers:

a. Removal  
b. Inspection  
c. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts

- Gasket (Appendix G, Item 45)
- Two O-rings (Appendix G, Item 217)
- O-ring (Appendix G, Item 203)

Manual References

- TM 9-2320-387-24P

Equipment Condition

- Engine oil filter removed (para. 3-5).

Maintenance Level

- Unit

FOLLOW-ON TASK: Install engine oil filter (para. 3-5).

---

a. Removal

1. Remove adapter bolt (6), gasket (5), two O-rings (4), engine oil filter adapter (3), and O-ring (1) from cylinder block (2). Discard O-ring (1), two O-rings (4), and gasket (5).
2. Remove reducer boss (7) from oil filter adapter (3).

b. Inspection

Inspect reducer boss (7) for damaged threads or cracks. Replace if defective.

c. Installation

1. Install reducer boss (7) on oil filter adapter (3) and tighten to 25 lb-ft (34 N·m).
2. Install O-ring (1) and engine oil filter adapter (3) on cylinder block (2) with two O-rings (4), gasket (5), and adapter bolt (6). Tighten adapter bolt (6) to 50 lb-ft (68 N·m).

---

Change 6  3-4.1
3-4.1. DUAL ENGINE OIL FILTERS AND ADAPTER MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Gasket (Appendix G, Item 45)
Two O-rings (Appendix G, Item 217)
O-ring (Appendix G, Item 203)
Two oil filters (Appendix G, Item 199)
Lubricating oil (Appendix C, Item 44)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Maintenance Level
Unit

NOTE

Have drainage container ready to catch oil.

1. Remove oil filters (4) from filter adapter (8). Discard filters (4).
2. Remove adapter bolt (5), gasket (6), two O-rings (7), oil filter adapter (8), and O-ring (2) from cylinder block (1). Discard O-ring (2), two O-rings (7), and gasket (6).
3. Remove reducer boss (3) and (9) from oil filter adapter (8).
4. Remove plug (10) from oil filter adapter (8).

b. Inspection

Inspect reducer boss (3) and (9) for damaged threads or cracks. Replace if defective.

c. Installation

1. Install plug (10) on oil filter adapter (8).
2. Install reducer boss (3) and (9) on oil filter adapter (8) and tighten to 25 lb-ft (34 N•m).
3. Install O-ring (2) and oil filter adapter (8) on cylinder block (1) with two O-rings (7), gasket (6), and adapter bolt (5). Tighten adapter bolt (5) to 50 lb-ft (68 N•m).
4. Apply a light coat of oil to filter gasket prior to installation.
5. Install oil filters (4) on oil filter adapter (8) until gasket contacts filter adapter (8). Tighten an additional 1/2–3/4 turn by hand.
3-4.1. DUAL ENGINE OIL FILTERS AND ADAPTER MAINTENANCE (Cont’d)

FOLLOW-ON TASKS: • Check engine oil and start engine (TM 9-2320-387-10) and check for leaks at oil filter and drainplug (par. 3-5).
• Lower and secure hood (TM 9-2320-387-10).
### 3-5. ENGINE OIL SERVICE

This task covers:

- **a. Oil Draining**
- **b. Filter Removal**
- **c. Filter Installation**
- **d. Oil Replenishing**

#### INITIAL SETUP:

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<tr>
<td>Do not drain oil when engine is hot.</td>
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</table>

**Maintenance Level**

Unit

---

#### a. Oil Draining

**WARNING**

Do not drain oil when engine is hot. Severe injury to personnel may result.

**NOTE**

- Park vehicle on a firm, level surface.
- Have drainage container ready to catch oil.

1. Remove drainplug (5) and gasket (4) from oil pan (3). Allow oil to drain completely.
2. Install gasket (4) and drainplug (5) on oil pan (3). Tighten drainplug (5) to 20 lb-ft (27 N•m).

#### b. Filter Removal

**NOTE**

Have drainage container ready to catch oil.

Remove oil filter (1) from filter adapter (2). Discard filter (1).

#### c. Filter Installation

1. Apply a light coat of oil to filter gasket prior to installation.
2. Install oil filter (1) on oil filter adapter (2) until gasket contacts filter adapter (2). Tighten an additional 1/2-3/4 turn by hand.

#### d. Oil Replenishing

**CAUTION**

Install a non-vented filler cap only. An incorrect filler cap will not seal properly, allowing water to enter and damage engine.

1. Remove filler cap (6) from filler tube (7). Fill with oil according to TM 9-2320-387-10.
2. Install filler cap (6) on filler tube (7).
FOLLOW-ON TASKS: • Start engine (TM 9-2320-387-10) and check for leaks at oil filter and drainplug.
• Lower and secure hood (TM 9-2320-387-10).
### 3-6. OIL PAN REPLACEMENT

This task covers:

- **a. Removal**
- **b. Installation**

#### INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Oil seal retainer (Appendix G, Item 253)
- Two lockwashers (Appendix G, Item 151)
- Silicone compound (Appendix C, Item 74)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Starter removed (para. 4-11).
- Oil dipstick tube removed (para. 3-2).

**General Safety Instructions**
- Do not drain oil when engine is hot.

**Maintenance Level**
- Unit

---

### a. Removal

**WARNING**

Do not drain oil when engine is hot. Severe injury to personnel may result.

**NOTE**

Have drainage container ready to catch oil.

1. Remove drainplug (7) and gasket (6) from oil pan (11) and drain oil. Install gasket (6) and drainplug (7) after oil is drained.
2. Remove two nuts (8), lockwashers (9), and starter cable support bracket (10) from studs (13). Discard lockwashers (9).
3. Remove twenty capscrews (5), two large capscrews (12), studs (13), and oil pan (11) from cylinder block (2). Remove any sealant from oil pan (11) and cylinder block (2).
4. Remove oil pan rear oil seal retainer (14) from rear main cap (1). Discard oil pan rear oil seal retainer (14).

---

### b. Installation

1. Apply a bead of silicone compound to each end of oil pan rear oil seal retainer (14) and install oil seal retainer (14) on rear main cap (1).

**NOTE**

Immediately install oil pan after application of sealant.

2. Apply a 3/16-in. (5-mm) bead of silicone compound around two large holes (3) on cylinder block (2). Apply a 3/16-in. (5-mm) bead of sealant around oil pan sealing surface (4) following sealant diagram.
3. Install oil pan (11) on cylinder block (2) with twenty capscrews (5), two large capscrews (12), and studs (13). Tighten capscrews (5) and studs (13) to 4-10 lb-ft (5-14 N·m). Tighten large capscrews (12) to 13-20 lb-ft (18-27 N·m).
4. Install starter cable support bracket (10) on studs (13) with two lockwashers (9) and nuts (8).
5. Tighten oil drainplug (7) to 20 lb-ft (27 N·m).
FOLLOW-ON TASKS:

- Fill engine oil to proper level (TM 9-2320-387-10).
- Install oil dipstick tube [para. 3-2].
- Install starter [para. 4-11].
3-7. ENGINE OIL COOLER SUPPLY AND RETURN LINES MAINTENANCE (Cont’d) (SERIAL NUMBERS 299999 AND BELOW)

This task covers:
   a. Removal
   b. Inspection
   c. Installation

INITIAL SETUP:

Tools
   General mechanic’s tool kit:
       automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
       automotive (Appendix B, Item 2)

Materials/Parts
   Tiedown strap (Appendix G, Item 326)
   Lockwasher (Appendix G, Item 144)
   Locknut (Appendix G, Item 77)

Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

Equipment Condition
   • Engine left splash shield removed (para. 10-23).
   • Engine access cover removed (para. 10-22).

General Safety Instructions
   Do not drain oil when engine is hot.

Maintenance Level
   Unit

WARNING
   Do not drain oil when engine is hot. Severe injury to personnel may result.

CAUTION
   Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE
   • Engine oil cooler supply and return lines are replaced basically the same. This procedure covers supply line replacement.
   • Have drainage container ready to catch oil.

   1. Disconnect supply line connector (5) from adapter (4) and allow oil to drain.
   2. Disconnect supply line connector (16) from oil cooler port (17).
   3. Remove locknut (3), washer (2), capscrew (15), and washer (2) from supply line clamp (14), brake line clamp (1), and frame bracket (13). Discard locknut (3).
   4. Remove capscrew (7), lockwasher (8), and clamp (9) from supply line (12) and engine mount bracket (10). Discard lockwasher (8).
   5. Remove tiedown strap (11) and supply line (12) from return line (6). Discard tiedown strap (11).

b. Inspection

Inspect adapter (4) for damaged threads or cracks. Replace if defective.

c. Installation

   1. Position supply line (12) in approximate mounting location along frame.
   2. Install supply line clamp (14) and brake line clamp (1) on frame bracket (13) with washer (2), capscrew (15), washer (2), and locknut (3). Tighten locknut (3) to 6 lb-ft (8 N•m).
   3. Connect supply line connector (16) to oil cooler port (17).
3-7. ENGINE OIL COOLER SUPPLY AND RETURN LINES MAINTENANCE (SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

4. Connect supply line connector (5) to adapter (4).
5. Secure supply line (12) to engine mount bracket (10) with clamp (9), lockwasher (8), and capscrew (7).
6. Secure supply line (12) to return line (6) with tiedown strap (11).

FOLLOW-ON TASKS: • Install engine left splash shield (para. 10-23).
                  • Fill oil to proper level (TM 9-2320-387-10).
                  • Start engine (TM 9-2320-387-10) and inspect for leaks at engine oil cooler, supply and return lines.
                  • Install engine access cover (para. 10-22).
3-7.1. ENGINE OIL COOLER SUPPLY AND RETURN LINES MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

- a. Removal
- b. Inspection
- c. Installation

INITIAL SETUP:

**Tools**

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**

- Two lockwashers (Appendix G, Item 144)
- Two locknuts (Appendix G, Item 77)
- Three tiedown straps (Appendix G, Item 323)
- Lockwasher (Appendix G, Item 145)

**Manual References**

- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**

- Engine left splash shield removed (para. 10-23.1).
- Oil filter removed (para. 3-5).

**General Safety Instructions**

- Do not drain oil when engine is hot.

**Maintenance Level**

- Unit

---

**WARNING**

Do not drain oil when engine is hot. Severe injury to personnel may occur.

**CAUTION**

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**

- Replacement procedures for engine oil cooler supply and return lines are basically the same. This procedure covers the supply line.
- Mark line connectors for installation.

---

**NOTE**

Have drainage container ready to catch oil.

1. Disconnect supply line connector (12) from adapter (11) and allow oil to drain.
2. Disconnect supply line connector (29) from oil cooler port (30).
3. Remove locknut (25), lockwashers (26), capscrew (1), oil and power steering lines bracket (3), and washers (2) and (27) from airlift bracket (4). Discard locknut (25) and lockwasher (26).
4. Remove capscrew (20), lockwasher (21), washer (22), and oil lines bracket (23) from steering gear case (24). Discard lockwasher (21).
5. Remove capscrew (14), two clamps (15) and (16), and oil line (13) from engine mount bracket (17).
6. Remove locknut (9), washer (8), capscrew (19), lockwasher (18), two clamps (6) and (7), and oil line (13) from oil lines bracket (23). Discard locknut (9) and lockwasher (18).
7. Remove three tiedown straps (5), (10), and (28) from engine oil and power steering lines.

---

**b. Inspection**

Inspect adapter (11) and oil cooler port (30) for damaged threads or cracks. If damaged, replace.
3-7.1. ENGINE OIL COOLER SUPPLY AND RETURN LINES MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

**c. Installation**

**NOTE**

Use of a longer capscrew may be necessary for installation of oil lines bracket.

1. Install three tiedown straps (5), (10), and (28) on engine oil and power steering lines.
2. Install oil line (13) on oil lines bracket (23) with two clamps (6) and (7), lockwasher (18), capscrew (19), washer (8), and locknut (9). Tighten locknut (9) to 6 lb-ft (8 N•m).
3. Install oil line (13) on engine mount bracket (17) with two clamps (15) and (16) and capscrew (14).
4. Install oil lines bracket (23) on steering gear case (24) with capscrew (20), lockwasher (21), and washer (22).
5. Install oil and power steering lines bracket (3) on airlift bracket (4) with capscrew (1), washers (2) and (27), lockwasher (26), and locknut (25).
6. Connect supply line connector (29) to oil cooler port (30).
7. Connect supply line connector (12) to adapter (11).

**FOLLOW-ON TASKS:**
- Install oil filter (para. 3-5).
- Install engine left splash shield (para. 10-23.1).
- Fill oil to proper level (TM 9-2320-387-10).
- Start engine (TM 9-2320-387-10) and inspect for leaks at engine oil cooler, supply, and return lines.
3-8. ENGINE, TRANSMISSION, AND POWER STEERING OIL COOLER ASSEMBLY MAINTENANCE (SERIAL NUMBERS 299999 AND BELOW)

This task covers:
   a. Removal  
   b. Installation  
   c. Cleaning and Inspection

INITIAL SETUP:

   Tools
   General mechanic's tool kit:  
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:  
      automotive (Appendix B, Item 2)

   Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

   Equipment Condition
   • Engine left splash shield removed (para. 10-23).
   • Headlight housing removed (para. 10-18).

   General Safety Instructions
   • Do not drain oil when engine is hot.
   • Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa).

   Maintenance Level
   Unit

WARNING

Do not drain oil when engine is hot. Severe injury to personnel may result.

CAUTION

• Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.
• Do not bend transmission oil cooler fins. Damaged fins reduce cooling efficiency, which may damage engine and/or transmission.

NOTE

• Have drainage container ready to catch oil.
• Tag all hoses for installation.

1. Disconnect two engine oil cooler supply and return lines (15) from engine oil cooler ports (11).
2. Loosen two hose clamps (2) and disconnect transmission fluid cooler line connector hoses (1) from transmission fluid cooler ports (3).
3. Loosen two hose clamps (13) and disconnect power steering fluid line hoses (12) from power steering fluid cooler ports (14).
4. Remove four socket-head screws (7) and oil cooler (16) from radiator (17).

NOTE

Perform steps 5 through 7 if vehicle is equipped with radiator cleaning components.
5. Remove two capscrews (4), washers (5), and support bracket (6) from oil cooler (16).
6. Remove capscrew (8), washer (9), clip (10), and spacer (10.1) from oil cooler (16).
7. Remove four capscrews (20), washers (19), and two hinges (18) from oil cooler (16).
c. Cleaning and Inspection

1. Remove four socket-head screws (7) securing oil cooler (16) to radiator (17).
2. Remove prop rod (6.1) from clip (10), raise oil cooler (16) and secure oil cooler (16) in place using prop rod (6.1).

**WARNING**
Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

3. Using water and compressed air, remove dirt, trash, and insects embedded in oil cooler (16) and radiator (17) fins.
4. Inspect oil cooler (16) for breaks, punctures, cracks, and splits. Replace oil cooler (16), if damaged.
5. Lower oil cooler (16) and secure on radiator (17) with four socket-head screws (7).
6. Secure prop rod (6.1) in clip (10).
FOLLOW-ON TASKS:
- Fill power steering fluid to proper level (TM 9-2320-387-10).
- Fill transmission oil to proper level (TM 9-2320-387-10).
- Fill engine oil to proper level (TM 9-2320-387-10).
- Install headlight housing (para. 10-18).
- Install engine left splash shield (para. 10-23).
- Start engine (TM 9-2320-387-10) and check for leaks.
3-8.1. ENGINE, TRANSMISSION, AND POWER STEERING OIL COOLER ASSEMBLY REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Eight anti-rotation washers (Appendix G, Item 318.2)
- Four lockwashers (Appendix G, Item 146)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Engine left splash shield removed (para. 10-23.1).
- Engine right splash shield removed (para. 10-24.1).

**General Safety Instructions**
- Do not drain oil when engine is hot.
- Maintenance Level
  - Unit

**WARNING**
- Do not drain oil when engine is hot. Severe injury to personnel may result.

**CAUTION**
- Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.
- Do not bend transmission oil cooler fins. Damaged fins reduce cooling efficiency, which may damage engine or transmission.

**NOTE**
- Have drainage container ready to catch oil.
- Tag all hoses for installation.

1. Loosen hose clamps (10) and (13) and remove power steering fluid hose lines (11) and (12) from power steering cooler ports (9) and (14).
2. Remove return line (15) and supply line (17) from oil cooler ports (16) and (18).
3. Remove two transmission fluid lines (27) and (29) from transmission fluid cooler ports (28) and (30).
4. Remove four capscrews (25), lockwashers (24), washers (23), and two hinges (22) from oil cooler (1).
5. Remove capscrew (6), washer (7), and clip (8) from oil cooler (1).
6. Remove four capscrews (2), eight anti-rotation washers (3) and (4), four washers (5), and oil cooler (1) from radiator (21). Discard anti-rotation washers (3) and (4).
7. Remove two nuts (26), capscrews (19), and brackets (20) from two hinges (22).

**b. Installation**

1. Install two brackets (20) on hinges (22) with two capscrews (19) and nuts (26).
2. Install oil cooler (1) on radiator (21) with four washers (5), eight anti-rotation washers (3) and (4), and four capscrews (2).
3. Install clip (8) on oil cooler (1) with washer (7) and capscrew (6).
4. Install hinges (22) on oil cooler (1) with four washers (23), lockwashers (24), and capscrews (25).
5. Install transmission fluid lines (27) and (29) on transmission fluid cooler ports (28) and (30).
6. Install supply line (17) and return line (15) on oil cooler ports (16) and (18).
7. Install power steering fluid hose lines (12) and (11) on power steering cooler ports (14) and (9) with hose clamps (13) and (10).
3-8.1. ENGINE, TRANSMISSION, AND POWER STEERING OIL COOLER ASSEMBLY REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASKS:
- Install engine right splash shield (para. 10-24.1).
- Install engine left splash shield (para. 10-23.1).
- Check and refill engine oil and transmission oil and power steering oil (TM 9-2320-387-10).
- Bleed power steering system (para. 8-27).
3-9. CRANKCASE DEPRESSION REGULATOR (CDR) VALVE AND BRACKET MAINTENANCE

This task covers:

a. Testing  
b. Removal  
c. Cleaning and Inspection  
d. Installation

INITIAL SETUP:

Test Equipment
Manometer, U-tube  
(Appendix B, Section IV, Item L)

Manual References
TM 9-2320-387-10  
TM 9-2320-387-24P

Tools
General mechanic's tool kit:  
avtomec (Appendix B, Item 1)  
Maintenance and repair shop equipment:  
avtomec (Appendix B, Item 2)

Equipment Condition
• Hood raised and secured (TM 9-2320-387-10).  
• Engine access cover removed (para. 10-22).

Maintenance Level
Unit

a. Testing

1. Remove engine oil dipstick from oil dipstick tube (para. 3-2).
2. Install manometer in dipstick tube.
3. Connect STE/ICE-R unit to DCA connector.

**NOTE**

To read manometer pressure, add amount the water travels in column above zero to the amount the water travels in column below zero.

4. Start engine and let idle; record water pressure. Pressure should be zero inches of water, or a slight vacuum.
5. Increase engine speed to 2,000 rpm; record water pressure. Pressure should be 2-5 in.
6. If pressures are not within specifications in steps 4 and 5, replace CDR valve (7) and repeat test.
7. Install engine oil dipstick in oil dipstick tube (para. 3-2).

b. Removal

**NOTE**

CDR valves on vehicles equipped with deep water fording kit contain two additional vent lines.

1. Loosen clamp (5) and disconnect CDR valve oil fill tube hose (4) from CDR valve (7).
2. Remove two screws (1), washers (2), and CDR valve (7) from CDR valve bracket (3) and intake crossover hose (6).
3. Remove two nuts (9) from CDR valve bracket (3) and intake manifold studs (10).
4. Remove two nuts (8) and CDR valve bracket (3) from two valve cover studs (11).
3-9. CRANKCASE DEPRESSION REGULATOR (CDR) VALVE AND BRACKET MAINTENANCE (Cont'd)

TO OIL DIPSTICK TUBE

2 IN. BELOW ZERO  2 IN. ABOVE ZERO

Diagram showing various components and numbered parts.
3-9. CRANKCASE DEPRESSION REGULATOR (CDR) VALVE AND BRACKET
MAINTENANCE (Cont'd)

c. Cleaning and Inspection

**CAUTION**

Do not clean CDR valve with drycleaning solvent. Drycleaning solvent may damage the diaphragm inside CDR valve.

1. Clean oil and carbon deposits from CDR valve (12) with a clean, lint-free cloth.
2. Inspect CDR valve (12) and lines for leaks, cracks, and restrictions. Replace if damaged.

d. Installation

1. Install CDR valve bracket (2) on two intake manifold studs (4) and valve cover studs (6).
2. Secure CDR valve bracket (2) to intake manifold (5) with two nuts (3). Tighten nuts (3) to 15 lb-ft (20 N·m).
3. Secure CDR valve bracket (2) to valve cover studs (6) with two nuts (1). Tighten nuts (1) to 10 lb-ft (14 N·m).
4. Install CDR valve (12) on CDR valve bracket (2) and intake crossover hose (11) with two washers (8) and screws (7). Tighten screws (7) to 15 lb-ft (20 N·m).
5. Connect CDR valve oil fill tube hose (9) to CDR valve (12) and tighten clamp (10).
3-9. CRANKCASE DEPRESSION REGULATOR (CDR) VALVE AND BRACKET MAINTENANCE (Cont'd)

FOLLOW-ON TASKS:
- Lower and secure hood (TM 9-2320-387-10).
- Install engine access cover (para. 10-22).
3-10. CDR VALVE HOSES REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Equipment Condition
CDR valve and bracket removed (para. 3-9).

Maintenance Level
Unit

a. Removal

1. Remove CDR valve intake crossover hose (3) from air horn (5).
2. Loosen clamp (2) and disconnect CDR valve oil fill tube hose (1) from oil fill tube (4).

b. Installation

1. Connect CDR valve oil fill tube hose (1) to oil fill tube (4) and tighten clamp (2).
2. Install CDR valve intake crossover hose (3) on air horn (5).

FOLLOW-ON TASK: Install CDR valve and bracket (para. 3-9).
# Section II. FUEL SYSTEM MAINTENANCE

## 3-11. FUEL SYSTEM MAINTENANCE TASK SUMMARY

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3-12. AIR CLEANER ASSEMBLY AND DUST UNLOADER MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)
Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

General Safety Instructions
Ensure loosened clamp straps are secured.

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

a. Removal

NOTE
For dust unloader replacement, perform steps 1 and 2 only.
1. Remove four screws (16) and dust unloader cover (15) from two support brackets (4).
2. Loosen clamp (17) and remove dust unloader (18) from air cleaner assembly (9).
3. Loosen clamp (5) and disconnect elbow (6) from air cleaner assembly (9).
4. Disconnect air restriction gauge hose (7) from fitting (8).
5. Remove outer strap clamps (10) and (12) from air cleaner assembly (9).
6. Disconnect vent line (3) from elbow (2).
7. Remove air cleaner assembly (9) from two support brackets (4).
8. Remove elbow (2) from air cleaner assembly (9).
9. Remove adapter (14) and tube (13) from air cleaner assembly (9).
10. Remove fitting (8) from air cleaner assembly (9).
11. Remove strap clamp (11) from air cleaner assembly (9).

b. Inspection

1. Inspect gasket (1) for cracks or breaks. Replace gasket (1) if defective.
2. Inspect elbow (2), fitting (8), and adapter (14) for damaged threads or cracks. Replace if defective.

c. Installation

NOTE
For dust unloader replacement, perform steps 10 and 11 only.
1. Install strap clamp (11) on air cleaner assembly (9).
2. Install fitting (8) on air cleaner assembly (9).
3. Install tube (13) on adapter (14).
4. Install tube (13) and adapter (14) on air cleaner assembly (9).
5. Install elbow (2) on air cleaner assembly (9).
3-12. AIR CLEANER ASSEMBLY AND DUST UNLOADER MAINTENANCE (Cont'd)

NOTE
If armor on M1151A1, M1152A1, M1165A1, or M1167 interferes with dust unloader, rotate air cleaner assembly away from armor to prevent interference.

6. Install air cleaner assembly (9) on two support brackets (4) with strap clamps (10), (11), and (12). Tighten clamps in the following sequence: (10), (11), and (12).

7. Connect elbow (6) to air cleaner assembly (9) and tighten clamp (5) to 50-60 lb-in. (6-7 N•m).

8. Connect air restriction gauge hose (7) to fitting (8).

9. Connect vent line (3) to elbow (2).

10. Install dust unloader (18) on air cleaner assembly (9) and tighten clamp (17) to 45-50 lb-in. (5-6 N•m).

11. Install dust unloader cover (15) on two support brackets (4) with four screws (16).

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-13. AIR CLEANER FILTER ELEMENT SERVICING

This task covers:

a. Removal
b. Inspection
c. Emergency Cleaning
d. Cleaning
e. Installation

INITIAL SETUP:

Tools

General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts

Detergent (Appendix C, Item 25)

Manual References

TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition

Hood raised and secured (TM 9-2320-387-10).

General Safety Instructions

- Do not use unauthorized cleaning methods or liquids.
- Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa).

Maintenance Level

Unit

WARNING

- Improper cleaning methods and use of unauthorized cleaning liquids can injure personnel and cause damage to equipment. Do not use anything other than compressed air, water, and detergent to clean elements.
- If NBC contamination is suspected, consult NBC officer or NBC NCO for appropriate handling instructions.

a. Removal

The vehicle air cleaner may be configured with either a ring clamp or over-center clamp.

1. Loosen screw (8), or unlatch and remove clamp (1), cover (2), and gasket (3) from air cleaner assembly (6).

CAUTION

Cover housing opening with screen or rag to prevent contaminants from entering air intake system and damaging engine.

2. Remove nut and washer assembly (7) and filter element (4) from stud (5) of air cleaner assembly (6).

b. Inspection

1. Check gasket (3) for dents, tears, rips, and other damage. Ensure gasket has not taken a set. Ensure there are no hard dirt ridges on sealing surfaces.

2. Inspect filter element (4) for holes and tears by looking through element toward a bright light. If pinpoints of light shine through, replace element. Holes that are large enough to let light through are large enough to let contaminants through. Another way to check for leaks or damage is to look for uneven dirt patterns. Ensure there is no rust or flaking paint on metal parts of filter. If the filter has already been cleaned three times, or if damaged, replace filter element (4).

3. Check air cleaner assembly (6) for holes, dents, rust, or any other damage that will interfere with proper sealing and allow unfiltered air to enter and destroy engine.

CAUTION

Do not strike ends of filter element on hard surface, or damage to filter element may result.

Remove dust or sand from filter element (4) by holding it so neither end faces ground, and gently tap around filter element (4).

c. Emergency Cleaning
3-13. AIR CLEANER FILTER ELEMENT SERVICING (Cont’d)

d. Cleaning

**WARNING**
Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personnel protective equipment (goggles/shield, gloves, etc.).

1. Hold nozzle at least 1 in. (25 mm) away from element (1) and direct compressed air against clean side of element (1) (in direction opposite to normal air flow). Move air stream up and down length of pleats until dust no longer blows out.

2. Prepare a solution of five gal. warm water 80-110°F (27-43°C) and one cup of non-sudsing detergent in a container large enough to submerge element (1).

3. Immerse element (1) completely in cleaning solution, swish for two minutes, soak element (1) for 15-20 min., then swish it around again to remove contaminants.

4. Remove element (1) from the solution and let drain.

5. Rinse element (1) with cool water 35-80°F (2-27°C) from clean side to dirty side (in direction opposite to normal air flow) with a gentle stream of water no more than 40 psi (276 kPa). If the clean side of element (1) was contaminated during soak cycle, rinse from both sides.

**CAUTION**
Do not use compressed air to speed drying time or damage to element may result.

6. Air-dry element (1) at normal room temperature until it is completely dry. Usually overnight is adequate, but temperature and humidity will affect drying time. If circulating air is used, do not exceed 180°F (82°C).

7. Inspect element (1) and discard if damaged. If not damaged, mark date of cleaning on element (1).

e. Installation

1. Remove screen or rag from housing opening.

**CAUTION**
When replacing filter element, ensure it is the 420 CFM element.

2. Install filter element (1) on stud (5) of air cleaner assembly (6) with nut and washer assembly (7). Tighten nut and washer assembly (7) to 20-40 lb-in (2-5 N·m).

**CAUTION**
When cover clamp is secured to end of filter body assembly, ensure clamp screw/latch is between three and six o’clock position to prevent damaging hood when hood is closed.

**NOTE**
Perform step 3 when using ring clamp.

3. Install gasket (4) and cover (3) on air cleaner assembly (6) with clamp (2). Tighten screw (8) to 35-40 lb-in (4-5 N·m).

**NOTE**
Perform step 3.1 when using over center clamp.

3.1 Install gasket (4) and cover (3) on air cleaner assembly (6) with clamp (2) as shown. Ensure a 0.250 in. gap is set with clamp in closed position.
FOLLOW-ON TASKS:  
- Lower and secure hood (TM 9-2320-387-10).
- Start engine (TM 9-2320-387-10) and ensure air restriction gauge on instrument panel does not show red.
3-14. AIR HORN REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: (Appendix B, Item 2)

**Materials/Parts**
- Adhesive (Appendix C, Item 10)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Hood raised and secured (TM 9-2320-387-10).

**Maintenance Level**
- Unit

---

**a. Removal**

1. Disconnect CDR hose (1) from air horn (2).
2. Loosen clamp (4) and disconnect air intake elbow (3) from air horn (2).

**CAUTION**

Cover opening of turbocharger intake to prevent foreign material from entering turbocharger and damaging engine.

3. Loosen clamp (5) and remove air horn (2) from turbocharger intake hose (6).
4. Remove adapter (7) from air horn (2).
5. Remove inserts (8) and (9) from air horn (2).

**b. Installation**

1. Install inserts (8) and (9) on air horn (2).
   1.1 Apply adhesive to adapter (7) and install adapter (7) on air horn (2).
2. Install air horn (2) on turbocharger intake hose (6) and tighten clamp (5) to 50-60 lb-in. (6-7 N·m).
3. Connect elbow (3) to air horn (2) and tighten clamp (4) to 50-60 lb-in. (6-7 N·m).
4. Connect CDR hose (1) to air horn (2).
FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-15. AIR HORN-TO-AIR CLEANER ELBOW REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

a. Removal

1. Loosen two clamps (3) and remove elbow (4) from air cleaner assembly (1) and air horn (2).
2. Remove two clamps (3) from elbow (4).

b. Installation

1. Install two clamps (3) on elbow (4).
2. Connect elbow (4) to air cleaner assembly (1) and air horn (2) and tighten two clamps (3) to 50-60 lb-in. (6-7 N•m).

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-16. AIR HORN SUPPORT BRACKET REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
   automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
   automotive (Appendix B, Item 2)

Materials/Parts
   Lockwasher (Appendix G, Item 185)

Manual References
   TM 9-2320-387-24P

Equipment Condition
   Air horn removed (para. 3-14).

Maintenance Level
   Unit

a. Removal

1. Remove nut (5), lockwasher (4), two clamps (3), and stud (2) from air horn support bracket (1) and cylinder head (7). Discard lockwasher (4).
2. Remove capscrew (6) and support bracket (1) from cylinder head (7).

b. Installation

1. Install air horn support bracket (1) on cylinder head (7) with stud (2).
2. Secure air horn support bracket (1) to cylinder head (7) with capscrew (6). Tighten capscrew (6) and stud (2) to 40 lb-ft (54 N·m).
3. Install two clamps (3) on stud (2) with lockwasher (4) and nut (5).

FOLLOW-ON TASK: Install air horn (para. 3-14).
3-17. AIR RESTRICTION GAUGE REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Maintenance Level</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>TM 9-2320-387-10</td>
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<td></td>
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<tr>
<td>TM 9-2320-387-24P</td>
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<td></td>
</tr>
</tbody>
</table>

**a. Removal**

1. Remove two screws (2) securing gauge (4) to bezel (1) and remove gauge (4) and gasket (3) from behind instrument panel (6).
2. Disconnect hose (5) and remove gauge (4).

**b. Installation**

1. Connect hose (5) to gauge (4).
2. Install gasket (3) and gauge (4) behind instrument panel (6) and secure to bezel (1) with two screws (2).

FOLLOW-ON TASK: Start engine (TM 9-2320-387-10) and check operation of air restriction gauge.
3-18. WEATHERCAP REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

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<tr>
<td>automotive (Appendix B, Item 2)</td>
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</tbody>
</table>

Manual References

TM 9-2320-387-24P

a. Removal

Remove clamp (2) and weathercap (1) from air intake duct (3).

b. Installation

Install weathercap (1) on air intake duct (3) with clamp (2). Tighten clamp (2) to 50-60 lb-in. (6-7 N•m).
3-19. AIR INTAKE ASSEMBLY AND BRACKET REPLACEMENT

This task covers:
  a. Removal
  b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Two locknuts (Appendix G, Item 106) (M1114 only)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Weathercap removed (para. 3-18).

---

**a. Removal**

1. Remove nut (5), washer (3), capscrew (2), and washer (3) from air intake assembly (1) and support bracket (4).
2. Loosen two clamps (6), and remove air intake assembly (1) and rubber boot (6.1) from air cleaner extension (7).

**NOTE**
Perform steps 3 and 4 for M1114 and step 5 for all other vehicles.

3. Remove two locknuts (11), capscrews (8), washers (9), and support bracket (4) from mounting bracket (10). Discard locknuts (11).
4. Remove two capscrews (14), washers (13), and mounting bracket (10) from windshield (12).
5. Remove two capscrews (16), washers (15), and support bracket (4) from windshield (12).

---

**b. Installation**

Perform steps 1 and 2 for M1114 and step 3 for all other vehicles.

1. Install mounting bracket (10) on windshield (12) with two washers (13) and capscrews (14). Tighten capscrews (14) to 6 lb-ft (8 N-m).
2. Install support bracket (4) on mounting bracket (10) with two washers (9), capscrews (8), and locknuts (11).
3. Install support bracket (4) on windshield (12) with two washers (15) and capscrews (16).
4. Install rubber boot (6.1) and air intake assembly (1) on air cleaner extension (7) with two clamps (6). Tighten clamps (6) to 50-60 lb-in. (6-7 N-m).
5. Install air intake assembly (1) on support bracket (4) with washer (3), capscrew (2), washer (3), and nut (5). Tighten nut (5) to 43 lb-ft (58 N-m).
FOLLOW-ON TASK: Install weathercap (para. 3-18).
3-20. AIR RESTRICTION GAUGE HOSE REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

**Tools**
General mechanic's tool kit:
automotive (Appendix B, Item 1)

**Manual References**
TM 9-2320-387-10
TM 9-2320-387-24P

**Equipment Condition**
Hood raised and secured (TM 9-2320-387-10).

**Maintenance Level**
Unit

---

a. Removal

1. Loosen five clamps (2) securing hose (5) to A-beam (1).
2. Disconnect hose (5) from air cleaner assembly (8).
3. Disconnect hose (5) from gauge (3) located behind instrument panel (4).
4. Remove hose (5) from five clamps (2) and through grommet (6) in cowl (7).

b. Installation

1. Route hose (5) through grommet (6) and five clamps (2) in cowl (7) and connect hose (5) to air cleaner assembly (8).
2. Connect hose (5) to gauge (3).
3. Tighten five clamps (2) on hose (5) and A-beam (1).

---

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-21. AIR INTAKE AND FUEL PUMP VENT LINES REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic’s tool kit:
      automotive (Appendix B, Item 1)

Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

Equipment Condition
   Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
   Unit

a. Removal

   NOTE
   • For fuel pump vent line replacement, perform steps 2, 3, and 4 only.
   • Insulation may need to be removed to access vent line.

1. Remove vent line (2) from air cleaner fitting (1) and tee fitting (8).
2. Loosen clamp (3) and disconnect vent line (4) from fuel pump (7).
3. Loosen clamp (5) and remove vent line (4) from tee fitting (6).
4. Remove two clamps (3) and (5) from vent line (4).

b. Installation

   NOTE
   For fuel pump vent line replacement, perform steps 2 and 3 only.

1. Connect vent line (2) to tee fitting (8) and air cleaner fitting (1).
2. Install clamps (3) and (5) on vent line (4).
3. Install vent line (4) on tee fitting (6) and fuel pump (7) and tighten clamps (3) and (5).
4. Install insulation if removed to access vent line (2).

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-22. DRAINAGE BRACKET REPLACEMENT

This task covers:

| a. Removal                      | b. Installation          |

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Equipment Condition**
- Air cleaner assembly removed [para. 3-12].

**Maintenance Level**
- Unit

**Manual References**
- TM 9-2320-387-24P

**a. Removal**

Remove three screws (2) and drainage bracket (3) from body (1).

**b. Installation**

Install drainage bracket (3) on body (1) with three screws (2).

FOLLOW-ON TASK: Install air cleaner assembly [para. 3-12].
3-23. FUEL INJECTION PUMP BOOT REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

a. Removal

Remove clamp (3) and boot (2) from injection pump (1).

b. Installation

Install boot (2) on injection pump (1) with clamp (3).

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
### 3-24. FUEL PUMP REPLACEMENT

This task covers:
- a. Removal
- b. Installation

**INITIAL SETUP:**

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<tr>
<td>Maintenance and repair shop equipment:</td>
<td>Equipment Condition</td>
</tr>
<tr>
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<td>Battery ground cables disconnected (para. 4-68).</td>
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<td>Mounting plate gasket (Appendix G, Item 193)</td>
<td>Do not perform this procedure near fire, flames, or sparks.</td>
</tr>
<tr>
<td>Fuel pump gasket (Appendix G, Item 35.1)</td>
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<tr>
<td>Grease (Appendix C, Item 34)</td>
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</tbody>
</table>

**WARNING**

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

**a. Removal**

**CAUTION**

Cover or plug all open hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**

Have drainage container ready to catch fuel.

1. Loosen clamp (14) and disconnect fuel inlet line (13) from fuel pump (2) and allow fuel to drain into container.
2. Disconnect fuel outlet line (12) from fuel pump (2) and allow fuel to drain into container.
3. Loosen clamp (3) and disconnect vent line (4) from fuel pump (2).
4. Remove two capscrews (1), fuel pump (2), and gasket (6) from fuel pump mounting plate (7). Discard gasket (6).
5. Remove two capscrews (11), fuel pump mounting plate (7), and gasket (8) from cylinder block (10). Discard gasket (8).
6. Remove pushrod (9) from cylinder block (10).

**b. Installation**

**NOTE**

GAA grease is used on pushrod to retain it in cylinder block during installation.

1. Apply grease on pushrod (9) and insert pushrod (9) into cylinder block (10). Turn over engine by hand until pushrod (9) fully retracts.
2. Install gasket (8) and mounting plate (7) on block (10) with two capscrews (11) for alignment of pump (2) to cylinder block (10).
3. Secure gasket (8) and mounting plate (7) to cylinder block (10) with two capscrews (11). Tighten capscrews (11) to 4-7 lb-ft (5-10 N·m).

3.1. Connect fuel outlet line (12) to fuel pump (2). Do not tighten fuel outlet line (12) at this time.

4. Install gasket (6) and fuel pump (2) on fuel pump mounting plate (7) and block (10) with two capscrews (1), ensuring lever (5) aligns with pushrod (9). Tighten capscrews (1) to 20-30 lb-ft (27-41 N·m).

5. Connect vent line (4) to fuel pump (2) and tighten clamp (3) to 10-20 lb-in. (1-2 N·m).

6. Tighten fuel outlet line (12) on fuel pump (2).

7. Connect fuel inlet line (13) to fuel pump (2) and tighten clamp (14).

FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Start engine (TM 9-2320-387-10) and check fuel pump and hoses for fuel leaks.
3-25. FUEL TANK AND SHIELD MAINTENANCE

This task covers:

a. Draining
b. Removal
c. Disassembly
d. Cleaning and Inspection
e. Assembly
f. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - (Appendix B, Item 2)

Materials/Parts
- Gasket (Appendix G, Item 37)
- Fourteen locknuts (Appendix G, Item 77)
- Three lockwashers (Appendix G, Item 144)
- Drycleaning solvent (Appendix C, Item 26)
- Adhesive (Appendix C, Item 2)
- Sealing compound (Appendix C, Item 62)
- Tiedown strap (Appendix G, Item 322)

Personnel Required
- One mechanic
- One assistant

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Battery ground cables disconnected (para. 4-68).
- Rear propeller shaft removed (para. 6-4).
- Right rear underbody armor removed (M1114 only) (para. 11-39).
- Right rear upper underbody armor (integrated) removed (para. 11-109 or para. 11-109.1).

General Safety Instructions
- Do not perform this procedure near fire, flames, or sparks.
- Drycleaning solvent is flammable and will not be used near an open flame.

Maintenance Level
- Unit

WARNING
Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

**a. Draining**

Have drainage container ready to catch fuel.

1. Remove fuel tank filler cap (1).
2. Remove drainplug (3) from fuel tank (2) and allow fuel to completely drain into container.

**CAUTION**
Do not overtighten drainplug. Drainplug must not turn in hole. Sharp edge of hole may cut rubber.

3. Install drainplug (3) flush with bottom of fuel tank (2).

**b. Removal**

Perform steps 1 through 1.2 if equipped with new vent line assembly.

1. Remove tiedown strap (13.1) from vent lines (14.1) and (4). Discard tiedown strap (13.1).
1.1. Remove vent line (14.1) from elbow (4.1).
1.2. Remove vent line (4) from elbow (4.2).
1.3. Remove vent line (4) from filler spout (5).
2. Remove locknut (15), washer (12), capscrew (11), washer (12), and clamp (13) from vent line (4) and body (14). Discard locknut (15).
3. Remove locknut (16), washer (7), capscrew (8), washer (7), and clamp (6) from filler spout (5). Discard locknut (16).

4. Loosen clamp (9) and remove hose (10) from spout (5).
5. Remove two nuts (15), washers (14), and capscrews (7) from fuel tank support straps (6) and (12) and remove lower straps (13).

6. Loosen two clamps (3) and disconnect fuel supply hoses (1) and (2) from fuel return line (4) and supply line (5).

**NOTE**
Perform step 7 if vehicle is equipped with vehicular heater.

7. Loosen clamp (17) and disconnect fuel supply hose (18) from vehicular heater fuel supply line (16).

8. Disconnect vent line (20) from tee (19).

9. Remove capscrew (22) and clamp (23) securing vent line (20) to body (24).

10. Remove nut (8), washer (9), capscrew (10), and rear strap (12) from strap bracket (11).

11. Lower fuel tank (21) for access to vent line (29) and clamp (28).

12. Disconnect vent line (20) from fitting (25) on fuel tank (21).

13. Remove locknut (26), washer (27), and clamp (28) from vent line (29) and fuel tank (21). Discard locknut (26).

14. Remove vent line (29) from vent line housing (30).

**NOTE**
Prior to removal, tag leads for installation.

15. Disconnect jumper leads 58J (33) and 28B (35) from body wiring harness (34).

16. Bend clamp (32) down and remove jumper harness (31).

17. Remove fuel tank (21) from vehicle.
3-25. FUEL TANK AND SHIELD MAINTENANCE (Cont'd)

c. Disassembly

1. Thoroughly clean outside of tank (18) to prevent dirt contamination.

2. Disconnect fuel supply line (31) from fuel supply tube (12) and fuel return line (30) from fuel return tube (34).

   **NOTE**
   Perform step 3 if vehicle is equipped with vehicular heater and auxiliary fuel line.

3. Disconnect auxiliary fuel supply and return lines (25) from fuel supply tubes (13).

4. Remove capscrew (27), clamp (29), fuel supply line (31), fuel return line (30), and shield (26) from fuel tank (18).

   4.1 Remove auxiliary fuel supply and return lines (25) and clamp (28), if installed. Remove crossover hose (27.2) and two clamps (27.1), if installed.

5. Remove two locknuts (7), washers (8), clamps (6), and jumper harness (5) from access cover (11). Discard locknuts (7).

   **NOTE**
   Prior to removal, tag leads for installation.

6. Disconnect jumper harness leads 28B (1) and 58J (2) from fuel level sender (35) and remove jumper harness (5).

7. Remove nine locknuts (9) and washers (10) securing access cover (11) to fuel tank (18). Discard locknuts (9).

8. Remove access cover (11), gasket (15), and retainer (33) from fuel tank (18). Discard gasket (15).

9. Mark position of fuel tubes (12), (34), and (13) on access cover (11).

   **NOTE**
   Note position of fuel strainer for installation.

10. Remove fuel strainer (14) from fuel supply tube (12).

11. Remove fuel supply tube (12) from access cover (11).

12. Remove fuel return tube (34) from access cover (11).

   **NOTE**
   - Perform step 13 if vehicle is equipped with vehicular heater and auxiliary fuel line.
   - Vehicles not equipped with a vehicular heater and auxiliary fuel line will have plugs instead of fuel supply tubes.

13. Remove two fuel supply tubes (13) from access cover (11).

14. Remove vent valve (4) and grommet (3) from access cover (11).

15. Remove vent line (19) from tee (20).

16. Loosen clamp (16) and remove filler spout hose (17) from tank (18).

17. Remove three capscrews (22), washers (24), lockwashers (23), and heat shield (21) from fuel tank (18). Discard lockwashers (23).

d. Cleaning and Inspection

   **WARNING**
   Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel or damage to equipment.
1. Use dry cleaning solvent to clean access cover (11), fuel supply line (31), fuel return line (30), auxiliary fuel supply and return lines (25), crossover hose (27.2), fuel supply tube (12), fuel return tube (34), fuel supply tubes (13), and inside of fuel tank (18).

2. Inspect access cover (11), fuel supply line (31), fuel return line (30), fuel supply tube (12), fuel return tube (34), strainer (14), tee (20), fitting (32), vent valve (4), and grommet (3) for cracks, wear, and breaks. Replace if cracked, worn, or broken.

3. Inspect auxiliary fuel supply and return lines (25), crossover hose (27.2), and fuel supply tubes (13) for cracks, wear, and breaks, if installed. Replace if cracked, worn, or broken.

4. Inspect fuel level sender (35) for damage. Replace if damaged.
3-25. FUEL TANK AND SHIELD MAINTENANCE (Cont'd)

e. Assembly

NOTE

- Use sealing compound on all vent line and fuel line connector threads before installation.
- Use fittings from old tank if installing new tank.

1. Install heat shield (21) on fuel tank (18) with three lockwashers (23), washers (24), and capscrews (22).
2. Install vent line (19) on tee fitting (20).
3. Install filler spout hose (17) on tank (18) and tighten clamp (16).
4. Apply sealing compound to threads of fuel supply tube (12). Install and align fuel supply tube (12) on access cover (11).
5. Apply sealing compound to threads of fuel return tube (33). Install and align fuel return tube (33) on access cover (11).

NOTE

Perform step 6 if vehicle is equipped with vehicular heater and auxiliary fuel line.

6. Apply sealing compound to threads of fuel supply tubes (13). Install and align two fuel supply tubes (13) on access cover (11).
7. Install grommet (3) and vent valve (4) on access cover (11).
8. Install fuel strainer (14) on fuel supply tube (12).
9. Apply adhesive to threads of nine locknuts (9). Install retainer (32), gasket (15), and access cover (11) on fuel tank (18) with nine washers (10) and locknuts (9). Tighten locknuts (9) to 72 lb-in. (8 N-m).
10. Connect jumper harness leads 28B (1) and 58J (2) to fuel level sender (34).
11. Apply adhesive to threads of two locknuts (7). Install jumper harness (5) on access cover (11) with two clamps (6), washers (8), and locknuts (7). Tighten locknuts (7) to 72 lb-in. (8 N-m).
12. Connect fuel supply line (31) to fuel supply tube (12), and fuel return line (30) to fuel return tube (33).

NOTE

Perform step 13 if vehicle is equipped with an vehicular heater and auxiliary fuel line.

13. Connect auxiliary fuel supply and return lines (25) to fuel supply tubes (13).
14. Connect crossover hose (27.2) to auxiliary fuel supply and return lines (25) and secure with two clamps (27.1)
15. Install shield (26), return line (30), supply line (31), clamp (29), and auxiliary fuel supply and return lines (25) and clamp (28), if installed, on fuel tank (18) with capscrew (27).
3-25. FUEL TANK AND SHIELD MAINTENANCE (Cont'd)

f. Installation

1. Position fuel tank (5) under vehicle.
2. Install jumper harness (6) in clamp (7) and bend clamp (7) up.
3. Connect jumper harness leads 58J (8) and 28B (10) to body wiring harness (9).

**NOTE**

Use sealing compound on all vent line connector threads before installation.

4. Connect vent line (4) to fuel tank (5) with clamp (3), washer (2), and locknut (1).
5. Connect vent line (12) to fitting (11) on fuel tank (5).

**NOTE**

Apply adhesive to threads of capscrews before installation.

6. Install rear strap (23) on strap bracket (22) with capscrew (21), washer (20), and nut (19). Tighten nut (19) to 23–27 lb-in. (2.6–3.1 Nm).

**NOTE**

Ensure front straps are flush with fuel tank and to right side of dimple in slot.

7. Raise fuel tank (5) and install two support straps (24) to straps (17) and (23) with two capscrews (18), washers (25), and nuts (26). Do not tighten nuts (26).
8. Connect vent line (12) to tee (31) on fuel tank (5).
9. Secure vent line (12) to body (34) with clamp (33) and screw (32).
10. Connect fuel supply hoses (13) and (30) to fuel return and supply lines (16) and (15) and tighten clamps (14).

**NOTE**

Perform step 11 if vehicle is equipped with vehicular heater.

11. Connect fuel supply hose (29) to vehicular heater fuel supply line (27) and tighten clamp (28).

**NOTE**

Ensure upper and lower straps are 1/2 in. (13 mm) apart after tightening nuts. Straps should not touch when properly installed. Straps must be replaced if upper or lower straps touch.

12. Tighten nuts (26) to 23–27 lb-in. (2.6–3.1 Nm).
13. Connect vent line (38) to filler spout (39).

**NOTE**

Perform steps 14, 15, and 17 if vehicle is equipped with new vent line assembly.

14. Connect vent line (38) to elbow (38.2).
15. Connect vent line (35.2) to elbow (38.1).
16. Secure vent line (38) to body (34) with clamp (35), washer (36), capscrew (47), washer (36), and locknut (37).
17. Secure vent line (35.2) to vent line (38) with tiedown strap (35.1).
18. Install filler spout (39) into hose (46) and tighten clamp (45).
19. Install filler spout (39) to body (34) with clamp (42), washer (43), capscrew (44), washer (41), and locknut (40). Tighten locknut (40) to 6 lb-ft (8 Nm).
3-25. FUEL TANK AND SHIELD MAINTENANCE (Cont'd)

FOLLOW-ON TASKS:
- Install right rear upper underbody armor (integrated) (para. 11-109 or para. 11-109.1)
- Install right rear underbody armor (M1114 only) (para. 11-39).
- Install rear propeller shaft (para. 6-4).
- Connect battery ground cables (para. 4-68).
- Fill fuel tank (TM 9-2320-387-10) and check for leaks.
3-26. FUEL TANK SUPPLY AND RETURN LINES REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

WARNING

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

CAUTION

Cover or plug all open hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE

Have drainage container ready to catch fuel.

1. Loosen four clamps (7) and disconnect hoses (6) from fuel tank return and supply lines (8).
2. Remove two locknuts (1), capscrews (5), washers (4), clamps (3), and return and supply lines (8) from front body bracket (2) and rear body bracket (10). Discard locknuts (1).
3. Remove three clips (9) from fuel supply and return lines (8).

b. Installation

1. Install return and supply lines (8) on front body bracket (2) and rear body bracket (10) with two clamps (3), washers (4), capscrews (5), and locknuts (1).
2. Connect supply and return lines (8) to four hoses (6) and tighten clamps (7).
3. Secure fuel supply and return lines (8) together with three clips (9).

b. Installation
3-26. FUEL TANK SUPPLY AND RETURN LINES REPLACEMENT (Cont'd)

FOLLOW-ON TASKS:  
- Install engine right splash shield (para. 10-24 or para. 10-24.1).
- Fill fuel tank (TM 9-2320-387-10) and check for fuel leaks.
3-27. AUXILIARY FUEL PICKUP AND RETURN LINES REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

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<th>Equipment Condition</th>
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<td>General mechanic’s tool kit: automotive (Appendix B, Item 1)</td>
<td>Fuel tank removed (para. 3-25).</td>
</tr>
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<tr>
<th>Materials/Parts</th>
<th>General Safety Instructions</th>
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<tr>
<td>Sealing compound (Appendix C, Item 60)</td>
<td>Do not perform this procedure near fire, flames, or sparks.</td>
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<table>
<thead>
<tr>
<th>Manual References</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-387-24P</td>
<td>Unit</td>
</tr>
</tbody>
</table>

**WARNING**

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

### a. Removal

Cover or plug all open hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**

Have drainage container ready to catch fuel.

1. Remove two clamps (6.1) and crossover hose (6.2) from auxiliary fuel return line (6) and auxiliary fuel pickup line (4).

1.1. Remove screw (5) and clamp (7) from fuel return line (6), fuel pickup line (4), and fuel line clamp (8).

2. Remove fuel pickup line (4) from fuel tube (3) on fuel tank (1).

3. Remove fuel return line (6) from fuel tube (2).

### b. Installation

1. Apply sealing compound to threads of fuel return line (6) and fuel pickup line (4).

2. Install fuel return line (6) on fuel tube (2) in fuel tank (1).

3. Install fuel pickup line (4) on fuel tube (3).

4. Install clamp (7) on fuel return line (6) and fuel pickup line (4) and secure to fuel line clamp (8) with screw (5).

5. Install crossover hose (6.2) on auxiliary fuel return line (6) and fuel auxiliary pickup line (4) with two clamps (6.1).
FOLLOW-ON TASK: Install fuel tank (para. 3-25).
3-28. FUEL TANK VENT LINE AND FILTER REPLACEMENT

This task covers:

a. Removal 

b. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts

- Tiedown strap (Appendix G, Item 321)
- Locknut (Appendix G, Item 77)

Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition

- Fuel tank removed (para. 3-25).
- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level

Unit

a. Removal

CAUTION

Cover or plug all open hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE

- For fuel tank vent line filter replacement, perform steps 5, 8, and 9 only.
- Insulation may need to be removed to access vent and fuel lines.

1. Remove clip (9) from fuel tank vent line (3) and vent line (6).
2. Remove two capscrews (2) securing clamps (1) and (7) and vent lines (3) and (6) to brackets (8).
3. Remove tiedown strap (4) from vent line (6) and fuel lines (5). Discard tiedown strap (4).
4. Disconnect vent line (3) from elbow (16).
5. Loosen two clamps (14) and remove vent line (15) from vent line filter (13) and elbow (16).
6. Remove two clamps (14) from vent line (15).
7. Remove two clamps (1) from vent line (3).

NOTE

Perform step 8 only when deep water fording kit is installed.

8. Disconnect deep water fording vent line (19) from vent line filter (13).
9. Remove locknut (12), washer (11), capscrew (18), clamp (10), and vent line filter (13) from body bracket (17). Discard locknut (12).

b. Installation

NOTE

For fuel tank vent line filter replacement, perform steps 1, 2, and 5 only.

1. Install clamp (10) and vent line filter (13) on body bracket (17) with capscrew (18), washer (11), and locknut (12).

NOTE

Perform step 2 only when deep water fording kit is installed.

2. Connect deep water fording vent line (19) to vent line filter (13).
3. Install two clamps (1) on vent line (3).
4. Install two clamps (14) on vent line (15).
5. Install vent line (15) on vent line filter (13) and elbow (16) and tighten two clamps (14).
6. Connect vent line (3) to elbow (16).
7. Install tiedown strap (4) around vent line (3), vent line (6), and fuel lines (5).
8. Secure vent lines (3) and (6) and two clamps (1) and (7) on brackets (8) with two capscrews (2).
9. Secure vent line (3) to vent line (6) with clip (9).
10. Install insulation if removed.

FOLLOW-ON TASKS: • Install fuel tank [para. 3-25].
• Lower and secure hood (TM 9-2320-387-10).
3-29. FUEL TANK FILLER CAP AND SPOUT MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Locknut (Appendix G, Item 77)
- Sealing compound (Appendix C, Item 64)
- Tiedown strap (Appendix G, Item 322)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Fuel tank drained (para. 3-25).
- Right rear underbody armor removed (M1114 only) (para. 11-39).

General Safety Instructions
- Do not perform this procedure near fire, flames, or sparks.

Maintenance Level
- Unit

WARNING

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

a. Removal

Perform steps 1.1, 2, and 7.1 if vehicle is equipped with new vent line assembly.

1. Remove filler cap (6) and detach cap chain clip (7) from filler spout (11).
1.1. Remove tiedown strap (17.2) from vent lines (17.1) and (1). Discard tiedown strap (17.2)
2. Disconnect vent lines (1) and (17.1) from elbows (2) and (2.2).
2.1. Disconnect vent line (1) from elbow (2.2).
3. Remove three nuts (3), washers (4), capscrews (5), and washers (4) from spout mounting ring (8).
4. Loosen clamp (16) securing filler spout (11) to hose (17).
5. Remove locknut (12), washer (13), capscrew (15), washer (13), and clamp (14) from filler spout (11).
Discard locknut (12).
6. Push filler spout (11) out of spout mounting ring (8) and remove filler spout (11) from hose (17).
7. Remove elbows (2) and (2.2) from tee fitting (2.1) or elbow (2.2) from filler spout (11).
7.1. Remove tee fitting (2.1) from filler spout (11).
8. Using handle (9), remove screen (10) from filler spout (11).

b. Inspection

Inspect screen (10) for damage, debris, or blockage. Replace if damaged, or if debris or blockage is detected.

c. Installation

Perform steps 1.1, 6, and 6.2 if vehicle is equipped with new vent line assembly.

1. Apply sealing compound to elbows (2) and (2.2) and install in tee fitting (2.1) or elbow (2.2) on filler spout (11).
3-29. FUEL TANK FILLER CAP AND SPOUT MAINTENANCE (Cont'd)

1. Apply sealing compound to tee fitting (2.1) and install on filler spout (11).
2. Align filler spout (11) with hose (17) and push filler spout (11) into hose (17).
3. Install filler spout (11) on spout mounting ring (8) with three washers (4), capscrews (5), washers (4), and nuts (3).
4. Tighten clamp (16) on hose (17).
5. Install filler spout (11) on body (18) with clamp (14), washer (13), capscrew (15), washer (13), and locknut (12). Tighten locknut (12) to 6 lb-ft (8 N·m).
6. Connect vent line (1) to elbow (2.2).
6.1. Connect vent line (17.1) to elbow (2).
6.2. Secure vent line (1) to vent line (17.1) with tiedown strap (17.2).
7. Using handle (9), install screen (10) in filler spout (11).
8. Attach filler cap chain clip (7) to filler spout (11) and install filler cap (6).

FOLLOW-ON TASKS: • Install right rear underbody armor (M1114 only) (para. 11-39).
• Fill fuel tank (TM 9-2320-387-10) and check filler spout for fuel leaks.
3-30. FUEL TANK FILLER SPOUT VENT LINE REPLACEMENT

This task covers:

a. Removal  

b. Inspection

INITIAL SETUP:

**Tools**

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**

- Locknut (Appendix G, Item 77)
- Tiedown strap (Appendix G, Item 322)
- Adhesive (Appendix C, Item 2)
- Sealing compound (Appendix C, Item 61)
- Elbow (Appendix G, Item 31.1)

Manual References

- TM 9-2320-387-24P

Equipment Condition

- Rear propeller shaft removed  
- Right rear underbody armor removed (M1114 only) (para. 11-39).

Maintenance Level

- Unit

**NOTE**

Perform steps 1, 3, 4, 6, and 7 if equipped with new style vent line assembly.

1. Remove clamp (3) and vent line (1) from fuel pump (2).
2. Disconnect vent line (5) from elbow (6) on fuel filler neck (7).
3. Disconnect vent line (14) from elbow (5.1) on fuel filler neck (7).
4. Remove tiedown strap (13) from vent lines (5) and (14).
5. Remove locknut (12), washer (11), capscrew (8), washer (9), and clamp (10) from body (4). Discard locknut (12).
6. Remove two capscrews (15) from clamps (17) on frame rail (16).
7. Remove vent line (14) and clamps (17) from vehicle.
3-30. FUEL TANK FILLER SPOUT VENT LINE REPLACEMENT (Cont’d)

8. Disconnect vent line (5) from fitting (18).
9. Remove fitting (18) from vent line (19).
10. Remove capscrew (22) from clamp (24) on crossmember (23) and remove clamp (24) from vent line (19).
11. Loosen two nuts (21) to allow access to elbow (25).
12. Disconnect vent line (19) from elbow (25) on fuel tank (26), cut vent line (19) closest to fuel tank (26), and remove vent line (19) from crossmember (23) and vehicle.
3-30. FUEL TANK FILLER SPOUT VENT LINE REPLACEMENT (Cont’d)

b. Installation

1. Position vent line (2) on vehicle and crossmember (13).
2. Install fitting (6), sleeve (4), and compression ring (5) on end of vent line (2), closest to fuel tank (3).
   
   **NOTE**
   
   Use sealing compound on all vent line connectors before installation.

3. Connect vent line (2) to elbow (1) on fuel tank (3).
4. Install fitting (8) on vent line (2).
5. Connect vent line (9) to fitting (8).
6. Install clamp (14) on vent line (2) and clamp (14) on frame rail (13) with capscrew (12).
   
   **NOTE**
   
   Upper and lower straps should be approximately 1/2 in. (13 mm) apart after tightening nuts. Straps should not touch when properly installed. Straps must be replaced if upper and lower straps touch.

7. Apply adhesive to threads of capscrews (10) and tighten nuts (11) to 23-27 lb-in (2.6-3 N•m).
   
   **NOTE**
   
   Perform steps 8, 9, 11, 12, and 14 if equipped with new style vent line assembly.

8. Position vent line (18) and two clamps (17) on vehicle.
9. Install two clamps (17) on frame rail (16) with capscrews (15).
10. Install vent line (9) and clamp (25) on body (19) with washer (24), capscrew (23), washer (27), and locknut (28).
11. Install tiedown strap (26) on vent lines (9) and (18).
12. Connect vent line (18) to elbow (20) on fuel filler neck (22).
13. Connect vent line (9) to elbow (21) on fuel filler neck (22).
14. Install vent line (18) on fuel pump (29) with clamp (30).
3-31. FILLER SPOUT HOSE REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)

Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition

- Fuel tank drained (para. 3-25).
- Right rear underbody armor removed (M1114 only) (para. 11-39).

General Safety Instructions

Do not perform this procedure near fire, flames, or sparks.

Maintenance Level

Unit

WARNING

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

a. Removal

1. Loosen clamps (4) and (3) securing hose (1) to fuel tank (5) and filler spout (2).
2. Slide hose (1) onto filler spout (2) until disconnected from fuel tank (5). Remove hose (1) from filler spout (2).

b. Installation

NOTE

Position clamps attaching filler hose to fuel tank as shown.

1. Install hose (1) on filler spout (2) and slide onto filler spout (2) until hose (1) clears fuel tank (5).
2. Connect hose (1) to fuel tank (5) and tighten clamps (3) and (4).

FOLLOW-ON TASKS:

- Install right rear underbody armor (M1114 only) (para. 11-39).
- Fill fuel tank (TM 9-2320-387-10) and check for leaks.
### 3-32. FUEL TANK HANGERS REPLACEMENT

This task covers:

a. Removal  
b. Installation

#### INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
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<tr>
<td>General mechanic's tool kit:</td>
<td>TM 9-2320-387-24P</td>
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<tr>
<td>automotive (Appendix B, Item 1)</td>
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<tr>
<td>Maintenance and repair shop equipment:</td>
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<tr>
<td>automotive (Appendix B, Item 2)</td>
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<td>Materials/Parts</td>
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<tr>
<td>Adhesive (Appendix C, Item 2)</td>
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</table>

**Equipment Condition**  
Fuel tank removed (para. 3-25).

**Maintenance Level**  
Unit

### a. Removal

1. Remove two nuts (3), washers (4), capscrews (5), and rear hangers (7) from supports (6).
2. Twist two front hangers (9) until tee handles (2) clear slots (11) in support (1) and remove front hangers (9).
3. Inspect four insulators (8) on front and rear hangers (9) and (7). Remove insulators (8), if damaged.

### b. Installation

1. Install four insulators (8) on front and rear hangers (9) and (7), if removed.
2. Install two front hangers (9) by inserting tee handles (2) up through slots (11) in support (1). Twist hangers (9) so that tee handles (2) are resting across slots (11) and against side of ridge (10).
   
   **NOTE**  
   Apply adhesive to threads of screws before installation.

3. Install two rear hangers (7) on supports (6) with capscrews (5), washers (4), and nuts (3).  
Tighten nuts (3) to 37 lb-ft (50 N·m).

---

FOLLOW-ON TASK: Install fuel tank (para. 3-25).
3-33. PRIMARY FUEL FILTER MAINTENANCE

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Two lockwashers (Appendix G, Item 145)
- Fuel filter bleeder tool (Appendix D, Fig. D-38) (optional)
- Sealing compound (Appendix C, Item 61)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Hood raised and secured (TM 9-2320-387-10).
- Engine access cover removed (para. 10-22).
- Fuel pressure transducer removed (para. 4-30).

**General Safety Instructions**
Do not perform this procedure near fire, flames, or sparks.

**Maintenance Level**
Unit

---

**WARNING**
Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

**CAUTION**
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**
Have drainage container ready to catch fuel.

1. Loosen two hose clamps (2) and disconnect fuel inlet hose (1) and fuel outlet hose (12) from fuel filter fittings (5).
2. Loosen hose clamp (8) and disconnect fuel filter drain hose (9) from fuel filter fitting (5).
3. Pull back insulation to allow access to capscrews (3), and remove two capscrews (3), lockwashers (4), and fuel filter bracket (10) from body (11). Discard lockwashers (4).
4. Loosen capscrew (6) and remove fuel filter (7) from fuel filter bracket (10).
5. Remove three fittings (5) from fuel filter (7).

---

**b. Installation**

1. Apply sealing compound to threads of three fittings (5). Install fittings (5) on fuel filter (7).
2. Install fuel filter (7) on fuel filter bracket (10) and tighten capscrew (6).
3. Install fuel filter bracket (10) on body (11) with two lockwashers (4) and capscrews (3). Tighten capscrews (3) to 15 lb-ft (20 N·m).
4. Connect drain hose (9) to fuel filter fitting (5) and tighten clamp (8) to 10-20 lb-in. (1-2 N·m).
5. Connect fuel inlet hose (1) and fuel outlet hose (12) to fuel filter fittings (5) and tighten two clamps (2) to 10-20 lb-in. (1-2 N·m).
c. Bleeding

NOTE
The bleeder tool used in steps 2, 3, and 5 is optional. The tool prevents fuel from spilling on engine.

1. Install fuel pressure transducer (para. 4-30).
2. Remove fuel filter bleeder screw (13) and install bleeder tool into hole.
3. Place open end of bleeder tool hose in clean, clear container.
4. Disconnect lead 54A (14) from solenoid (15).

CAUTION
Do not operate starter continuously for more than 20 seconds; wait 10 to 15 seconds between periods of operation. Failure to do this may result in damage to the starter.

5. Crank engine and watch fuel. When air bubbles stop coming through hose, remove bleeder tool, and install bleeder screw (13). Tighten bleeder screw (13) to 40-50 lb-in. (4-6 N-m).

6. Dispose of fuel in accordance with local SOP.

7. Connect lead 54A (14) to fuel solenoid (15).

FOLLOW-ON TASKS: • Start engine (TM 9-2320-387-10) and check for fuel leaks.
• Lower and secure hood (TM 9-2320-387-10).
• Install engine access cover (para. 10-22).
3-33.1. SECONDARY FUEL FILTER REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Two lockwashers (Appendix G, Item 145)
- Sealing compound (Appendix C, Item 61)
- Locknut (Appendix G, Item 133)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

General Safety Instructions
- Do not perform this procedure near fire, flames, or sparks.

Maintenance Level
- Unit

WARNING

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

a. Removal

CAUTION

Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE

Have drainage container ready to catch fuel.

1. Remove locknut (1), capscrew (2), and secondary filter (4) from mounting bracket (3).
   Discard locknut (1).
2. Loosen two hose clamps (6) and disconnect fuel inlet hose (5) and fuel outlet hose (9) from fuel filter fittings (7) and (8).
3. Remove two capscrews (10), lockwashers (11), and mounting bracket (3) from left engine mounting bracket (12). Discard lockwashers (11).

b. Installation

1. Install mounting bracket (3) on left engine mounting bracket (12) with two lockwashers (11) and capscrews (10).
2. Connect fuel inlet hose (5) and fuel outlet hose (9) on fuel filter fittings (7) and (8) and tighten two hose clamps (6) to 10–20 lb-in. (1-2 N·m).
3. Install secondary filter (4) on mounting bracket (3) with capscrew (2) and locknut (1).
FOLLOW-ON TASKS:
- Bleed fuel system [para. 3-33].
- Start engine (TM 9-2320-387-10) and check for fuel leaks.
3-34. FUEL FILTER ELEMENT MAINTENANCE

This task covers:

a. Element Removal
b. Cleaning and Inspection
c. Element Installation

INITIAL SETUP:

**Tools**
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Fuel/water filter element kit (Appendix G, Item 36)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Fuel pressure transducer removed para. 4-30.

**General Safety Instructions**
- Do not perform this procedure near fire, flames, or sparks.
- Drycleaning solvent is flammable and will not be used near an open flame.

**Maintenance Level**
- Unit

---

**WARNING**

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

a. Element Removal

**CAUTION**

Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

1. Loosen two hose clamps (2) and disconnect fuel inlet hose (1) and fuel outlet hose (15) from fuel filter cover (3).
2. Loosen hose clamp (7) and disconnect fuel filter drain hose (8) from filter housing (6).
3. Remove nut (11), capscrew (9), and filter housing (6) from fuel filter bracket (10).
4. Remove three capscrews (4), washers (5), and cover (3) from filter housing (6).
5. Remove O-ring (14) from filter housing (6). Discard O-ring (14).
6. Remove filter element (12) and separator (13) from filter housing (6).

b. Cleaning and Inspection

**WARNING**

Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

1. Use drycleaning solvent to clean all metallic parts.
2. Inspect filter housing (6) and cover (3) for distortion or damage. Replace if damaged.
3. Inspect separator (13) for dirt, contamination, or damage. Replace if dirty, contaminated, or damaged.
3-34. FUEL FILTER ELEMENT MAINTENANCE (Cont’d)

c. Element Installation

1. Install filter element (12) into filter housing (6).
2. Install separator (13) on filter element (12).
3. Install O-ring (14) on filter housing (6).
4. Install cover (3) on filter housing (6) with three washers (5) and capscrews (4). Tighten capscrews (4) to 50-60 lb-in. (6-7 N•m).
5. Install filter housing (6) in fuel filter bracket (10) with capscrew (9) and nut (11).
6. Connect fuel filter drain hose (8) to filter housing (6) and tighten clamp (7) to 10-20 lb-in. (1-2 N•m).
7. Connect fuel inlet hose (1) and fuel outlet hose (15) to fuel filter cover (3) and tighten clamps (2) to 10-20 lb-in. (1-2 N•m).

FOLLOW-ON TASK: Bleed fuel filter (para. 3-33).
3-35. FUEL FILTER DRAIN HOSE AND VALVE REPLACEMENT

This task covers:

| a. Removal | b. Installation |

INITIAL SETUP:

<table>
<thead>
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<th>Equipment Condition</th>
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<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>Hood raised and secured (TM 9-2320-387-10).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials/Parts</th>
<th>General Safety Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nut and lockwasher assembly (Appendix G, Item 197)</td>
<td>Do not perform this procedure near fire, flames, or sparks.</td>
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<th>Manual References</th>
<th>Maintenance Level</th>
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<td>Unit</td>
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<td>TM 9-2320-387-24P</td>
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<table>
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<tr>
<th>Personnel Required</th>
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</thead>
<tbody>
<tr>
<td>One mechanic</td>
</tr>
<tr>
<td>One assistant</td>
</tr>
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</table>

**WARNING**

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

**a. Removal**

1. Loosen clamp (7) and disconnect drain hose (10) from fuel filter drainvalve (6).
2. Remove nut (13) and fuel filter drainvalve (6) from splash shield (12) (M1114 only) or bracket (14) (all other vehicles).
3. Loosen clamp (2) and disconnect fuel filter drain hose (10) from fuel filter assembly (1).
4. Remove nut and lockwasher assembly (5), capscrew (11), clamp (4), and drain hose (10) from cowl panel (3). Discard nut and lockwasher assembly (5).
5. Remove capscrew (9), drain hose (10), and clamp (8) from panel (3).

**CAUTION**

Cover or plug all open hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**

- For fuel filter drainvalve replacement, perform steps 1 and 2 only.
- Have drainage container ready to catch fuel.

**b. Installation**

For fuel filter drainvalve replacement, perform steps 4 and 5 only.

1. Install drain hose (10) on cowl panel (3) with clamp (8) and capscrew (9).
2. Install drain hose (10) on cowl panel (3) with clamp (4), capscrew (11), and nut and lockwasher assembly (5).
3. Connect drain hose (10) to fuel filter assembly (1) and tighten clamp (2).
4. Install fuel filter drainvalve (6) on splash shield (12) (M1114 only) or bracket (14) (all other vehicles) with nut (13).
5. Connect drain hose (10) to fuel filter drainvalve (6) and tighten clamp (7).
FOLLOW-ON TASKS:  • Start engine (TM 9-2320-387-10) and check for leaks.
  • Lower and secure hood (TM 9-2320-387-10).
This task covers:

a. Removal
b. Cleaning and Inspection
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Material/Parts
O-ring (Appendix G, Item 210)

Equipment Condition
Air horn removed [para. 3-14]

General Safety Instructions

- Do not perform this procedure near fire, flames, or sparks.
- Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa).

Maintenance Level
Unit

WARNING

Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

a. Removal

CAUTION

Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

1. Remove clamp (2) and hose (1) from injection pump check valve (3).
2. Remove check valve (3) and O-ring (4) from injection pump (5). Discard O-ring (4).

b. Cleaning and Inspection

WARNING

Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

Examine lower end of check valve (3), where ball seats, for evidence of debris. If debris is present, blow compressed air through check valve. Replace check valve (3) if debris remains, or if check valve (3) fails to function properly.

c. Installation

1. Install O-ring (4) and check valve (3) on injection pump (5).
2. Connect hose (1) to check valve (3) with clamp (2).
FOLLOW-ON TASK: Install air horn (para. 3-14).
3-37. FUEL INJECTION RETURN HOSES REPLACEMENT

This task covers:

a. Fuel Drain-Back Hose Removal
b. Fuel Drain-Back Hose Installation
c. Tube-to-Nozzle Hose Removal
d. Tube-to-Nozzle Hose Installation
e. Nozzle-to-Nozzle Hose Removal
f. Nozzle-to-Nozzle Hose Installation
g. Nozzle Cap Removal
h. Nozzle Cap Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
- Engine access cover removed (para. 10-22).
- Air horn removed (para. 3-14).

WARNING
Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

CAUTION
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE
Have drainage container ready to catch fuel.

a. Fuel Drain-Back Hose Removal

1. Loosen two clamps (2) and remove hose (3) from injection pump (4) and fuel drain-back tube (1).
2. Remove two clamps (2) from hose (3).

b. Fuel Drain-Back Hose Installation

1. Install two clamps (2) on hose (3).
2. Connect hose (3) to injection pump (4) and fuel drain-back tube (1) with two clamps (2).

c. Tube-to-Nozzle Hose Removal

1. Loosen two clamps (5) and remove hose (6) from nozzle (7) and fuel drain-back tube (1).
2. Remove two clamps (5) from hose (6).

d. Tube-to-Nozzle Hose Installation

1. Install two clamps (5) on hose (6).
2. Connect hose (6) to nozzle (7) and fuel drain-back tube (1) with two clamps (5).
3-37. FUEL INJECTION RETURN HOSES REPLACEMENT (Cont'd)
3-37. FUEL INJECTION RETURN HOSES REPLACEMENT (Cont'd)

e. Nozzle-to-Nozzle Hose Removal

1. Loosen two clamps (5) and disconnect hose (6) from two nozzles (4).
2. Remove two clamps (5) from hose (6).

f. Nozzle-to-Nozzle Hose Installation

1. Install two clamps (5) on hose (6).
2. Connect hose (6) to two nozzles (4) with two clamps (5).

g. Nozzle Cap Removal

Remove clamp (2) and cap (1) from rear nozzle nipple (3).

h. Nozzle Cap Installation

Install cap (1) on rear nozzle nipple (3) with clamp (2).
FOLLOW-ON TASKS:  
- Install air horn [para. 3-14].  
- Install engine access cover (para. 10-22).  
- Start engine (TM 9-2320-387-10) and check for fuel leaks.
3-38. FUEL DRAIN-BACK TUBE REPLACEMENT

This task covers:
  a. Removal
  b. Installation

INITIAL SETUP:

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WARNING
Diesel fuel is highly flammable. Do not perform this procedure near fire, flames, or sparks. Severe injury or death may result.

a. Removal

1. Remove nut (17), washer (18), and engine wiring harness clamp (15) from stud (19).
2. Remove stud (19), fuel drain-back tube (5), clamp (20), fuel supply line (14), and clamp (16) from cylinder head (23).
3. Loosen two clamps (10) and disconnect two hoses (11) from fuel drain-back tube (5).
4. Loosen clamp (22) and disconnect fuel return hose (21) from fuel drain-back tube (5).
5. Loosen clamp (4) and disconnect fuel drain-back hose (3) from fuel drain-back tube (5).
6. Remove nut (7), washer (8), clamp (9), and fuel-drain-back tube (5) from valve cover stud (6).
7. Remove capscrew (1), washer (24), and clamp (12) from front engine cover (13).
8. Remove drain-back tube (5).

b. Installation

1. Position fuel drain-back tube (5) in front of injection pump (2).
2. Connect fuel return hose (21) to fuel drain-back tube (5) with clamp (22).
3. Connect two hoses (11) to fuel drain-back tube (5) with two clamps (10).
4. Connect fuel drain-back hose (3) to fuel drain-back tube (5) with clamp (4).
5. Install fuel drain-back tube (5) on valve cover stud (6) with clamp (9), washer (8), and nut (7). Tighten nut (7) to 13-20 lb-ft (18-27 N·m).
6. Install fuel drain-back tube (5) on front engine cover (13) with clamp (12), washer (24), and capscrew (1). Tighten capscrew (1) to 40 lb-ft (54 N·m).
7. Install fuel supply line (14), clamp (16), fuel drain-back tube (5), and clamp (20) on cylinder head (23) with stud (19).
8. Install wiring harness clamp (15) on stud (19) with washer (18) and nut (17).
FOLLOW-ON TASKS:
- Install air horn (para 3-14).
- Start engine (TM 9-2320-387-10) and check for fuel leaks.
3-39. GLOW PLUG REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools  
General mechanic's tool kit:  
automotive (Appendix B, Item 1)  
Maintenance and repair shop equipment:  
automotive (Appendix B, Item 2)

Special Tools  
Socket, 3/8 in. (Appendix B, Item 144)

Manual References
TM 9-2320-387-10  
TM 9-2320-387-24P

Equipment Condition
- Battery ground cables disconnected (para. 4-68).  
- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

a. Removal

1. Disconnect electrical lead 575 (3) from glow plug (2).

**NOTE**  
If glow plug is damaged or broken, notify unit commander.  
Damaged or broken glow plugs are removed at DS maintenance (para. 15-22).

2. Remove glow plug (2) from cylinder head (1).

b. Installation

**NOTE**  
HMMWV glow plugs have bullet-shaped tips, not flat tips.

1. Install glow plug (2) in cylinder head (1). Tighten glow plug (2) to 8-12 lb-ft (11-16 N·m).

2. Connect electrical lead 575 (3) to glow plug (2).

FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-68).  
- Lower and secure hood (TM 9-2320-387-10).
3-40. RIGHT FUEL INJECTION LINES BRACKET REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:  
automotive (Appendix B, Item 1)  
Maintenance and repair shop equipment:  
automotive (Appendix B, Item 2)

Manual References
TM 9-2320-387-24P

Equipment Condition
- Engine access cover removed (para. 10-22).  
- Air horn removed (para. 3-14).

Maintenance Level
Unit

a. Removal

1. Remove two screw-assembled washers (6), clamps (5), and clamp (7) from bracket (1).
2. Inspect two clamps (5) for cracks or breaks. Replace if defective.
3. Remove two nuts (3), washers (2), and bracket (1) from valve cover studs (4).

b. Installation

1. Install bracket (1) on two valve cover studs (4) with washers (2) and nuts (3). Tighten nuts (3) to 13-20 lb-ft (18-27 N·m).
2. Install two clamps (5) and clamp (7) on bracket (1) with two screw-assembled washers (6). Tighten screw-assembled washers (6) to 3-4 lb-ft (4-5 N·m).

FOLLOW-ON TASKS:
- Install air horn (para. 3-14).
- Install engine access cover (para. 10-22).
3-41. LEFT FUEL INJECTION LINES BRACKET REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**

- General mechanic’s tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

**Manual References**

- TM 9-2320-387-10
- TM 9-2320-387-24P

---

**a. Removal**

1. Remove screw-assembled washer (2) and clamp (1) from bracket (5).
2. Remove screw-assembled washer (8) and clamp (9) from bracket (5).
3. Remove two screw-assembled washers (3) and oil dipstick tube (4) from bracket (5).
4. Remove two nuts (6), washers (7), and bracket (5) from valve cover studs (10).

---

**b. Installation**

1. Install bracket (5) on two valve cover studs (10) with washers (7) and nuts (6). Tighten nuts (6) to 13-20 lb-ft (18-27 N·m).
2. Secure oil dipstick tube (4) to bracket (5) with two screw-assembled washers (3). Tighten screw-assembled washers (3) to 3-4 lb-ft (4-5 N·m).
3. Install clamp (9) on bracket (5) with screw-assembled washer (8). Tighten screw-assembled washer (8) to 3-4 lb-ft (4-5 N·m).
4. Install clamp (1) on bracket (5) with screw-assembled washer (2). Tighten screw-assembled washer (2) to 3-4 lb-ft (4-5 N·m).

---

**Follow-on Tasks:**

- Install engine access cover (para. 10-22).
- Lower and secure hood (TM 9-2320-387-10).
### 3-42. ACCELERATOR SYSTEM MAINTENANCE TASK SUMMARY

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3-43. ACCELERATOR LINKAGE MAINTENANCE

This task covers:

a. Removal
b. Installation
c. Inspection
d. Adjustment

INITIAL SETUP:

<table>
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<th>Tools</th>
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<tr>
<td>General mechanic’s tool kit: automotive (Appendix B, Item 1) Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>One mechanic One assistant</td>
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<table>
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<th>Materials/Parts</th>
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</table>

a. Removal

1. Remove cotter pin (18) and washer (17) and disconnect accelerator cable clevis (16) from accelerator pedal rod (14). Discard cotter pin (18).

2. Remove hitch pin (1) and washer (2) and disconnect hand throttle clevis (3) from accelerator pedal rod (14).

3. Remove assembled locknut (19) and harness clamp (21) from lower capscrew (25). Discard assembled locknut (19).

4. Remove three locknuts (22), washers (23), capscrews (25), washers (24.1), and two accelerator rod retainers (24) from cowl (20). Discard locknuts (22).

**NOTE**
Bushing halves may detach from accelerator pedal rod during removal.

5. Pull accelerator pedal rod (14) forward through gasket (5) in cowl (20) and remove accelerator rod (14).

6. Remove accelerator rod retainers (24) and bushing halves (4) from accelerator pedal rod (14).

7. Remove gasket (5) from cowl (20).

8. Remove locknut (11), washer (12), capscrew (15), and accelerator cable clevis (16) from body bracket (13). Discard locknut (11).

9. Remove nut (10), capscrew (7), and clamps (6) and (9) from A-beam (8). Remove clamp (9) from accelerator cable (28).

10. Loosen two nuts (27) and disconnect accelerator cable (28) from engine bracket (31).

11. Disconnect throttle return spring (29) from engine bracket (31).

12. Remove accelerator cable clip (26), accelerator cable (28), and accelerator cable end (32) from injection pump throttle shaft (30).
b. Inspection

Inspect throttle spring (4) for damage. Replace if defective.
3-43. ACCELERATOR LINKAGE MAINTENANCE (Cont’d)

c. Installation

1. Connect accelerator cable (3) to injection pump throttle shaft (6).
2. Position throttle shaft lever (5) to full throttle position and secure accelerator cable (3) to injection pump throttle shaft (6) with accelerator cable clip (1).
3. Connect throttle return spring (4) to engine bracket (7).
4. Install cable assembly (3) on engine bracket (7) and tighten two nuts (2).
5. Install clamp (17) on cable assembly (3) and install clamps (14) and (17) to A-beam (16) with capscrew (15) and nut (18).
6. Install accelerator cable clevis (24) on body bracket (21) with capscrew (23), washer (20), and locknut (19).
7. Position gasket (13) to cowl (28).
8. Apply lubricating oil on accelerator bushing halves (12) and accelerator pedal rod (22) at accelerator rod retainer (32).
9. Position accelerator rod retainers (32) and bushing halves (12) onto accelerator pedal rod (22), ensuring retainers (32) are properly seated over bushing halves (12).
10. Install accelerator rod retainers (32), accelerator pedal rod (22), and gasket (13) on cowl (28) with three washers (32.1), capscrews (33), washers (31), and locknuts (30). Install clamp (29) on lower capscrew (33) with assembled locknut (27).
11. Connect hand throttle clevis (11) to accelerator pedal rod (22) with washer (10) and hitch pin (9).
12. Connect accelerator cable clevis (24) to accelerator pedal rod (22) with washer (25) and cotter pin (26).

d. Adjustment

1. Loosen two accelerator cable nuts (2) on engine bracket (7).
2. Fully depress accelerator pedal.
3. Hold throttle shaft lever (5) in full throttle position.
4. Adjust accelerator cable nuts (2) up or down so accelerator cable end (8) holds throttle shaft lever (5) in full throttle position.
5. Tighten two nuts (2) securing accelerator cable (3) to engine bracket (7).
6. Release accelerator pedal and ensure throttle shaft lever (5) returns all the way to idle position.
FOLLOW-ON TASKS:  
- Install engine access cover (para. 10-22).
- Lower and secure hood (TM 9-2320-387-10).
- Start engine (TM 9-2320-387-10) and check for proper accelerator operation.
3-44. ACCELERATOR PEDAL REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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a. Removal

Remove cotter pin (3), washer (4), spring (2), pin (6), and accelerator pedal (5) from accelerator rod (1). Discard cotter pin (3).

b. Installation

Install accelerator pedal (5) and spring (2) on accelerator rod (1) with pin (6), washer (4), and cotter pin (3).

FOLLOW-ON TASK: Start engine (TM 9-2320-387-10) and check for proper accelerator operation.
3-45. ENGINE IDLE SPEED ADJUSTMENT

This task covers:

Engine Idle Speed Adjustment

INITIAL SETUP:

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**WARNING**

Keep hands and arms away from fan blade and drivebelts while engine is running or serious injury may result.

1. Start engine (TM 9-2320-387-10) and bring engine to operating temperature.
2. Note idle speed and disconnect lead 569B (2) from injection pump (4). If change in idle speed is noted, refer to para. 2-28, Fuel System Tests. If no change in idle speed is noted, connect lead 569B (2) to injection pump (4).
3. Set engine idle speed to 700 rpm (± 25 rpm) by turning idle speed adjusting screw (1) on throttle shaft lever (3).

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-46. HAND THROTTLE CONTROL CABLE AND BRACKET REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts

Four locknuts (Appendix G, Item 77)
O-ring (Appendix G, Item 212)

Personnel Required
One mechanic
One assistant

Manual References
TM 9-2320-387-24P

Maintenance Level
Unit

a. Removal

1. Remove four screws (7), washers (6), and instrument cluster (8) from instrument panel (3) and pull instrument cluster (8) away to allow access to speedometer cable (4).

2. Loosen nut (5) and disconnect speedometer cable (4) from speedometer (1).

3. Remove hitch pin (19) and washer (18) and disconnect hand throttle clevis (16) from accelerator rod (17).

4. Remove locknut (21), washer (9), screw (10), washer (9), and hand throttle cable (11) from bracket (12). Discard locknut (21).

5. Remove two locknuts (13), washers (14), capscrews (20), washers (14), spacers (12.1), and bracket (12) from boot (14.1) and cowl (15). Discard locknuts (13).

6. Loosen nut (25) and remove hand throttle cable (11) from bracket (23).

7. Remove locknut (29), washer (27), capscrew (26), and washer (27) from bracket (23) and instrument panel (3). Discard locknut (29).

8. Remove nut (22), screw (24), and bracket (23) from instrument panel (3).

9. Remove setscrew (30) and handle (31) from hand throttle cable (11).


b. Installation

1. Install O-ring (32) and nut (25) on hand throttle cable (11).

2. Install handle (31) on hand throttle cable (11) with setscrew (30).

3. Install bracket (23) on instrument panel (3) with screw (24) and nut (22). Do not tighten nut (22).

4. Align holes in bracket (23), instrument panel (3), and steering column bracket (28) and install washer (27), capscrew (26), washer (27), and locknut (29).

5. Tighten screw (24) and nut (22).

6. Install hand throttle cable (11) on bracket (23) and tighten nut (25).

7. Install bracket (12) and two spacers (12.1) on cowl (15) and boot (14.1) with two washers (14), capscrews (20), washers (14), and locknuts (15).

8. Install hand throttle cable (11) on bracket (12) with washer (9), screw (10), washer (9), and locknut (21).

9. Connect clevis (16) to accelerator rod (17) with washer (18) and hitch pin (19).

10. Connect speedometer cable (4) to speedometer (1), ensuring core (2) engages with square hole in speedometer (1), and tighten nut (5).

11. Install instrument cluster (8) in instrument panel (3) with four washers (6) and screws (7).
ROTATED 90 DEGREES
Section IV. EXHAUST SYSTEM MAINTENANCE

3-47. EXHAUST SYSTEM MAINTENANCE TASK SUMMARY

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3-48. TAILPIPE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Gasket (Appendix G, Item 39)
- Three locknuts (Appendix G, Item 106)
- Two lockwashers (Appendix G, Item 144)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

General Safety Instructions
Do not touch hot exhaust system components with bare hands.

Maintenance Level
Unit

WARNING
Do not touch hot exhaust system components with bare hands. Severe injury may result.

a. Removal

1. Remove three locknuts (9), washers (6), capscrews (5), and washers (6) from tailpipe (1) and muffler (7). Discard locknuts (9).
2. Remove two nuts (3), lockwashers (4), and U-bolt (10) from tailpipe (1) and hanger (2). Discard lockwashers (4).
3. Remove tailpipe (1) and gasket (8) from muffler (7). Discard gasket (8).

3-90 Change 2
1. Install gasket (8) and tailpipe (1) on muffler (7) with three washers (6), capscrews (5), washers (6), and locknuts (9). Tighten locknuts (9) to 26 lb-ft (35 N·m).

2. Install tailpipe (1) on hanger (2) with U-bolt (10), two lockwashers (4), and nuts (3).

FOLLOW-ON TASK: Start engine (TM 9-2320-387-10) and check for exhaust leaks.
3-49. MUFFLER AND CATALYTIC CONVERTER REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Material Parts

- Nine locknuts (Appendix G, Item 106)
- Gasket (Appendix G, Item 39)
- Seven lockwashers (Appendix G, Item 145)

Manual References

TM 9-2320-387-24P

Equipment Condition

Tailpipe removed (para. 3-48).

General Safety Instructions

Do not touch hot exhaust system components with bare hands.

N O T E

It may be necessary to lower rear propeller shaft (para. 6-4) to gain access to locknuts on muffler hanger.

WARNING

Do not touch hot exhaust system components with bare hands.
Severe injury may result.

a. Removal

CAUTION

Support muffler and catalytic converter during replacement.
Failure to do so may result in damage to equipment.

1. Remove two clamps (14) and heat shield (15) from crossover pipe (17).
2. Remove two nuts (13), U-bolt (23), and support bracket (20) from heat shield (10) and catalytic converter (24).
3. Remove two nuts (6), lockwashers (5), and washers (4) from heat shield (10). Discard lockwashers (5).
4. Remove capscrew (7), lockwasher (8), and Y-clip (9) at location A and screw (12), lockwashers (11) and (28), and nut (29) at location B and heat shield (10) from bracket (27). Discard lockwashers (8), (11), and (28).
5. Remove two nuts (25), washers (26), capscrews (31), washers (30), and bracket (27) from muffler (32).
6. Remove three locknuts (18), washers (19), capscrews (22), and washers (21) from catalytic converter (24) and crossover pipe (17). Discard locknuts (18).
7. Remove two nuts (40), lockwashers (39), and U-bolt (37) from catalytic converter (24) and support bracket (38). Discard lockwashers (39).

b. Installation

1. Install bracket (42), insulator (36), and retaining plate (45) on muffler (32) with two washers (34), capscrews (44), washers (46), and locknuts (41). Tighten locknuts (41) to 10 lb-ft (14 N-m).
2. Install muffler (32) and two retaining plates (35) on muffler hanger (1) with four washers (34), capscrews (33), washers (2), and locknuts (3).
3. Install catalytic converter (24) on support bracket (38) with U-bolt (37), two lockwashers (39), and nuts (40).
4. Install gasket (16) and catalytic converter (24) on crossover pipe (17) with three washers (21), capscrews (22), washers (19), and locknuts (18). Tighten locknuts (18) to 26 lb-ft (35 N·m).
5. Install bracket (27) on muffler (32) with two washers (30), capscrews (31), washers (26), and nuts (25).
6. Install bracket (27) on heat shield (10) with Y-clip (9), lockwasher (8), and screw (7) at location A and two lockwashers (11) and (28), screw (12), and nut (29) at location B.
7. Install heat shield (10) on muffler (32) with two washers (4), lockwashers (5), and nuts (6).
8. Install heat shield (10) and bracket (20) on catalytic converter (24) with U-bolt (23) and two nuts (13).
9. Install heat shield (15) on crossover pipe (17) with two clamps (14). Tighten clamps (14) to 60 lb-in. (7 N·m).

FOLLOW-ON TASK: Install tailpipe (para. 3-48).
3-50. EXHAUST PIPE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Three locknuts (Appendix G, Item 106)
- Gasket (Appendix G, Item 39)

Equipment Condition
- Right rear heat shield removed [para. 3-58]

General Safety Instructions
- Do not touch hot exhaust system components with bare hands.

Maintenance Level
- Unit

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

WARNING
Do not touch hot exhaust system components with bare hands. Severe injury may result.

a. Removal

1. Remove two clamps (12) and heat shield (11) from exhaust pipe (3).
2. Remove three locknuts (5), washers (4), capscrews (7), washers (4), and exhaust pipe (3) from catalytic converter (2). Discard locknuts (5).
3. Remove two capscrews (8), washers (9), flange (10), and exhaust pipe (3) from wastegate housing (1).
4. Remove and discard gasket (6).

b. Installation

1. Install flange (10) and exhaust pipe (3) on wastegate housing (1) with two washers (9) and capscrews (8).
2. Install gasket (6) and exhaust pipe (3) on catalytic converter (2) with three washers (4), capscrews (7), washers (4), and locknuts (5). Tighten locknuts (5) to 26 lb-ft (35 N·m).
3. Install heat shield (11) on exhaust pipe (3) with two clamps (12).
3-50. EXHAUST PIPE REPLACEMENT (Cont’d)

FOLLOW-ON TASKS:
- Start engine (TM 9-2320-387-10) and check for exhaust leaks.
- Install right rear heat shield (para. 3-58).
3-51. MANIFOLD-TO-TURBOCHARGER EXHAUST PIPE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Equipment Condition
Rear heat shield removed (para. 3-52).

General Safety Instructions
Do not touch hot exhaust system components with bare hands.

Maintenance Level
Unit

WARNING
Do not touch hot exhaust system components with bare hands. Severe injury may result.

NOTE
The replacement procedure for left and right manifold-to-turbocharger exhaust pipes is basically the same. This procedure covers the left exhaust pipe.

a. Removal

1. Loosen clamp (5) and remove exhaust pipe (1) from exhaust manifold (4). Slide clamp (5) onto pipe (1).
2. Loosen clamp (2) and remove exhaust pipe (1) from turbocharger (3). Slide clamp (2) onto exhaust pipe (1).
3. Remove clamps (2) and (5) from exhaust pipe (1).

b. Installation

1. Install two clamps (2) and (5) on exhaust pipe (1).
2. Install exhaust pipe (1) on turbocharger (3) and tighten clamp (2).
3. Install exhaust pipe (1) on exhaust manifold (4) and tighten clamp (5).

FOLLOW-ON TASK: Install rear heat shield (para. 3-52).
3-52. REAR HEAT SHIELD REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:  
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Equipment Condition
Right rear heat shield removed (para. 3-58).

WARNING
Do not touch hot exhaust system components with bare hands.  
Severe injury may result.

a. Removal

1. Remove capscrew (7) from rear heat shield (2) and left exhaust manifold (5).
2. Remove capscrew (1) from rear heat shield (2) and left cylinder head (6).
3. Remove two capscrews (3) and rear heat shield (2) from turbocharger (4).

b. Installation

1. Install rear heat shield (2) on turbocharger (4) with two capscrews (3).
2. Install rear heat shield (2) on left cylinder head (6) with capscrew (1).
3. Install rear heat shield (2) on left exhaust manifold (5) with capscrew (7).

FOLLOW-ON TASK: Install right rear heat shield (para. 3-58).
3-53. TAILPIPE HANGER REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

**Materials/Parts**
- Six locknuts (Appendix G, Item 106)

**Manual References**
- TM 9-2320-387-24P

**General Safety Instructions**
- Do not touch hot exhaust system components with bare hands.

**Maintenance Level**
- Unit

---

**WARNING**

Do not touch hot exhaust system components with bare hands.
Severe injury may result.

**a. Removal**

1. Remove four locknuts (5), washers (4), capscrews (9), washers (4), two insulator reinforcement plates (10), and insulator (8) from tailpipe hanger (6). Discard locknuts (5).
2. Remove two locknuts (1), washers (2), capscrews (7), washers (2), and tailpipe hanger (6) from frame (3). Discard locknuts (1).

**b. Installation**

1. Install tailpipe hanger (6) on frame (3) with two washers (2), capscrews (7), washers (2), and locknuts (1). Tighten capscrews (7) to 26 lb-ft (35 N·m).
2. Install insulator (8) and two insulator reinforcement plates (10) on tailpipe hanger (6) with four washers (4), capscrews (9), washers (4), and locknuts (5).
3-54. TAILPIPE INSULATOR REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Equipment Condition
Tailpipe removed [para. 3-48].

General Safety Instructions
Do not touch hot exhaust system components with bare hands.

Maintenance Level
Unit

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Four locknuts (Appendix G, Item 106)
Two lockwashers (Appendix G, Item 144)

Manual References
TM 9-2320-387-24P

WARNING
Do not touch hot exhaust system components with bare hands. Severe injury may result.

a. Removal

1. Remove four locknuts (5), washers (6), capscrews (9), washers (8), two reinforcement plates (7), and insulator (11) from tailpipe hanger (4). Discard locknuts (5).

2. Remove two capscrews (3), lockwashers (2), reinforcement plate (1), and U-bolt clamp (10) from insulator (11). Discard lockwashers (2).

b. Installation

1. Install reinforcement plate (1) and U-bolt clamp (10) on insulator (11) with two lockwashers (2) and capscrews (3). Tighten capscrews (3) to 10 lb-ft (14 N-m).

2. Install insulator (11) and two reinforcement plates (7) on tailpipe hanger (4) with four washers (8), capscrews (9), washers (6), and locknuts (5). Tighten locknuts (5) to 10 lb-ft (14 N-m).

FOLLOW-ON TASK: Install tailpipe [para. 3-48].
# 3-55. MUFFLER SUPPORT BRACKET MAINTENANCE

This task covers:

- **Removal**
- **Disassembly**
- **Assembly**
- **Installation**

## INITIAL SETUP:

### Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

### Materials/Parts

- Four locknuts (Appendix G, Item 106)

### Manual References

- **Equipment Condition**: Muffler and catalytic converter removed (para. 3-49).
- **Maintenance Level**: Unit

### TM 9-2320-387-24P

## a. Removal

**NOTE**

Hold bolt heads on transfer case securely to prevent changing torque or damaging transfer case seal.

Remove two locknuts (1), washers (2), and support bracket assembly (3) from transfer case (4). Discard locknuts (1).

## b. Disassembly

1. Remove two locknuts (9), washers (8), capscrews (5), washers (6), mounting bracket (11), and washers (6) from support plate (10). Discard locknuts (9).
2. Remove two insulators (7) from mounting plate (11).

## c. Assembly

1. Install two insulators (7) in mounting bracket (11).
2. Install two washers (6) between mounting bracket (11) and support plate (10) with two washers (6), capscrews (5), washers (8), and locknuts (9). Tighten locknuts (9) to 15 lb-ft (20 N·m).

## d. Installation

**NOTE**

Hold bolt heads on transfer case securely to prevent changing torque or damaging transfer case seal.

Install support bracket assembly (3) on transfer case (4) with two washers (2) and locknuts (1). Tighten locknuts (1) to 15 lb-ft (20 N·m).
FOLLOW-ON TASK: Install muffler and catalytic converter (para. 3-49).
3-56. RIGHT EXHAUST MANIFOLD HEAT SHIELD REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

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**WARNING**

Do not touch hot exhaust system components with bare hands. Severe injury may result.

**a. Removal**

1. Remove two capscrews (5), lockwashers (6), and harness clamps (4) from right exhaust manifold heat shield (3). Discard lockwashers (6).
2. Remove four capscrews (7) and right exhaust manifold heat shield (3) from exhaust manifold (2) and cylinder head (1).

**b. Installation**

1. Install right exhaust manifold heat shield (3) on exhaust manifold (2) and cylinder head (1) with four capscrews (7).
2. Install two harness clamps (4) on right exhaust manifold heat shield (3) with two lockwashers (6) and capscrews (5).
FOLLOW-ON TASKS:
- Install right rear heat shield [para. 3-58].
- Install starter [para. 4-11].
- Start engine (TM 9-2320-387-10) and check for exhaust leaks.
- Lower and secure hood (TM 9-2320-387-10).
3-57. EXHAUST MANIFOLDS REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

**Tools**
General mechanic's tool kit: automotive (Appendix B, Item 1)

Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Manual References**
TM 9-2320-387-24P

**Equipment Condition**
- Oil dipstick tube removed (para. 3-2) (left side only).
- 200-ampere alternator removed (para. 4-5) (left side only).

**Equipment Condition (Cont’d)**
- Air horn removed (para. 3-14) (right side only).
- Right exhaust manifold heat shield removed (para. 3-56) (right side only).
- Rear heat shield removed (para. 3-52) (left side only).

**General Safety Instructions**
Do not touch hot exhaust system components with bare hands.

**Maintenance Level**
Unit

**WARNING**

Do not touch hot exhaust system components with bare hands. Severe injury may result.

**NOTE**

The replacement procedure for right and left exhaust manifolds is basically the same. This procedure covers the right exhaust manifold.

**a. Removal**

1. Loosen and slide clamp (4) onto exhaust pipe (5).
2. Remove four (eight if left side) capscrews (1) and exhaust manifold (2) from cylinder head (3).
3. Clean all gasket material from head mounting surface and manifold mating surface.

**CAUTION**

Alternate screw tightening. Flanges may break when each screw is tightened completely before others are snugged up.

1. Install exhaust manifold (2) on cylinder head (3) with four (eight if left side) capscrews (1). Tighten capscrews (1) to 25-33 lb-ft (34-45 N-m).
2. Install exhaust pipe (5) on exhaust manifold (2) and tighten clamp (4).
FOLLOW-ON TASKS:
- Install 200-ampere alternator (para. 4-3) (left side only).
- Install oil dipstick tube (para. 3-2) (left side only).
- Install rear heat shield (para. 3-52) (left side only).
- Install air horn (para. 3-14) (right side only).
- Install right exhaust manifold heat shield (para. 3-56) (right side only).
3-58. RIGHT REAR HEAT SHIELD REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

**Tools**  
General mechanic's tool kit: automotive (Appendix B, Item 1)

**Manual References**  
TM 9-2320-387-24P

**Equipment Condition**  
Engine access cover removed (para. 10-22).

**General Safety Instructions**  
Do not touch hot exhaust system components with bare hands.

**Maintenance Level**  
Unit

---

**WARNING**  
Do not touch hot exhaust system components with bare hands. Severe injury may result.

**a. Removal**

1. Remove capscrew (6) from transmission dipstick tube (5), right rear heat shield (4), rear heat shield (1), and wastegate housing (7).
2. Remove two capscrews (3) and right rear heat shield (4) from right exhaust manifold heat shield (2).
3. Remove nut (8), washers (9) and (11), and screw (10) from heat shields (4) and (12) and separate heat shields (4) and (12).

**b. Installation**

1. Assemble heat shields (4) and (12) with screw (10), washers (11) and (9), and nut (8).
2. Install right rear heat shield (4) on right exhaust manifold heat shield (2) with two capscrews (3).
3. Install right rear heat shield (4) and transmission dipstick tube (5) on rear heat shield (1) and wastegate housing (7) with capscrew (6).

---

**FOLLOW-ON-TASK:** Install engine access cover (para. 10-22).
3-59. MUFFLER HANGER REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

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Manual References

TM 9-2320-387-24P

a. Removal

Remove three locknuts (4), six washers (3), three screws (5), and muffler hanger (1) from frame rail (2).

Discard locknuts (4).

b. Installation

Install muffler hanger (1) on frame rail (2) with three screws (5), six washers (3), and three locknuts (4).

Tighten locknuts (4) to 75 lb-ft (102 N·m).

FOLLOW-ON TASK: Install muffler and catalytic converter (para. 3-49).
### Section V. COOLING SYSTEM MAINTENANCE

#### 3-60. COOLING SYSTEM MAINTENANCE TASK SUMMARY

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<td>3-85.1</td>
<td>Transfer Case Cooler Lines Maintenance (Serial Numbers 300000 and Above)</td>
<td>3-192</td>
</tr>
</tbody>
</table>
3-61. COOLING SYSTEM SERVICING

This task covers:

a. Depressurizing
b. Draining System
c. Preventive Cleaning
d. Filling System

INITIAL SETUP:

| Tools                                      | Manual References (Cont’d)               |
|                                           | TM 750-254                               |
| General mechanic’s tool kit:              | TB 750-651                               |
|   automotive (Appendix B, Item 1)         |                                          |
| Maintenance and repair shop equipment:    |                                          |
|   automotive (Appendix B, Item 2)         |                                          |
| Test Equipment                            |                                          |
|   Radiator tester (Appendix B, Item 49)   |                                          |
| Materials/Parts                           |                                          |
|   Antifreeze (Appendix C, Items 14 and 15)|                                          |
| Manual References                         |                                          |
|   TM 9-2320-387-10                        |                                          |
|   TM 9-2320-387-24P                       |                                          |

| General Safety Instructions               |                                          |
| Do not remove surge tank filler cap before releasing internal pressure. |

| Equipment Condition                      |                                          |
| Hood raised and secured (TM 9-2320-387-10)|                                          |

| Maintenance Level                        |                                          |
| Unit                                      |                                          |

a. Depressurizing

WARNING

Do not remove surge tank filler cap before depressurizing system when engine temperature is above 185°F (85°C). Steam or hot coolant under pressure may cause severe burns.

1. If engine is hot, remove surge tank filler cap (1) by placing a thick cloth over cap (1). Press down and turn counterclockwise to its first stop to release internal pressure.
2. After pressure has escaped, press down and turn cap (1) counterclockwise again and remove.

b. Draining System

1. If engine is hot, depressurize system (see task a.).

NOTE

Have drainage container ready to catch coolant.

2. Open drainvalve (4) and allow system to drain.
3. Close drainvalve (4).

c. Preventive Cleaning

1. For preventive cleaning, refer to TB 750-651.
2. Test surge tank filler cap (1); refer to TM 750-254.
3-61. COOLING SYSTEM SERVICING (Cont’d)

d. Filling System

**CAUTION**

- Type 1, ethylene glycol (green), and Type 2, propylene glycol (purple), should never be mixed due to their difference in toxic properties. Failure to comply may result in damage to equipment.
- Using antifreeze without mixing it with water can cause high operating temperatures, blockage of cooling system passages, and damage to water pump seals.

**NOTE**

- Type 1 antifreeze is an ethylene glycol based coolant, green in color. Type 1 can be added to factory-filled pink coolant. When it becomes necessary to flush factory coolant, Type 1, ethylene glycol, will be used. When mixing Type 1 antifreeze with water, distilled water is recommended. Tap water should only be used in emergency situations.
- The cooling system for the vehicles covered in this manual has a 26 qt (24.6 L) capacity. Continue filling and allow air to escape. Ensure surge tank coolant level is 3/4 full before securing filler cap.
- Ensure vent hose is routed above air intake to allow for purging of air in cooling system.

1. Ensure radiator drain valve (4) is closed and heater control valve (3) is open (pull TEMP knob on dash to MAX position).
2. Fill system with proper antifreeze solution. See table 3-1 for preparation of antifreeze solutions.
3. Secure filler cap (1) to surge tank (2).
4. Run engine at fast idle (approximately 1,500 rpm) until engine temperature reaches 190°F (88°C), opening thermostat to circulate coolant.
5. Depressurize system (see task a.).
6. Fill with proper antifreeze solution until surge tank (2) is 3/4 full. See table 3-1 for preparation of antifreeze solutions.
7. Secure filler cap (1) to surge tank (2).
8. Run engine at fast idle (approximately 1,500 rpm) until temperature reaches 190°F (88°C), opening thermostat, and stop engine.
9. Depressurize system (see task a.). Use tester to ensure proper coolant protection is provided.
10. Secure filler cap (1) to surge tank (2).
### Table 3-1. Guide for Preparation of Antifreeze Solutions.

<table>
<thead>
<tr>
<th>LOWEST EXPECTED AMBIENT TEMPERATURE</th>
<th>PINTS PER GALLON OF COOLANT CAPACITY</th>
<th>ARCTIC GRADE ANTIFREEZE -90°F (-68°C) A-A-52624</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>+20</td>
<td>-7</td>
<td>1-1/2 (.71 L)</td>
</tr>
<tr>
<td>+10</td>
<td>-12</td>
<td>2 (.95 L)</td>
</tr>
<tr>
<td>0</td>
<td>-18</td>
<td>2-3/4 (1.3 L)</td>
</tr>
<tr>
<td>-10</td>
<td>-23</td>
<td>3-1/4 (1.5 L)</td>
</tr>
<tr>
<td>-20</td>
<td>-29</td>
<td>3-1/2 (1.7 L)</td>
</tr>
<tr>
<td>-30</td>
<td>-34</td>
<td>4 (1.9 L)</td>
</tr>
<tr>
<td>-40</td>
<td>-40</td>
<td>4-1/4 (2.0 L)</td>
</tr>
<tr>
<td>-50</td>
<td>-46</td>
<td>4-1/2 (2.1 L)</td>
</tr>
<tr>
<td>-55</td>
<td>-48</td>
<td>4-3/4 (2.2 L)</td>
</tr>
<tr>
<td>Below -60</td>
<td>Below -51.1</td>
<td>Use arctic grade antifreeze -90°F (-68°C)</td>
</tr>
</tbody>
</table>

FOLLOW-ON TASKS: • Start engine (TM 9-2320-387-10) and check cooling system for leaks.  
• Lower and secure hood (TM 9-2320-387-10).
This task covers:

a. Removal
b. Cleaning and Inspection
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
- automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
- automotive (Appendix B, Item 2)

Materials/Parts
- Locknut (Appendix G, Item 92)
- Four locknuts (Appendix G, Item 77)
- Six locknuts (Appendix G, Item 106)
- Eight lockwashers (Appendix G, Item 146)

Personnel Required
- One mechanic
- One assistant

Manual References
TM 9-2320-387-24P

Equipment Condition
- Cooling system drained
  (para. 3-61).
- Oil cooler removed
  (para. 3-8).
- Hood removed (para. 10-9).

General Safety Instructions
Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa).

Maintenance Level
Unit

CAUTION
Do not bend radiator fins. Damaged fins reduce cooling efficiency, which may damage engine.

NOTE
The radiator and fan shroud are removed as a unit.

1. Loosen clamp (2) and disconnect radiator inlet hose (1) from radiator (3).
2. Loosen clamp (5) and disconnect surge tank-to-radiator vent hose (4) from adapter (6).
3. Disconnect control valve hose (14) from elbow (16).
4. Disconnect fan drive hose (17) from fan drive (18).
5. Disconnect elbow (16) from shroud bulkhead adapter (15).
6. Remove clamp (9) and lower radiator front hose (10) from radiator (3).
7. Remove locknut (27), washer (28), capscrew (34), washer (33), washer (32), lower mount (30), and large washer (29) from radiator (3) and frame bracket (31). Discard locknut (27).
8. Remove four locknuts (11), washers (12), and capscrews (13) from two support brackets (8) and airlift brackets (7). Discard locknuts (11).
9. Loosen nut (26) and release tension from cross brace (23).
10. Remove four locknuts (25), washers (24), capscrews (36), and crossbrace (23) from airlift brackets (7). Discard four locknuts (25).
11. Lift radiator (3) up and remove from vehicle.
12. Remove eight capscrews (35), lockwashers (37), two retaining strips (38), and fan shroud (39) from radiator (3). Discard lockwashers (37).
13. Remove two locknuts (19), large washers (20), bracket (40) (left side), brackets (21), support brackets (8), and insulators (22) from radiator studs (22.1). Discard locknuts (19).
b. Cleaning and Inspection

**WARNING**
Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

1. Remove dirt, trash, and insects embedded in radiator fins using water and compressed air.
2. Inspect radiator adapter (25) for damage. Replace adapter (25) if damaged.
3. Inspect radiator (9) for breaks, punctures, cracks, and splits. Replace radiator (9) if broken, punctured, cracked, or split.
4. Inspect shroud bulkhead adapter (26) for damage. Replace bulkhead adapter (26) if damaged.
5. Inspect fan shroud (21) for cracks, splits, and breaks. Repair fan shroud (21) if cracked, split, or broken. Replace fan shroud (21) if damaged beyond repair.
6. Inspect fan drive hose (27) for cracks or damage. Replace if cracked or damaged.

**CAUTION**
To ensure proper cooling of engine, upper edge of shroud must align with radiator top tank seam or damage to equipment may result.

1. Install fan shroud (21) on radiator (9), with shroud edge (22) aligning with tank seam (23), with two retaining strips (20), eight lockwashers (17), and capscrews (18). Tighten capscrews (18) to 6 lb-ft (8 N·m).
2. Install two brackets (3), insulators (4), support brackets (24), and bracket (28) (left side), on radiator stud (4.1) with two large washers (2) and new locknuts (1). Tighten locknuts (1) to 20 lb-ft (27 N·m).
3. Install radiator (9) on frame bracket (14), aligning two support brackets (24) to airlift brackets (29).
4. Install support brackets (24) on airlift brackets (29) with four capscrews (32), washers (31), and locknuts (30). Do not tighten locknuts (30).
5. Install radiator (9), large washer (12), and mount (13) on frame bracket (14) with washer (11), washer (15), capscrew (16), washer (11), and locknut (10). Do not tighten capscrew (16).
6. Install crossbrace (5) on airlift brackets (29) with four capscrews (19), washers (6), and locknuts (7).
7. Tighten nut (8) on crossbrace (5) until slack is removed.
3-62. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE
(SERIAL NUMBERS 299999 AND BELOW) (Cont'd)
NOTE

- Fan shroud should be aligned so the following dimensions are maintained. Adjustments may be made by sliding the radiator/shroud assembly. Distance A from the edge of shroud ring and rear edge of fan must be 1-1/2 ± 1/4 in. (38.1 ± 6 mm). Measure distance A at the 2, 4, 8, and 10 o’clock positions.
- Fan blade to fan shroud clearance, distance between the top of the fan blade and fan shroud, must not be less than 1/4 in. (6 mm) at any position.

8. Align fan shroud (11) and tighten four locknuts (10) to 26 lb-ft (35 N•m). Tighten capscrew (7) to 30 lb-ft (41 N•m).
9. Connect lower radiator front hose (9) to radiator (3) and tighten clamp (8) to 85-95 lb-in. (9.6-10.7 N•m).
10. Connect fan drive hose (15) to fan drive (16).
11. Connect elbow (14) to bulkhead adapter (13).
12. Connect control valve hose (12) to elbow (14).
13. Connect radiator inlet hose (1) to radiator (3) and tighten clamp (2) to 85-95 lb-in. (9.6-10.7 N•m).
14. Connect surge tank-to-radiator vent hose (4) to adapter (6) and tighten clamp (5) to 10-20 lb-in. (1-2 N•m).
FOLLOW-ON TASKS:
- Fill cooling system (para. 3-61).
- Install oil cooler (para. 3-8).
- Bleed power steering system (para. 8-27).
- Install hood (para. 10-9).
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal  
b. Cleaning and Inspection  
c. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Ten lockwashers (Appendix G, Item 146)
- Four locknuts (Appendix G, Item 106)
- Four lockwashers (Appendix G, Item 144)
- Five locknuts (Appendix G, Item 77)
- Locknut (Appendix G, Item 262.2)
- Six lockwashers (Appendix G, Item 145)

**Personnel Required**
- One mechanic
- One assistant

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Cooling system drained ([para. 3-61](#)).
- Oil cooler removed ([para. 3-8.1](#)).
- Airlift bracket-to-hood seal removed ([para. 10-55](#)).
- Hood removed ([para. 10-9](#)).

**General Safety Instructions**
- Compressed air used for cleaning purposes must not exceed 30 psi (207 kPa).

**Maintenance Level**
- Unit

---

**CAUTION**

Do not bend radiator fins. Damaged fins reduce cooling efficiency, which may damage engine.

---

**NOTE**

The radiator and lower fan shroud are removed as a unit.

1. Loosen hose clamp (2) and remove inlet hose (1) from radiator (3).
2. Loosen hose clamp (4) and remove lower radiator hose (5) from radiator (3).
3. Loosen hose clamp (7) and remove surge tank-to-radiator vent hose (8) from adapter (6).
4. Remove two capscrews (11), lockwashers (10), washers (9), and pressure valve bracket (13) from bracket (12). Discard lockwashers (10).
5. Loosen outboard nut (18) and locknut (19), and release tension from crossbrace (14).
6. Remove four capscrews (15), lockwashers (16), and crossbrace (14) from two airlift brackets (17). Discard lockwashers (16).
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE  
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

7. Remove nut (1), washer (2), bracket (3), and left support bracket (4) from left radiator stud (5).
8. Remove two locknuts (6), washers (7), capscrews (10), lockwashers (9), washers (8), and left support bracket (4) from left airlift bracket (11). Discard locknuts (6) and lockwashers (9).
9. Remove nut (15), washer (14), and right support bracket (13) from right radiator stud (12).
10. Remove two locknuts (21), washers (20), capscrews (17), lockwashers (18), washers (19), and right support bracket (13) from right airlift bracket (16). Discard locknuts (21) and lockwashers (18).
11. Remove three locknuts (24), washers (23), capscrews (34), washers (35), and upper fan shroud (22) from lower fan shroud (28). Discard locknuts (24).
12. Remove two capscrews (33), lockwashers (32), and rubber shield (31) from upper fan shroud (22) and radiator (25). Discard lockwashers (32).
13. Remove two locknuts (26), washers (27), capscrews (30), washers (29), and upper fan shroud (22) from lower fan shroud (28). Discard locknuts (26).
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE  
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

14. Remove locknut (2), capscrew (9), washer (8), large washer (7), spacer (6), large washer (3), and spacer (4) from radiator (1) and mounting bracket (5). Discard locknut (2).
15. Lift radiator (1) up and remove from vehicle.
16. Remove eight capscrews (10) and (13), lockwashers (11) and (14), fan shroud shields (12) and (15), and lower fan shroud (16) from radiator (1). Discard lockwashers (11) and (14).

b. Cleaning and Inspection

WARNING
Compressed air used for cleaning purposes must not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.). Failure to comply may result in injury to personnel.

1. Remove dirt, trash, and insects embedded in radiator fins using water and compressed air.
2. Inspect radiator adapter (18) for damage. Replace adapter (18) if damaged.
3. Inspect radiator (1) for breaks, punctures, cracks, and splits. Replace radiator (1) if broken, punctured, cracked, or split.
4. Inspect upper fan shroud (17) for cracks, splits, and breaks. Repair upper fan shroud (17) if cracked, split, or broken. Replace fan shroud if damaged.
5. Inspect lower fan shroud (16) for cracks, splits, and breaks. Repair lower fan shroud (16) if cracked, split, or broken. Replace lower fan shroud (16) if damaged.

c. Installation

CAUTION
To ensure proper cooling of engine, upper edge of shroud must align with radiator top tank seam or damage to equipment may result.

1. Install fan shroud shields (12) and (15) and lower fan shroud (16) on radiator (1) with eight lockwashers (14) and (11) and eight capscrews (13) and (10).
2. Install radiator (1), on mounting bracket (5) with large washer (7), washer (8), capscrew (9), spacer (4), large washer (3), spacer (6), and locknut (2).
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

3. Install upper fan shroud (1) on lower fan shroud (7) with two washers (8), capscrews (9), washers (6), and locknuts (5).

4. Install rubber shield (10) on upper fan shroud (1) and radiator (4) with two lockwashers (11) and capscrews (12).

5. Install upper fan shroud (1) on lower fan shroud (7) with three washers (14), capscrews (13), washers (2), and locknuts (3).

6. Install right support bracket (16) on right airlift bracket (19) with two washers (22), lockwashers (21), capscrews (20), washers (23), and locknuts (24).

7. Install right support bracket (16) on right radiator stud (15) with washer (17) and nut (18).

8. Install left support bracket (28) on left airlift bracket (35) with two washers (32), lockwashers (33), capscrews (34), washers (31), and locknuts (30).

9. Install left support bracket (28) on left radiator stud (29) with bracket (27), washer (26), and nut (25).
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE  
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
10. Install crossbrace (14) on two airlift brackets (17) with four lockwashers (16) and capscrews (15).
11. Tighten outboard nut (18) and locknut (19) on crossbrace (14) until slack is removed.
12. Secure pressure valve bracket (13) to bracket (12) with two washers (9), lockwashers (10), and capscrews (11).
13. Install surge tank-to-radiator vent hose (8) on adapter (6) with hose clamp (7). Tighten hose clamp (7) to 10–20 lb-in. (1–2 N•m).
14. Install lower radiator hose (5) on radiator (3) with hose clamp (4). Tighten hose clamp (4) to 85–95 lb-in. (9.6–10.7 N•m).
15. Install radiator inlet hose (1) on radiator (3) with hose clamp (2). Tighten hose clamp (2) to 85–95 lb-in. (9.6–10.7 N•m).
3-62.1. RADIATOR AND FAN SHROUD ASSEMBLY MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASKS:  
- Install hood (para. 10-9)  
- Install airlift bracket-to-hood seal (para. 10-55).  
- Install oil cooler [para. 3-8.1].  
- Fill cooling system [para. 3-61].
3-62.2. UPPER FAN SHROUD REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

**Tools**  
General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**  
Five locknuts (Appendix G, Item 77)
Two lockwashers (Appendix G, Item 146)

**Manual References**
TM 9-2320-387-10
TM 9-2320-387-24P

**Equipment Condition**
Right splash shield removed (para. 10-24.1).

**Maintenance Level**
Unit

---

**a. Removal**

1. Remove three locknuts (3), washers (2), capscrews (13), and washers (14) from upper fan shroud (1) and lower fan shroud (7). Discard locknuts (3).

2. Remove two capscrews (12), lockwashers (11), and rubber shield (10) from upper fan shroud (1) and radiator (4). Discard lockwashers (11).

3. Remove two locknuts (5), washers (6), capscrews (9), washers (8), and upper fan shroud (1) from lower fan shroud (7). Discard locknuts (5).

**b. Installation**

1. Install upper fan shroud (1) on lower fan shroud (7) with two capscrews (9), washers (8), washers (6), and locknuts (5).

2. Install rubber shield (10) on upper fan shroud (1) and radiator (4) with two lockwashers (11) and capscrews (12).

3. Secure upper fan shroud (1) to lower fan shroud (7) with three washers (14), capscrews (13), washers (2), and locknuts (3).
FOLLOW-ON TASK: Install right splash shield (para. 10-24.1).
3-63. AIRLIFT-TO-SHROUD SHIELD ASSEMBLY REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Radiator and fan shroud removed (para. 3-62)

**Maintenance Level**
- Unit

---

**a. Removal**

Remove three screws (3) and shield assembly (2) from airlift bracket (1).

**b. Installation**

Install shield assembly (2) on airlift bracket (1) with three screws (3).

---

**FOLLOW-ON TASK:** Install radiator and fan shroud (para. 3-62).
3-64. RADIATOR SUPPORTS REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools

- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts

- Six locknuts (Appendix G, Item 106)

Manual References

- TM 9-2320-387-24P

Equipment Condition

- Left splash shield removed (para. 10-23).
- Right splash shield removed (para. 10-24).

Maintenance Level

- Unit

a. Removal

1. Remove two locknuts (1), large washers (2), bracket (3) (left side), brackets (4), support brackets (7), and insulators (6) from radiator studs (5). Discard locknuts (1).
2. Remove four locknuts (11), washers (9), capscrews (8), and two support brackets (7) from airlift brackets (10). Discard locknuts (11).

b. Installation

1. Install two support brackets (7) on airlift brackets (10) with four capscrews (8), washers (9), and locknuts (11). Do not tighten locknuts (11).
2. Install two brackets (4), insulators (6), support brackets (7), and bracket (3) (left side) on two radiator studs (5) with large washers (2) and locknuts (1). Tighten locknuts (1) to 20 lb-ft (27 N•m).
3. Tighten four locknuts (11) to 26 lb-ft (35 N•m).

FOLLOW-ON TASKS:

- Install left splash shield (para. 10-23).
- Install right splash shield (para. 10-24).
3-64.1. RADIANI supports replacement (Serial numbers 300000 and above)

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools:
   General mechanic's tool kit: automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts:
   Two lockwashers (Appendix G, Item 144)
   Two locknuts (Appendix G, Item 106)
   Two lockwashers (Appendix G, Item 146)

Manual References
   TM 9-2320-387-24P

Equipment Condition:
   • Engine left splash shield removed (para. 10-23.1).
   • Engine right splash shield removed (para. 10-24.1).

Maintenance Level
   Unit

NOTE
   Replacement procedures for left and right radiator support brackets are basically the same. This procedure shows the left side.

a. Removal

   NOTE
   Perform step 1 for left side only.

   1. Remove two capscrews (14), lockwashers (13), washers (12), and pressure valve bracket (15) from bracket (3). Discard lockwasher (13).
   2. Remove two locknuts (6), washers (7), capscrews (10), lockwashers (9), and washers (8) from airlift bracket (11). Discard locknuts (6) and lockwashers (9).
   3. Remove nut (1), washer (2), bracket (3), and support bracket (4) from radiator support (5).

b. Installation

   1. Install support bracket (4) on radiator support (5) with bracket (3), washer (2), and nut (1). Tighten nut (1) to 26 lb-ft (35 N-m).
   2. Secure support bracket (4) to airlift bracket (11) with two washers (8), lockwashers (9), capscrews (10), washers (7), and locknuts (6).

   NOTE
   Perform step 3 for left side only.

   3. Install pressure valve bracket (15) on bracket with two washers (12), lockwashers (13), and capscrews (14).
FOLLOW-ON TASKS:  • Install engine right splash shield (para. 10-24.1).
• Install engine left splash shield (para. 10-23.1).
3-65. SURGE TANK REPLACEMENT

This task covers:

a. Removal  

b. Installation

INITIAL SETUP:

Tools

general mechanic's tool kit:  
automotive (Appendix B, Item 1)  

Maintenance and repair shop equipment:  
automotive (Appendix B, Item 2)

Manual References

TM 9-2320-387-24P

Equipment Condition

Cooling system drained, as required [para. 3-61].

Maintenance Level

Unit

NOTE

Tag hoses prior to disconnection.

a. Removal

1. Loosen clamp (3) and disconnect surge tank-to-radiator vent hose (6) from surge tank (2).
2. Loosen clamp (4) and disconnect surge tank-to-water crossover vent hose (5) from surge tank (2).
3. Loosen clamp (9) and disconnect surge tank-to-lower radiator hose (8) from surge tank (2).
4. Open two clamps (1) on surge tank (2) and bracket (10).
5. Disconnect surge tank overflow hose (7) and remove surge tank (2) from bracket (10).

b. Installation

1. Install surge tank (2) on bracket (10) with two clamps (1).
2. Connect surge tank-to-lower radiator hose (8) to surge tank (2) and tighten clamp (9).

NOTE

Ensure vent hose is routed above air intake to allow for purging of air in cooling system.

3. Connect surge tank-to-water crossover vent hose (5) to surge tank (2) and tighten clamp (4) to 10–20 lb-in. (1–2 N·m).
4. Connect surge tank-to-radiator vent hose (6) to surge tank (2) and tighten clamp (3) to 10–20 lb-in. (1–2 N·m).
5. Connect surge tank overflow hose (7) to surge tank (2).

FOLLOW-ON TASK: Fill cooling system [para. 3-61].
3-66. SURGE TANK-TO-RADIATOR VENT HOSE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Equipment Condition
- Cooling system depressurized (para. 3-61)

Maintenance Level
- Unit

Manual References
- TM 9-2320-387-24P

a. Removal

1. Loosen two clamps (2) and remove vent hose (3) from radiator (4) and surge tank (1).
2. Remove two clamps (2) from vent hose (3).

b. Installation

1. Install two clamps (2) on vent hose (3).

NOTE

Ensure vent hose is routed above air intake to allow for purging of air in cooling system.

2. Install vent hose (3) on surge tank (1) and radiator (4) and tighten two clamps (2) to 10–20 lb-in. (1–2 N·m).

FOLLOW-ON TASK: Tighten coolant filler cap (para. 3-61).
3-67. SURGE TANK-TO-WATER CROSSED VENT HOSE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
- automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
- automotive (Appendix B, Item 2)

Manual References

TM 9-2320-387-24P

Equipment Condition

Cooling system depressurized (para. 3-61).

Maintenance Level

Unit

a. Removal

1. Loosen two clamps (2) and remove vent hose (3) from water crossover (4) and surge tank (1).
2. Remove two clamps (2) from vent hose (3).

b. Installation

1. Install two clamps (2) on vent hose (3).

NOTE

Ensure vent hose is routed above air intake to allow for purging of air in cooling system.

2. Install vent hose (3) on surge tank (1) and water crossover (4) and tighten two clamps (2) to 10–20 lb-in. (1–2 N•m).

FOLLOW-ON TASK: Tighten coolant filler cap (para. 3-61).
3-68. THERMOSTAT BYPASS HOSE REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Equipment Condition
Cooling system drained, as required (para. 3-61).

Maintenance Level
Unit

a. Removal

1. Loosen two clamps (2) and remove thermostat bypass hose (3) from water pump (4) and water crossover (1).
2. Remove two clamps (2) from hose (3).

b. Installation

1. Install two clamps (2) on thermostat bypass hose (3).
2. Install hose (3) on water pump (4) and water crossover (1) and tighten two clamps (2).

FOLLOW-ON TASK: Fill cooling system (para. 3-61).
3-68.1. THERMOSTAT BYPASS HOSE REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

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<th>b. Installation</th>
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INITIAL SETUP:

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<td>automotive (Appendix B, Item 1)</td>
<td>(para. 3-61).</td>
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<td>Unit</td>
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<td>TM 9-2320-387-24P</td>
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</tbody>
</table>

**a. Removal**

1. Loosen clamps (2) and (4) and remove thermostat bypass hose (3) from water pump (5) and water crossover (1).
2. Remove clamps (2) and (4) from thermostat bypass hose (3).

**b. Installation**

1. Install clamps (2) and (4) on thermostat bypass hose (3).
2. Install thermostat bypass hose (3) on water pump (5) and water crossover (1) with clamps (2) and (4).
3-68.1. THERMOSTAT BYPASS HOSE REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASK: Fill cooling system [para. 3-61].
### 3-69. FAN DRIVE HOSE AND QUICK-DISCONNECT REPLACEMENT

This task covers:

- **a. Removal**
- **b. Installation**

#### INITIAL SETUP:

<table>
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<th>Manual References</th>
<th>Equipment Condition</th>
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<td>Sealing compound (Appendix C, Item 60)</td>
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<td>Maintenance Level</td>
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<tr>
<td>One mechanic</td>
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<td>Hood raised and secured (TM 9-2320-387-10).</td>
<td>Unit</td>
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<tr>
<td>One assistant</td>
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#### a. Removal

**NOTE**
Have container ready to catch fluid.

1. Remove control valve hose (9) from elbow (5).
2. Remove elbow (5) from bulkhead adapter bushing (8).
3. Remove nut (6), washer (7), and bulkhead adapter bushing (8) with bulkhead adapter (11) from shroud (4).
4. Release fan drive hose quick-disconnect (2) and remove hose (1) from fan drive (3).
5. Remove bulkhead adapter bushing (8) from bulkhead adapter (11).
6. Remove bulkhead adapter (11) from fan drive hose (1).
7. Remove female end of quick-disconnect (2) from fan drive hose (1).
8. Remove male end of quick-disconnect (12) from fan drive (3).

#### b. Installation

**NOTE**
Apply sealing compound to all pipe threads during installation.

1. Install male end of quick-disconnect (12) on fan drive (3).
2. Install female end of quick-disconnect (2) on fan drive hose (1).
3. Install bulkhead adapter (11) on fan drive hose (1).
4. Install bulkhead adapter bushing (8) on bulkhead adapter (11).
5. Install bulkhead adapter (11) and bulkhead adapter bushing (8) on shroud (4) with washer (7) and nut (6).
6. Install hose (1) and fan drive hose quick-disconnect (2) on fan drive (3).
7. Install elbow (5) on bulkhead adapter bushing (8).
8. Install control valve hose (9) on elbow (5).
FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-70. RADIATOR INLET HOSE REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

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<th>Tools</th>
<th>Equipment Condition</th>
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<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>Cooling system depressurized [para. 3-61].</td>
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<tr>
<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td></td>
</tr>
</tbody>
</table>

Manual References

TM 9-2320-387-24P

a. Removal

1. Loosen two clamps (2) and remove inlet hose (3) from radiator (1) and water crossover (4).
2. Remove two clamps (2) from hose (3).

b. Installation

1. Install two clamps (2) on inlet hose (3).
2. Install hose (3) on water crossover (4) and radiator (1) and tighten two clamps (2) to 85-95 lb-in. (10-11 N-m).

FOLLOW-ON TASK: Tighten coolant filler cap [para. 3-61].
3-71. RADIATOR LOWER TUBE ASSEMBLY REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Two locknuts (Appendix G, Item 77)
- Sealing compound (Appendix C, Item 62)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Cooling system drained (para. 3-61)

Maintenance Level
- Unit

a. Removal

1. Remove drainvalve (11) from radiator lower tube assembly (10).
2. Remove two locknuts (5), washers (3), capscrews (2), and washers (3) from radiator lower tube assembly (10) and frame bracket (4). Discard locknuts (5).
3. Loosen clamp (7) and disconnect water pump inlet hose (6) from radiator lower tube assembly (10).
4. Loosen clamp (8) and disconnect surge tank-to-lower radiator hose (9) from radiator lower tube assembly (10).
5. Loosen clamp (12) and disconnect lower radiator hose (1) from radiator lower tube assembly (10).
6. Remove radiator lower tube assembly (10).

b. Installation

1. Install radiator lower tube assembly (10) on frame bracket (4) with two washers (3), capscrews (2), washers (3), and locknuts (5). Tighten locknuts (5) to 6 lb-ft (8 N•m).
2. Connect lower radiator hose (6) to radiator lower tube assembly (10) and tighten clamp (7) to 85-95 lb-in. (10-11 N•m).
3. Connect surge tank-to-lower radiator hose (9) to radiator lower tube assembly (10) and tighten clamp (8) to 85-95 lb-in. (10-11 N•m).
4. Connect water pump inlet hose (1) to radiator lower tube assembly (10) and tighten clamp (12) to 85-95 lb-in. (10-11 N•m).
5. Apply sealant-type tape to threads of drainvalve (11) and install drainvalve (11) on radiator lower tube assembly (10).

FOLLOW-ON TASK: Fill cooling system (para. 3-61).
3-71.1. RADIATOR LOWER TUBE ASSEMBLY REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Two locknuts (Appendix G, Item 77)
- Sealing compound (Appendix C, Item 62)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Cooling system drained (para. 3-61).

Maintenance Level
- Unit

a. Removal

1. Remove drainvalve (15) from radiator lower tube assembly (11).
2. Loosen clamp (7) and disconnect water pump inlet hose (8) from radiator lower tube assembly (11).
3. Loosen clamp (10) and disconnect surge tank-to-lower radiator hose (9) from radiator lower tube assembly (11).
4. Loosen clamp (16) and disconnect lower radiator hose (1) from radiator lower tube assembly (11).
5. Loosen clamp (13) and disconnect transfer case coolant hose (12) from tee (14).
6. Remove two locknuts (6), washers (5), capscrews (2), washers (3), and radiator lower tube assembly (11) from frame bracket (4). Discard locknuts (6).
7. Remove tee (14) from radiator lower tube assembly (11).

B. Installation

1. Apply sealing compound to threads of tee (14) and install tee (14) on radiator lower tube assembly (11).
2. Install radiator lower tube assembly (11) on frame bracket (4) with two capscrews (2), washers (3), washers (5), and locknuts (6). Tighten locknuts (6) to 72 lb-in. (8 N•m).
3. Connect transfer case coolant hose (12) to tee (14) with clamp (13).
4. Connect lower radiator hose (1) to radiator lower tube assembly (11) and tighten clamp (16) to 85-95 lb-in. (10-11 N•m).
5. Connect surge tank-to-lower radiator hose (9) to radiator lower tube assembly (11) and tighten clamp (10) to 85-95 lb-in. (10-11 N•m).
6. Connect water pump inlet hose (8) to radiator lower tube assembly (11) and tighten clamp (7) to 85-95 lb-in. (10-11 N•m).
7. Apply sealing compound to threads of drainvalve (15) and install drainvalve (15) on radiator lower tube assembly (11).
FOLLOW-ON TASK: Fill cooling system [para. 3-61].
3-72. LOWER RADIATOR HOSE REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Equipment Condition
Cooling system drained [para. 3-61].

Maintenance Level
Unit

Manual References
TM 9-2320-387-24P

a. Removal

1. Loosen two clamps (2) and remove lower radiator hose (3) from radiator (1) and lower tube assembly (4).
2. Remove two clamps (2) from hose (3).

b. Installation

1. Install two clamps (2) on lower radiator hose (3).
2. Install hose (3) on lower tube assembly (4) and radiator (1) and tighten two clamps (2) to 85-95 lb-in. (10-11 N-m).

FOLLOW-ON TASK: Fill cooling system [para. 3-61].
3-73. WATER PUMP INLET HOSE REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit: automotive (Appendix B, Item 1)

Equipment Condition
Cooling system drained (para. 3-61)

Maintenance Level
Unit

Manual References
TM 9-2320-387-24P

a. Removal

1. Loosen two clamps (2) and remove water pump inlet hose (3) from water pump (1) and lower tube assembly (4).
2. Remove two clamps (2) from hose (3).

b. Installation

1. Install two clamps (2) on water pump inlet hose (3).
2. Install hose (3) on lower tube assembly (4) and water pump (1) and tighten two clamps (2) to 90-125 lb-in. (10-14 N-m).

FOLLOW-ON TASK: Fill cooling system (para. 3-61).
3-74. SURGE TANK-TO-LOWER RADIATOR TUBE HOSE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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<td>Unit</td>
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</table>

**a. Removal**

1. Loosen two clamps (2) and remove hose (3) from surge tank (1) and tube assembly (4).
2. Remove two clamps (2) from hose (3).

**b. Installation**

1. Install two clamps (2) on hose (3).
2. Install hose (3) on surge tank (1) and tube assembly (4) and tighten two clamps (2).

FOLLOW-ON TASK: Fill cooling system [para. 3-61].
3-75. SURGE TANK OVERFLOW HOSE REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
- Unit

a. Removal

1. Remove overflow hose (2) from surge tank filler neck (1).
2. Loosen clamp (3) and remove hose (2) from body (4).

b. Installation

1. Connect overflow hose (2) to surge tank filler neck (1).
2. Install hose (2) on body (4) and tighten clamp (3).

FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-76. THERMOSTAT REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

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<th>Manual References</th>
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<td>Sealing compound (Appendix C, Item 61)</td>
<td>Maintenance Level</td>
</tr>
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</table>

**a. Removal**

1. Remove capscrew (5), stud (4), thermostat housing (3), thermostat (2), and gasket (6) from water crossover (1). Discard gasket (6).
2. Clean gasket surface on water crossover (1) and thermostat housing (3).

**b. Installation**

1. Install thermostat (2) into water crossover (1), ensuring valve sensor (7) points toward crossover (1).
2. Position gasket (6) on thermostat housing (3). Apply sealing compound to fastener threads and insert capscrew (5) and stud (4) to align gasket (6).
3. Install thermostat housing (3) over thermostat (2) and on water crossover (1) with capscrew (5) and stud (4). Tighten capscrew (5) and stud (4) to 25 lb-ft (34 N•m).

**FOLLOW-ON TASK:** Fill cooling system [para. 3-61].
3-76.1. THERMOSTAT REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts

Gasket (Appendix G, Item 41)
Sealing compound (Appendix C, Item 61)
Lockwasher (Appendix G, Item 185)

Manual References

TM 9-2320-387-24P

Equipment Condition

Cooling system drained, as required (para. 3-61).

Maintenance Level

Unit

**a. Removal**

1. Remove capscrew (2), washer (3), wiring harness (4), and clamp (1) from bracket (5).
2. Remove nut (7), lockwasher (6), and bracket (5) from stud (8). Discard lockwasher (6).
3. Remove stud (8), capscrew (9), thermostat housing (10), gasket (11), and thermostat (12) from water crossover (14). Discard gasket (11).
4. Clean gasket surface on water crossover (14) and thermostat housing (10).

**b. Installation**

1. Install thermostat (12) into water crossover (14), ensuring valve sensor (13) points toward water crossover (14).
2. Position gasket (11) on thermostat housing (10). Apply sealing compound to fastener threads and insert capscrew (9) and stud (8) to align gasket (11).
3. Install thermostat housing (10) over thermostat (12) and on water crossover (14) with capscrew (9) and stud (8). Tighten capscrew (9) and stud (8) to 25 lb-ft (34 N•m).
4. Install bracket (5) on stud (8) with lockwasher (6) and nut (7).
5. Install clamp (1) and wiring harness (4) on bracket (5) with washer (3) and capscrew (2).
FOLLOW-ON TASK: Fill cooling system [para. 3-61].
3-77. WATER PUMP PULLEY REPLACEMENT

This task covers:
  a. Removal  
  b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
  automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
  automotive (Appendix B, Item 2)

Special Tools
  Hex-head driver, 6 mm
  (Appendix B, Item 146)

Materials/Parts
  Sealing compound (Appendix C, Item 63)

Manual References
  TM 9-2320-387-24P

Equipment Condition
  • Fan drive and fan blade removed (para. 3-80).
  • Serpentine drivebelt removed (para. 3-81).

Maintenance Level
  Unit

NOTE

200-AMP dual voltage regulator shown.

a. Removal

Using hex-head driver, remove four socket-head screws (1) and water pump pulley (2) from water pump (3).

b. Installation

1. Install water pump pulley (2) on water pump (3).
2. Apply sealing compound to four socket-head screws (1), and install screws (1) on water pump pulley (2) and water pump (3). Tighten screws (1) to 15-20 lb-ft (20-27 N\cdot m).

FOLLOW-ON TASKS:
  • Install fan drive and fan blade (para. 3-80).
  • Install serpentine drivebelt (para. 3-81).
3-78. WATER PUMP AND ADAPTER PLATE MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts

- Gasket (Appendix G, Item 49)
- Pipe sealing compound (Appendix C, Item 62)
- Sealing compound (Appendix C, Item 63)
- Anaerobic gasket sealer (Appendix C, Item 58)

Manual References

TM 9-2320-387-24P

Equipment Condition

- Engine oil filler tube removed [para. 3-3].
- Water pump inlet hose removed [para. 3-73].
- Water pump pulley removed [para. 3-77].
- Thermostat bypass hose removed [para. 3-68 or para. 3-68.1].
- Tensioner, idler pulleys, and mounting hardware removed [para. 3-82].
- Power steering pump removed [para. 8-23 or para. 8-23.1].

Maintenance Level

Unit

a. Removal

1. Remove bypass nipple (4) from water crossover (3).
2. Remove studs (1), (13), (8), and (7), four capscrews (11), washers (12), two capscrews (9), capscrew (10), water pump (6), and adapter plate (5) from timing gear cover (2).
3. Remove seven capscrews (15), adapter plate (5), and gasket (14) from water pump (6). Discard gasket (14).
4. Clean remaining gasket material and sealing compound from sealing surfaces on adapter plate (5), water pump (6), and timing gear cover (2).
5. Remove heater hose nipple (17), elbow (16), and bypass hose adapter (19) from water pump (6).

b. Inspection

1. Inspect water pump (6) for cracks, breaks, or loose impeller. Replace if cracked, broken, or impeller is loose.
2. Inspect adapter plate (5) for corrosion. If adapter plate (5) is excessively corroded, replace.
3. Inspect elbow (16), heater hose nipple (17), and bypass hose adapter (19) for stripped threads and breaks. If damaged, replace.
4. Inspect rivet (18) for damage or looseness. Replace if damaged or loose. Apply sealing compound to replacement rivet (18) prior to installation.
3-78. WATER PUMP AND ADAPTER PLATE MAINTENANCE (Cont'd)

c. Installation

**CAUTION**

Ensure water pump P/N 23500085 is used on 6.5L engines or damage to equipment will result.

1. Install gasket (6) and adapter plate (7) on water pump (5) with seven capscrews (8). Tighten capscrews (8) to 13-20 lb-ft (18-27 N·m).

**NOTE**

Perform step 2 if a new water pump is being installed.

2. Apply sealing compound to rivet (3) and install in water pump (5).
3. Apply anaerobic gasket sealer to sealing surfaces on adapter plate (7) following diagram shown.
4. Apply pipe sealing compound to capscrew (16).
5. Install adapter plate (7) and water pump (5) on timing gear cover (10) with two long studs (19), stud (14), stud with thick hex (13), and capscrew (16).
6. Install two capscrews (15), studs (9), four washers (18), and capscrews (17). Tighten studs (9) and capscrews (15) and (17) to 13-20 lb-ft (18-27 N·m). Tighten studs (19), (14), and (13) to 25-37 lb-ft (34-50 N·m).
7. Apply pipe sealing compound to threads of elbow (1), heater hose nipple (2), and bypass hose adapter (4) and install in water pump (5).
8. Coat threads of bypass nipple (12) with pipe sealing compound and install in water crossover (11).
FOLLOW-ON TASKS:

- Install power steering pump (para. 8-23 or para. 8-23.1).
- Install tensioner, idler pulleys, and mounting hardware (para. 3-82).
- Install water pump pulley (para. 3-77).
- Install water pump inlet hose (para. 3-73).
- Install engine oil filler tube (para. 3-3).
- Install thermostat bypass hose (para. 3-68 or para. 3-68.1).
This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Two gaskets (Appendix G, Item 44)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Cooling system drained (para. 3-61).
- Fan temperature switch removed (para. 4-34).
- Glow plug controller/temperature sensor removed (para. 4-33).
- Thermostat removed (para. 3-76).

Maintenance Level
- Unit

a. Removal

1. Loosen three clamps (2) and disconnect hoses (1) from water crossover (4).
2. Remove four capscrews (6), water crossover (4), and two gaskets (7) from cylinder head (8). Discard gaskets (7).
3. Clean gasket surface on water crossover (4) and cylinder head (8).

b. Inspection

Inspect thermostat bypass nipple (3), surge tank hose nipple (5), and water pump hose adapter (9) for cracks or breaks. Replace if defective.

c. Installation

1. Install two gaskets (7) and water crossover (4) on cylinder head (8) with four capscrews (6). Tighten capscrews (6) to 25-35 lb-ft (34-48 N•m).
2. Connect three hoses (1) to water crossover (4) and tighten clamps (2).
FOLLOW-ON TASKS:

- Install thermostat [para. 3-76].
- Install glow plug controller/temperature sensor [para. 4-33].
- Install fan temperature switch [para. 4-34].
- Fill cooling system [para. 3-61].
This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts

- Two gaskets (Appendix G, Item 44)
- Lockwasher (Appendix G, Item 185)

Manual References

- TM 9-2320-387-24P

Equipment Condition

- Glow plug controller/temperature sensor removed (para. 4-33)
- Thermostat removed (para. 3-76.1)

Maintenance Level

Unit

---

**a. Removal**

1. Loosen hose clamps (2) and (19) and disconnect hoses (1) and (18) from water crossover (24).
2. Loosen hose clamp (15) and disconnect hose (16) from water crossover (24).
3. Remove cooling hose (23) from elbow (4).
4. Remove nut (5), lockwasher (6), washer (7), ground wire (8), and ground strap (9) from stud (10).
   Discard lockwasher (6).
5. Remove stud (10), washer (11), three capscrews (21), and water crossover (24) from cylinder heads (14) and (17).
6. Remove gaskets (13) and (20) from cylinder heads (14) and (17). Discard gaskets (13) and (20).
7. Remove elbow (4) from water crossover (24).

**b. Inspection**

1. Clean gasket surface on water crossover (24) and cylinder heads (14) and (17).
2. Inspect thermostat bypass nipple (22), surge tank hose nipple (3), and water pump hose adapter (12) for cracks or breaks. Replace if defective.

**c. Installation**

1. Install elbow (4) on water crossover (24).
2. Install gaskets (13) and (20) on cylinder heads (14) and (17).
3. Install water crossover (24) on cylinder heads (14) and (17) with stud (10), washer (11), and three capscrews (21). Tighten capscrews (21) and stud (10) to 25-35 lb-ft (34-48 N·m).
4. Install ground wire (8) and ground strap (9) on stud (10) with washer (7), lockwasher (6), and nut (5).
5. Install cooling hose (23) on elbow (4).
6. Connect hose (16) on water crossover (24) and install hose clamp (15).
7. Connect hoses (1) and (18) on water crossover (24) and tighten hose clamps (2) and (19).
3-79.1. WATER CROSSOVER MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASKS:

- Install thermostat (para. 3-76.1).
- Install glow plug controller/temperature sensor (para. 4-33).
3-80. FAN DRIVE AND FAN BLADE MAINTENANCE (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

Special Tools

- Hex-head driver, 8 mm (Appendix B, Item 145)

Materials/Parts

- Four lockwashers (Appendix G, Item 144)
- Sealing compound (Appendix C, item 62)

Manual References

- TM 9-2320-387-24P

Equipment Condition

- Radiator and shroud removed (optional) [para. 3-62]

Maintenance Level

- Unit

NOTE

- Mark position of fan blade for installation.
- It may be necessary to apply compressed air to clutch adapter to disengage fan drive clutch, allowing access to socket-head screws.

1. Disconnect control valve hose (2) from bulkhead adapter (3).
2. Disconnect female end of quick-disconnect (4) from male end of quick-disconnect (1).
3. Using hex-head driver, remove four socket head screws (8) and fan drive assembly (6) from water pump pulley (5).
4. Remove four nuts (9), lockwashers (10), and fan blade (11) from fan drive (12). Discard lockwashers (10).

b. Inspection

Inspect clutch adapter (7) and fan blade (11) for damaged threads, cracks, bent blades, or breaks. Replace if defective.

c. Installation

1. Align fan blade (11) on fan drive (12) and install with four lockwashers (10) and nuts (9). Tighten nuts (9) to 26 lb-ft (35 N•m).
2. Apply sealing compound to four socket-head screws (8) and install fan drive assembly (6) on water pump pulley (3) with socket-head screws (8). Tighten socket-head screws (8) to 45 lb-ft (61 N•m).
3. Connect female end of quick-disconnect (4) to male end of quick-disconnect (1).
4. Connect control valve hose (2) to bulkhead adapter (3).
FOLLOW-ON TASK: Install radiator and shroud (if removed) (para. 3-62).
3-80.1. FAN BLADE AND FAN CLUTCH MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:
   a. Removal
   b. Inspection
   c. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
      automotive (Appendix B, Item 2)

Materials/Parts
   Four lockwashers (Appendix G, Item 144)
   Sealing compound (Appendix C, Item 71)
   Six lockwashers (Appendix G, Item 145)

Manual References
   TM 9-2320-387-24P

Equipment Condition
   Radiator and fan shroud assembly removed (para. 3-62.1).

Maintenance Level
   Unit

---

a. Removal

1. Remove four capscrews (2), lockwashers (3), washers (4), and fan blade (5) from geared fan drive hub (6). Discard lockwashers (3).
2. Remove six capscrews (7), lockwashers (8), washers (9), and fan blade (5) from fan clutch (1). Discard lockwashers (8).

b. Inspection

Inspect fan blade (5), geared fan drive hub (6), and fan clutch (1) for damaged threads, cracks, bent blades or breaks. Replace if damaged.

c. Installation

CAUTION

Balance holes must face down towards geared fan drive hub.

1. Apply sealing compound to capscrews (2) and (7).
2. Install fan clutch (1) on fan blade (5) with six washers (9), lockwashers (8), and capscrews (7). Tighten capscrew (7) to 13-16 lb-ft (18-22 N•m).
3. Install fan blade (5) on geared fan drive hub (6) with four washers (4), lockwashers (3), and capscrews (2). Tighten capscrew (2) to 37 lb-ft (50 N•m).
3-80.1. FAN BLADE AND FAN CLUTCH MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASK: Install radiator and fan shroud assembly [para. 3-62.1].
3-80.2. GEARED FAN DRIVE AND UPPER FRONT REAR CROSSMEMBER REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:  
automotive (Appendix B, Item 1)  
Maintenance and repair shop equipment:  
automotive (Appendix B, Item 2)

Materials/Parts
Five lockwashers (Appendix G, Item 144)  
Four locknuts (Appendix G, Item 106)

Manual References
TM 9-2320-387-24P

Equipment Condition
- Fan blade and fan clutch removed (para. 3-80.1)
- Geared fan driveshaft removed (para. 3-80.3)
- Front differential vent line removed (para. 6-14.1)

Maintenance Level
Unit

---

a. Removal

1. Remove vent line (1) from nipple (2).
2. Remove nipple (2) from angle adapter (3).
3. Remove four locknuts (8), washers (7), capscrews (4), washers (5), front rear crossmember (6), and geared fan drive (16) from two crossmember brackets (15). Discard locknuts (8).
4. Remove three capscrews (14), washers (13), and lockwashers (12) from front rear crossmember (6) and geared fan drive (16). Discard lockwashers (12).
5. Remove two capscrews (9), lockwashers (10), washers (11), and geared fan drive (16) from front rear crossmember (6). Discard lockwashers (10).
6. Remove oil feed tube (18) and two adapters (17) from geared fan drive (16).

b. Installation

1. Install two adapters (17) and oil feed tube (18) on geared fan drive (16).
2. Install geared fan drive (16) on front rear crossmember (6) with three washers (12), lockwashers (13), and capscrews (14). Do not tighten capscrews (14).
3. Secure geared fan drive (16) to front rear crossmember (6) with two washers (11), lockwashers (10), and capscrews (9). Tighten capscrews (9) to 37 lb-ft (50 N•m).
4. Tighten capscrews (14) to 37 lb-ft (50 N•m).
5. Install geared fan drive (16) and front rear crossmember (6) on two crossmember brackets (15) with four washers (5), capscrews (4), washers (7), and locknuts (8).
6. Install nipple (2) on angle adapter (3).
7. Install vent line (1) on nipple (2).
3-80.2. GEARED FAN DRIVE AND UPPER FRONT REAR CROSSMEMBER REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASKS:
- Install front differential vent line [para. 6-14.1].
- Install geared fan driveshaft [para. 3-80.3].
- Install fan blade and fan clutch [para. 3-80.1].
3-80.3. GEARED FAN DRIVESHAFT MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Sealing compound (Appendix C, Item 71)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

NOTE
Rotate crankshaft pulley accordingly to access capscrews.

a. Removal

1. Remove six capscrews (1) and geared fan driveshaft (8) from geared fan drive (6).
2. Remove four capscrews (7) and geared fan driveshaft (8) from coupler plate (3).

NOTE
• Rotate crankshaft pulley accordingly to access capscrews.
• Hold alternator clutch pulley adapter to keep crankshaft from rotating.

3. Remove four capscrews (4) and coupler plate (3) from lower crankshaft pulley assembly (5).
4. Remove four grease fittings (2) from geared fan driveshaft (8).

b. Inspection

Inspect grease fittings (2). Replace if damaged.

c. Installation

1. Install four grease fittings (2) on geared fan driveshaft (8).

NOTE
• Rotate crankshaft pulley accordingly to access capscrews.
• Hold alternator clutch pulley adapter to keep crankshaft from rotating.

2. Install coupler plate (3) on lower crankshaft puller assembly (5) with four capscrews (4).
3. Install geared fan driveshaft (8) on coupler plate (3) with four capscrews (7).
4. Apply sealing compound to six capscrews (1). Install geared fan driveshaft (8) on geared fan drive (6) with six capscrews (1).
3-80.3. GEARED FAN DRIVESHAFT MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASK: Lower and secure hood. (TM 9-2320-387-10).
3-81. SERPENTINE DRIVEBELT MAINTENANCE  
(SERIAL NUMBERS 196900 AND BELOW)

This task covers:
   a. Removal
   b. Installation
   c. Alignment

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
<th>Equipment Condition</th>
<th>Maintenance Level</th>
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<td>Hood raised and secured (TM 9-2320-387-10).</td>
<td>Unit</td>
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<td>Pulley alignment tool</td>
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<td>(Appendix D, Fig. D-107)</td>
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<td>Personnel Required</td>
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</tr>
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<td>One mechanic</td>
<td></td>
<td></td>
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<tr>
<td>One assistant</td>
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</tr>
</tbody>
</table>

NOTE
200-AMP dual voltage regulator shown.

a. Removal

1. Position 3/8-in. breaker bar or, as appropriate, a 1/2-in. ratchet wrench on belt tensioner (7) and move tensioner (7) clockwise to loosen drivebelt (9).

ON M1114 vehicles equipped with A/C, the compressor pulley is used in place of the lower idler pulley.

2. Remove drivebelt (9) from power steering pump pulley (3), alternator pulley (2), water pump pulley (4), crankshaft pulley (5), air conditioning compressor or idler pulley (8), two upper idler pulleys (1), and tensioner pulley (6). Release belt tensioner (7).

CAUTION
Serpentine drivebelt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation or foreign objects introduced into belt path.

NOTE
Check pulley and pulley grooves for damage and debris prior to installing serpentine drivebelt.

b. Installation

1. Position 3/8-in. breaker bar, or as appropriate, a 1/2-in. ratchet wrench on belt tensioner (7) and move tensioner (7) clockwise to allow installation of drivebelt (9).

2. Feed drivebelt (9) into grooves on crankshaft pulley (5), air conditioning compressor or idler pulley (8), two upper idler pulleys (1), alternator pulley (2), power steering pump pulley (3), water pump pulley (4), and tensioner pulley (6). Release belt tensioner (7).
3-81. SERPENTINE DRIVEBELT MAINTENANCE (SERIAL NUMBERS 196900 AND BELOW) (Cont’d)
c. Alignment

**CAUTION**

Serpentine belt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation or foreign objects introduced into belt path. Damage to equipment may result.

**NOTE**

Ensure tab of pulley alignment tool seats flush against back side of crankshaft pulley.

1. Position tab (1) of pulley alignment tool (5) behind crankshaft pulley (6) and straight edge portion (4) of pulley alignment tool (5) across power steering pump pulley (2) and alternator pulley (3). Tab (1) on pulley alignment tool (5) should seat flush against back side of crankshaft pulley (6). Straight edge portion (4) of pulley alignment tool (5) should seat flush against power steering pump pulley (2) and alternator pulley (3). If pulley alignment is not flush, rotate engine and recheck alignment in several locations. Proceed to step 3 if pulleys are out of alignment.

2. Position straight edge portion (4) of pulley alignment tool (5) against idler pulleys (7) and check for bent mounting bracket (8). If mounting bracket (8) is bent, refer to para. 3-82 for replacement.

**NOTE**

If any adjustments are made while performing steps 3 through 8, start engine and check for proper tracking of belt.

3. Check all pulleys (2), (3), (6), (7), and (12) for mud or foreign objects lodged in grooves.

**NOTE**

Power steering pump pulley must be flush with end of power steering pump shaft.

4. Check power steering pump pulley (2) for proper installation. Refer to para. 8-23.

5. Check power steering pump (11) and power steering/alternator mounting bracket (10) for proper installation and security of mounting hardware. Refer to paras. 4-3 and 8-23.

6. Check alternator pulley (3) for proper installation. Refer to para. 4-2.

7. Check alternator (9) for proper installation and security of mounting hardware. Refer to para. 4-5.

8. Check idler pulleys (7) and mounting bracket (8) for proper installation and security of mounting hardware. Refer to para. 3-82.

9. Repeat steps 1 and 2 to verify alignment.
FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
3-81.1. SERPENTINE DRIVEBELT MAINTENANCE (SERIAL NUMBERS 196901 THROUGH 299999)

This task covers:

a. Removal  
b. Installation  
c. Alignment

INITIAL SETUP:

Tools

General mechanic's tool kit:  
automotive (Appendix B, Item 1)  
Maintenance and repair shop equipment:  
automotive (Appendix B, Item 2)  
Pulley alignment tool  
(Appendix D, Fig. D-107)

Manual References

TM 9-2320-387-10

Equipment Condition

Hood raised and secured (TM 9-2320-387-10).

Maintenance Level

Unit

Personnel Required

One mechanic
One assistant

NOTE

200-AMP dual voltage regulator shown.

a. Removal

1. Position 3/8-in. breaker bar or, as appropriate, 1/2-in. ratchet wrench on belt tensioner (10) and move belt tensioner (10) clockwise to loosen drivebelt (2).

NOTE

On M1114 vehicles equipped with A/C, the compressor pulley is used in place of the lower idler pulley.

2. Remove drivebelt (2) from power steering pump pulley (6), idler pulley (5), alternator pulley (4), water pump pulley (8), crankshaft pulley (7), air conditioning compressor or idler pulley (1), two upper idler pulleys (3), and belt tensioner pulley (9). Release belt tensioner (10).

CAUTION

Serpentine drivebelt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path.

NOTE

Check pulley and pulley grooves for damage and debris prior to installing serpentine belt.

b. Installation

1. Position 3/8-in. breaker bar or, as appropriate, 1/2-in. ratchet wrench on belt tensioner (10) and move belt tensioner (10) clockwise to allow installation of drivebelt (2).

2. Feed drivebelt (2) into grooves on crankshaft pulley (7), air conditioning compressor or idler pulley (1), two upper idler pulleys (3), alternator pulley (4), idler pulley (5), power steering pump pulley (6), water pump pulley (8), and tensioner pulley (9). Release belt tensioner (10).
3-81.1. SERPENTINE DRIVEBELT MAINTENANCE (SERIAL NUMBERS 196901 THROUGH 299999) (Cont’d)

A/C COMPRESSOR OR IDLER PULLEY
GROOVED IDLER PULLEY #3
IDLER PULLEY #2
IDLER PULLEY #1
WATER PUMP
TENSIONER
CRANKSHAFT
POWER STEERING
ALTERNATOR

TENSIONER
(SHOWN AT NORMAL POSITION)
3-81.1. SERPENTINE DRIVEBELT MAINTENANCE (SERIAL NUMBERS 196901 THROUGH 299999) (Cont’d)

CAUTION

Serpentine drivebelt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path. Damage to equipment may result.

NOTE

Ensure tab of pulley alignment tool seats flush against back side of crankshaft pulley.

1. Position tab (1) on pulley alignment tool (4) behind crankshaft pulley (5) and place straightedge portion of pulley alignment tool (4) across power steering pump pulley (2) and alternator pulley (3). Tab (1) on pulley alignment tool (4) should seat flush against back side of crankshaft pulley (5). Straightedge portion of pulley alignment tool (4) should seat flush against power steering pump pulley (2) and alternator pulley (3). If pulley alignment is not flush, rotate engine and recheck alignment in several locations. Proceed to step 3 if pulleys are out of alignment.

2. Position straightedge portion of pulley alignment tool (4) against idler pulleys (7) and (8) and check for bent mounting bracket (9). If mounting bracket (9) is bent, refer to para. 3-82.6 for replacement.

NOTE

If any adjustments are made while performing steps 3 through 8, start engine and check for proper tracking of belt.

3. Check all pulleys (2), (3), (6), (7), (8) and (5) for mud or foreign objects lodged in grooves.

NOTE

Power steering pump pulley must be flush with end of power steering pump shaft.

4. Check power steering pump pulley (2) for proper installation. Refer to para. 8-23.1.

5. Check power steering/alternator mounting bracket (11) for proper installation and security of mounting hardware. Refer to para. 4-3.1 and 8-23.1.

6. Check alternator pulley (3) for proper installation. Refer to para. 4-2.1.

7. Check alternator (10) for proper installation and security of mounting hardware. Refer to para. 4-5.

8. Check idler pulleys (8) and (12) and mounting bracket (9) for proper installation and security of mounting hardware. Refer to para. 3-82.7 and 3-82.6.

9. Repeat steps 1 and 2 to verify alignment.
FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10)
3-81.2. SERPENTINE DRIVEBELT MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal
b. Installation
c. Alignment

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)
- Pulley alignment tool (Appendix D, Fig. D-107)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Geared fan driveshaft removed

Maintenance Level
- Unit

Personnel Required
- One mechanic
- One assistant

NOTE
200-AMP dual voltage regulator shown.

a. Removal

1. Position 3/8-in. breaker bar or, as appropriate, 1/2-in. ratchet wrench on belt tensioner (10) and move belt tensioner (10) clockwise to loosen drivebelt (2).

2. Remove drivebelt (2) from power steering pump pulley (6), idler pulley (5), alternator pulley (4), water pump pulley (8), crankshaft pulley (7), air conditioning compressor or idler pulley (1), two upper idler pulleys (3), and belt tensioner pulley (9). Release belt tensioner (10).

CAUTION
Serpentine drivebelt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path.

NOTE
Check pulley and pulley grooves for damage and debris prior to installing serpentine belt.

b. Installation

1. Position 3/8-in. breaker bar or, as appropriate, 1/2-in. ratchet wrench on belt tensioner (10) and move belt tensioner (10) clockwise to allow installation of drivebelt (2).

2. Feed drivebelt (2) into grooves on crankshaft pulley (7), air conditioning compressor or idler pulley (1), two upper idler pulleys (3), alternator pulley (4), idler pulley (5), power steering pump pulley (6), water pump pulley (8), and tensioner pulley (9). Release belt tensioner (10).
3-81.2. SERPENTINE DRIVBELT MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
3-81.2. SERPENTINE DRIVEBELT MAINTENANCE  
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

**c. Alignment**

**CAUTION**

Serpentine drivebelt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path. Damage to equipment may result.

**NOTE**

Ensure tab of pulley alignment tool seats flush against back side of crankshaft pulley.

1. Position tab (1) on pulley alignment tool (4) behind crankshaft pulley (5) and place straightedge portion of pulley alignment tool (4) across power steering pump pulley (2) and alternator pulley (3). Tab (1) on pulley alignment tool (4) should seat flush against back side of crankshaft pulley (5). Straightedge portion of pulley alignment tool (4) should seat flush against power steering pump pulley (2) and alternator pulley (3). If pulley alignment is not flush, rotate engine and recheck alignment in several locations. Proceed to step 3 if pulleys are out of alignment.

2. Position straightedge portion of pulley alignment tool (4) against idler pulleys (7) and (8) and check for bent mounting bracket (9). If mounting bracket (9) is bent, refer to para. 3-82 for replacement.

**NOTE**

If any adjustments are made while performing steps 3 through 8, start engine and check for proper tracking of belt.

3. Check all pulleys (2), (3), (6), (7), (8) and (5) for mud or foreign objects lodged in grooves.

**NOTE**

Power steering pump pulley must be flush with end of power steering pump shaft.

4. Check power steering pump pulley (2) for proper installation. Refer to para. 8-23

5. Check power steering/alternator mounting bracket (11) for proper installation and security of mounting hardware. Refer to para. 4-3 and para. 8-23

6. Check alternator pulley (3) for proper installation. Refer to para. 4-2

7. Check alternator (10) for proper installation and security of mounting hardware. Refer to para. 4-5

8. Check idler pulleys (8) and (12) and mounting bracket (9) for proper installation and security of mounting hardware. Refer to para. 3-82

9. Repeat steps 1 and 2 to verify alignment.
3-81.2. SERPENTINE DRIVEBELT MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASK: Install geared fan driveshaft (para. 3-80.3).
3-82. TENSIONER, IDLER PULLEY’S, AND MOUNTING HARDWARE REPLACEMENT
(SERIAL NUMBERS 196900 AND BELOW)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
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<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>Fan drive and fan blade removed (para. 3-80), Serpentine drivebelt removed (para. 3-81).</td>
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</table>

<table>
<thead>
<tr>
<th>Materials/Parts</th>
<th>Maintenance Level</th>
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</thead>
<tbody>
<tr>
<td>Two lockwashers (Appendix G, Item 185)</td>
<td>Unit</td>
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<tr>
<td>Three lockwashers (Appendix G, Item 183)</td>
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</tbody>
</table>

Manual References

TM 9-2320-387-24P

a. Removal

1. Remove capscrew (12) and tensioner (11) from mounting bracket (8).
2. Remove two nuts (6), lockwashers (5), washers (4), capscrews (1), washers (2), supports (3.1), idler pulleys (3), and dust covers (2.1) from mounting bracket (8). Discard lockwashers (5).

**NOTE**

- On M1114 vehicles equipped with A/C, the compressor pulley is in place of the lower idler pulley.
- Perform step 3 for M1113 models only.

3. Remove nut (20), lockwasher (19), washer (18), support (17), screw (13), washer (14), dust cover (15), and air conditioner compressor pulley or lower idler pulley (16) from mounting bracket (8). Discard lockwasher (19).
4. Remove two capscrews (10) and lockwashers (9) from water pump (7). Discard lockwashers (9).
5. Remove screw (7.1), collar washer (6.1), and mounting bracket (8) from engine (6.2).

b. Installation

1. Install mounting bracket (8) on engine (6.2) with collar washer (6.1) and screw (7.1).
2. Install lockwashers (9) and two capscrews (10) on water pump (7).

**NOTE**

Pulleys will turn if they are installed correctly. If pulleys do not turn, they may be installed incorrectly. Ensure dust covers are seated properly on pulleys.

3. Install two idler pulleys (3) and dust covers (2.1) on mounting bracket (8) with two supports (3.1), washers (2), capscrews (1), washers (4), lockwashers (5), and nuts (6).

**NOTE**

- On M1114 vehicles equipped with A/C, the compressor pulley is in place of the lower idler pulley.
- Perform step 4 for M1113 models only.

4. Install idler pulley (16) and support (17) on mounting bracket (8) with dustcover (15), washer (14), screw (13), washer (18), lockwasher (19), and nut (20).
5. Install tensioner (11) on mounting bracket (8) with capscrew (12).
FOLLOW-ON TASKS:
- Install serpentine drivebelt [para. 3-81].
- Install fan drive and fan blade [para. 3-80].
3-82.1. TENSIONER AND MOUNTING HARDWARE REPLACEMENT (SERIAL NUMBERS 196901 AND ABOVE)

This task covers:

<table>
<thead>
<tr>
<th>a. Removal</th>
<th>b. Installation</th>
</tr>
</thead>
</table>

**INITIAL SETUP:**

**Tools**
- General mechanic’s tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Lockwasher (Appendix G, Item 144)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Fan drive and fan blade removed [para. 3-80].
- Serpentine drivebelt removed [para. 3-81.1].

**Maintenance Level**
- Unit

**a. Removal**

1. Remove capscrew (1), lockwasher (2), washer (3), and tensioner (5) from mounting bracket (4). Discard lockwasher (2).

**b. Installation**

1. Install tensioner (5) on mounting bracket (4) with washer (3), lockwasher (2), and capscrew (1).

**FOLLOW-ON TASKS:**
- Install serpentine drivebelt [para. 3-81.1].
- Install fan drive and fan blade [para. 3-80].
This task covers:

- a. Removal
- b. Installation

**INITIAL SETUP:**

**Tools**
- General mechanic’s tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Lockwasher (Appendix G, Item 174)
- Three lockwashers (Appendix G, Item 144)

**Manual References**
- TM 9-2320-387-24P

**a. Removal**

1. Remove screw (1), pulley support (5), idler pulley (4), retainer (3), and lockwasher (2) from support (6). Discard lockwasher (2).
2. Remove three screws (10), washers (8), lockwashers (9), and support (6) from mounting bracket (7). Discard lockwashers (9).

**b. Installation**

1. Install support (6) on mounting bracket (7) with three lockwashers (9), washers (8), and screws (10).
2. Install pulley support (5) and idler pulley (4) on support (6) with lockwasher (2), retainer (3), and screw (1).

**FOLLOW-ON TASK:** Install serpentine drivebelt (para. 3-81.1).
3-82.3. GROOVED IDLER PULLEY AND SUPPORT REPLACEMENT (SERIAL NUMBERS 196901 AND ABOVE)

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
- Lockwasher (Appendix G, Item 174)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Serpentine drivebelt removed (para. 3-81.1)

Maintenance Level
- Unit

a. Removal

Remove screw (1), pulley support (6), grooved idler pulley (5), cover (4), two washers (3), and lockwasher (2) from mounting bracket (7). Discard lockwasher (2).

b. Installation

Install pulley support (6) and grooved idler pulley (5) on mounting bracket (7) with lockwasher (2), washers (3), cover (4), and screw (1).

FOLLOW-ON TASK: Install serpentine drivebelt (para. 3-81.1).
3-82.4. MOUNTING BRACKET REPLACEMENT, VEHICLES W/O A/C (SERIAL NUMBERS 196901 AND ABOVE)

This task covers:
   a. Removal    b. Installation

INITIAL SETUP:

   Tools
   - General mechanic’s tool kit:
     automotive (Appendix B, Item 1)
   - Maintenance and repair shop equipment:
     automotive (Appendix B, Item 2)

   Materials/Parts
   - Two lockwashers (Appendix G, Item 185)
   - Adhesive sealant (Appendix C, Item 3.1)

   Manual References
   - TM 9-2320-387-24P

   Equipment Condition
   - Idler pulley and support removed [para. 3-82.2]
   - Tensioner removed [para. 3-82.1]
   - Grooved idler pulley removed [para. 3-82.3]

   Maintenance Level
   - Unit

a. Removal
1. Remove two nuts (6) and lockwashers (5) from studs (4) on water pump (3). Discard lockwashers (5).
2. Remove two screws (1) and mounting bracket (7) from engine (2).

b. Installation
1. Apply sealant to threads of two screws (1), and install mounting bracket (7) on engine (2) with screws (1). Do not tighten screws (1).
2. Secure mounting bracket (7) to studs (4) on water pump (3) with two lockwashers (5) and nuts (6). Tighten screws (1) to 43-51 lb-ft (58-69 N·m) and nuts (6) to 33-41 lb-ft (45-56 N·m).

FOLLOW-ON TASKS:
- Install grooved idler pulley [para. 3-82.3].
- Install tensioner [para. 3-82.1].
- Install idler pulley and support [para. 3-82.2].
3-82.5. MOUNTING BRACKET REPLACEMENT, VEHICLES W/ A/C (SERIAL NUMBERS 196901 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Two lockwashers (Appendix G, Item 185)
- Adhesive sealant (Appendix C, Item 3.1)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- A/C compressor removed (para. 25-20.2)
- Tensioner removed (para. 3-82.1)
- Grooved idler pulley removed (para. 3-82.3)

Maintenance Level
- Unit

a. Removal

1. Remove two nuts (6) and lockwashers (5) from studs (4) on water pump (3). Discard lockwashers (5).
2. Remove two screws (1) and mounting bracket (7) from engine (2).

b. Installation

1. Apply sealant to threads of two screws (1), and install mounting bracket (7) on engine (2) with screws (1). Do not tighten screws (1).
2. Secure mounting bracket (7) to studs (4) on water pump (3) with two lockwashers (5) and nuts (6). Tighten screws (1) to 43-51 lb-ft (58-69 N•m) and nuts (6) to 33-41 lb-ft (45-56 N•m).

FOLLOW-ON TASKS:
- Install grooved idler pulley (para. 3-82.3)
- Install tensioner (para. 3-82.1)
- Install A/C compressor (para. 25-20.2)
### 3-82.6. IDLER PULLEY REPLACEMENT (SERIAL NUMBERS 196901 AND ABOVE)

This task covers:

<table>
<thead>
<tr>
<th>a. Removal</th>
<th>b. Installation</th>
</tr>
</thead>
</table>

#### INITIAL SETUP:

**Tools**

General mechanic’s tool kit: automotive (Appendix B, Item 1)

Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**

Two lockwashers (Appendix G, Item 138)

**Manual References**

TM 9-2320-387-24P

**Equipment Condition**

Serpentine drivebelt removed [para. 3-81.1]

**Maintenance Level**

Unit

---

#### a. Removal

1. Remove screw (15), pulley support (10), idler pulley (11), cover (12), two washers (13), and lockwasher (14) from idler pulley bracket (8) and alternator/pump support (9). Discard lockwasher (14).

2. Remove screw (1), spacer (7), pulley support (6), idler pulley (5), cover (4), two washers (3), and lockwasher (2) from idler pulley bracket (8) and alternator/pump support (9). Discard lockwasher (2).

#### b. Installation

1. Install spacer (7), pulley support (6), and idler pulley (5) on idler pulley bracket (8) and alternator/pump support (9) with cover (4), two washers (3), lockwasher (2), and screw (1). Do not tighten screw (1).

2. Install pulley support (10) and idler pulley (11) on idler pulley bracket (8) and alternator/pump support (9) with cover (12), two washers (13), lockwasher (14), and screw (15). Tighten screws (1) and (15) to 33-41 lb-ft (45-56 N·m)

---

FOLLOW-ON TASK: Install serpentine drivebelt [para. 3-81.1].
3-82.7. IDLER PULLEY BRACKET REPLACEMENT (SERIAL NUMBERS 196901 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**

General mechanic’s tool kit:
- automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
- automotive (Appendix B, Item 2)

**Materials/Parts**

Lockwasher (Appendix G, Item 144)

**Manual References**

TM 9-2320-387-24P

**Equipment Condition**

Idler pulleys removed (para. 3-82.6).

**Maintenance Level**

Unit

---

**a. Removal**

Remove screw (1), washer (3), lockwasher (2), and idler pulley bracket (4) from alternator/pump support (5). Discard lockwasher (2).

**b. Installation**

1. Install idler pulley bracket (4) on alternator/pump support (5) with washer (3), lockwasher (2), and screw (1).

**NOTE**

Tighten idler pulley bracket screw (1) after idler pulleys have been installed and tightened.

2. Tighten screw (1) to 33-41 lb-ft (45-56 N·m).

---

FOLLOW-ON TASK: Install idler pulleys (para. 3-82.6).
3-83. FAN DRIVE FRICITION LINING REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Disconnect battery ground cables (para. 4-68).

WARNING

Prior to loosening screws on fan drive retaining plates, disconnect fan drive hose from fan drive. Failure to do so may result in injury to personnel or damage to equipment.

NOTE

It may be necessary to apply compressed air to clutch adapter to disengage fan drive clutch, allowing access to friction lining screws.

1. Remove six screws (1) and three retaining plates (2) from fan drive (3).
2. Remove two friction linings (4) from fan drive (3).

b. Installation

1. Install two friction linings (4) on fan drive (3).
2. Install three retaining plates (2) on fan drive (3) with six screws (1). Tighten screws (1) to 22 lb-in. (2.5 N-m).

FOLLOW-ON TASK: Connect battery ground cables (para. 4-68).
## INITIAL SETUP:

**Tools**
- General mechanic’s tool kit: 
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: 
  - automotive (Appendix B, Item 2)

**Materials/Parts**
- Sealing compound, pipe (Appendix C, Item 62)
- Four lockwashers (Appendix G, Item 146)
- Four lockwashers (Appendix G, Item 190.1)
- Lockwasher (Appendix G, Item 190.2)
- Two locknuts (Appendix G, Item 82)
- Two locknuts (Appendix G, Item 77)
- Locknut (Appendix G, Item 106)
- Two O-rings (Appendix G, Item 218)
- Two O-rings (Appendix G, Item 221)
- Four tiedown straps (Appendix G, Item 323)
- Tiedown strap (Appendix G, Item 329)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Battery ground cables disconnected (para. 4-68).
- Rear brake protection guards removed (para. 7-11).
- Rear propeller shaft removed (para. 6-4).

**General Safety Instructions**
- Allow differential to cool.
- Hood must be supported during hood prop rod and bracket removal.

**Maintenance Level**
- Unit

### a. Front Hoses and Relief Valve Removal

**WARNING**
Allow differential to cool before performing this task. Severe injury to personnel may result.

**CAUTION**
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**
- Have drainage container ready to catch oil.
- For ease of identification during installation, tag with tape all hose ends that route to the left port on the rear differential oil cooler. Left port is inlet side.

1. Remove locknut (1), washer (2), and bolt (5) from clamps (3) and (4). Discard locknut (1).
2. Remove clamp (3) from bypass hose (6).
3. Loosen three clamps (19) from tee (20).
4. Disconnect bypass hose (6) and return hoses (22) and (21) from tee (20).
5. Disconnect bypass hose (13) from union (15).
6. Disconnect bypass hose (6) from union (26).
7. Remove two bolts (18), washers (17), relief valve (14), and reinforcement (23) from splash shield (7).
8. Remove union (15) and O-ring (16) from top of relief valve (14). Discard O-ring (16).
9. Remove union (26) and O-ring (24) from side of relief valve (14). Discard O-ring (24).
**WARNING**

Hood must be supported during hood prop rod and bracket removal. Failure to support hood may cause injury to personnel or damage to equipment.

10. Remove four screws (12), lockwashers (11), hood prop rod (8), and bracket (10) from left splash shield (7) and air lift bracket (9). Discard lockwashers (11).
11. Remove three screws (14), washers (15), and access cover (18) from left splash shield (3).

**NOTE**
Perform steps 13 through 18 for M1113 and steps 12 through 15 and 18 for M1114.

12. Remove nut (23) and fuel filter drain valve (24) from left splash shield (3).

13. Remove four screws (19), washers (21), and lockwashers (20) from plate (22) and left splash shield (3). Discard lockwashers (20).

14. Remove locknut (1), two washers (2), and screw (16) from support bracket (17) and left splash shield (3). Discard locknut (1).

15. Remove locknut (7), two washers (8), and screw (10) from master cylinder bracket (9) and left splash shield (3). Discard locknut (7).

16. Remove locknut (5), two washers (6), and screw (11) from left splash shield (3) and airlift bracket (4). Discard locknut (5).

17. Remove screw (12) and lockwasher (13) from left splash shield (3) and airlift bracket (4). Discard lockwasher (13).

18. Remove locknut (28), screw (25), clamp (26), and harness (27) from left splash shield (3). Remove left splash shield (3) from vehicle. Discard locknut (28).
3-84. DIFFERENTIAL COOLER LINES REPLACEMENT (SERIAL NUMBERS 188974 AND BELOW (Cont’d))

19. Remove hose clamp (31) and hose (32) from outlet port (30) on power steering cooler (29).
20. Disconnect hose (32) from tee (36) on upper tube (37) on front intermediate crossmember (38).
21. Disconnect tee (36) from upper tube (37).
22. Disconnect tee (36) from hose (34).
23. Remove tiedown strap (33) from hose (34) and elbow (35). Discard tiedown strap (33).
24. Disconnect hose (1) from adapter (5) on hydraulic control valve (4).
25. Remove adapter (5) from hydraulic control valve (4).
26. Disconnect hose (1) from lower tube (2) on intermediate crossmember (3).
3-84. DIFFERENTIAL COOLER LINES REPLACEMENT (SERIAL NUMBERS 188974 AND BELOW (Cont'd))

b. Oil Cooler Hoses and Tubes Removal

**WARNING**

Allow differential to cool before performing this task. Severe injury to personnel may result.

**CAUTION**

Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**

- Have drainage container ready to catch oil.
- For ease of identification during installation, tag with tape all tube ends that route to the left port on the rear differential oil cooler. Left port is inlet side.

1. Remove two hose clamps (1) from front intermediate crossmember (8) and tubes (3) and (7).
2. Disconnect tube (7) from union (6) on tube (5).
3. Disconnect tube (3) from union (6) on tube (4).
4. Remove tubes (3) and (7) from right frame rail (2) and front intermediate crossmember (8).
5. Remove two nuts (3), washers (4), screws (10), and washers (4) from clamps (2).
6. Remove tubes (7) and (8) and two clamps (2) from lower transmission oil cooler lines (11).
7. Disconnect tubes (7) and (8) from hoses (5) and (6).
8. Remove unions (1) from tubes (7) and (8).
9. Remove bolt (21), washer (22), and two spacers (12) from two clamps (20) and front tunnel support brace (13).

10. Remove tapping screw (19) and washer (18) from two clamps (20) and rear tunnel support brace (15).

11. Remove tapping screw (19) and washer (18) from two clamps (20) and center tunnel support brace (14).

12. Remove six clamps (20) from tubes (16) and (17).
13. Pull hoses (1) and (2) towards rear of vehicle and remove three tiedown straps (3) from hoses (1) and (2). Discard tiedown straps (3).
14. Disconnect tube (7) from right-hand hose (2) and remove right-hand hose (2) from vehicle.

15. Disconnect tube (4) from left-hand hose (1) and remove left-hand hose (1) from vehicle.

16. Remove tiedown strap (13) from differential support brace (8) and hoses (5) and (6). Discard tiedown strap (13).

17. Disconnect hose (6) and remove O-ring (9) from right port (10) on cooler cover assembly (11). Discard O-ring (9).

18. Disconnect hose (5) and remove O-ring (9) from left port (12) on cooler cover assembly (11). Discard O-ring (9).

19. Remove hose (6) and tube (7) from vehicle.

20. Remove hose (5) and tube (4) from vehicle.
3-84. DIFFERENTIAL COOLER LINES REPLACEMENT (SERIAL NUMBERS 188974 AND BELOW) (Cont’d)

21. Disconnect hose (4) from tube (1).
22. Disconnect hose (3) from tube (2).
c. Oil Cooler Hoses and Tubes Installation

**NOTE**

Remove all protective caps and plugs from tubes and hoses prior to connecting.

1. Connect hose (3) to tube (4).
2. Connect hose (2) to tube (1).
3. Route hose (3) and tube (4) over rear crossmember (5) and along rear differential support brace (6).
4. Route hose (2) and tube (1) over rear crossmember (5) and along rear differential support brace (6).
3-84. DIFFERENTIAL COOLER LINES REPLACEMENT (SERIAL NUMBERS 188974 AND BELOW) (Cont’d)

**NOTE**

Ensure hoses have O-rings installed on ends that connect to cooler cover assembly.

5. Connect hose (1) and O-ring (7) to left port (6) on cooler cover assembly (4).
6. Connect hose (2) and O-ring (3) to right port (5) on cooler cover assembly (4).
7. Route left-hand hose (11) over transfer case and connect to tube (10).
8. Route right-hand hose (8) over transfer case and connect to tube (9).
9. Connect hose (11) to tube (12).
10. Connect hose (8) to tube (13).
3-84. DIFFERENTIAL COOLER LINES REPLACEMENT (SERIAL NUMBERS 188974 AND BELOW) (Cont'd)

11. Install six clamps (8) on tubes (5) and (6).
12. Secure tubes (5) and (6) to center tunnel support brace (3) with two clamps (8), washer (7), and tapping screw (9).
13. Secure tubes (5) and (6) to rear tunnel support brace (4) with two clamps (8), washer (7), and tapping screw (9).
14. Secure tubes (5) and (6) to front tunnel support brace (2) with two spacers (1), clamps (8), washer (7), and bolt (10).
15. Secure hoses (12) and (13) to differential support brace (11) with tiedown strap (14).
16. Secure hoses (15) and (16) together with three tiedown straps (17).
17. Install unions (18) on tubes (22) and (23).
18. Install two clamps (19) on tubes (22) and (23).
19. Position tubes (22) and (23) up against right frame rail (24) and under idler arm (27).
20. Secure tubes (22) and (23) and four clamps (19) to lower transmission oil cooler line (26) with two washers (20), screws (25), washers (20), and nuts (21).
21. Connect hoses (15) and (16) to tubes (22) and (23).
22. Position tubes (3) and (8) adjacent to right frame rail (2) and front intermediate crossmember (6).
23. Connect tube (3) to union (7) on tube (4).
24. Connect tube (8) to union (7) on tube (5).
25. Install two hose clamps (1) on front intermediate crossmember (6) and tubes (3) and (8).
d. Front Hoses and Relief Valve Installation

NOTE
Remove all protective caps and plugs from tubes and hoses prior to connecting.

1. Connect hose (1) to lower tube (2) on front intermediate crossmember (3), and route along left inner cowl (6) to hydraulic control valve (4).

NOTE
Do not apply pipe sealing compound on first two threads of adapter.

2. Apply pipe sealing compound to threads of adapter (5) and install on hydraulic control valve (4).

3. Connect hose (1) to adapter (5) on hydraulic control valve (4).
4. Connect tee (6) to hose (3).
5. Connect tee (6) to upper tube (7), and route hose (3) under elbow (4) on fan shroud (5) and under brake limiter bracket (2).
6. Install tiedown strap (1) on hose (3) and fan shroud elbow (4).

**NOTE**
Ensure that hose and tee are positioned towards fan shroud and away from moving parts when tightening.
7. Connect hose (12) to tee (6) on upper tube (7) on front intermediate crossmember (8) and route to outlet port (10) on power steering oil cooler (9).

8. Install hose (12) on outlet port (10) with hose clamp (11).
3-84. DIFFERENTIAL COOLER LINES REPLACEMENT (SERIAL NUMBERS 188974 AND BELOW) (Cont’d)

NOTE
Perform steps 9 through 15 and 17 for M1113 and steps 9, 10, and 13 through 17 for M1114.

9. Install left splash shield (3) on vehicle.
10. Install harness (27) and clamp (26) on left splash shield (3) with screw (25) and locknut (28).
11. Install screw (12) and lockwasher (13) on left splash shield (3) and airlift bracket (4).
12. Install screw (11), two washers (6), and locknut (5) on left splash shield (3) and airlift bracket (4).
13. Install left splash shield (3) on master cylinder bracket (9) with two washers (8), screw (10), and locknut (7).
14. Install left splash shield (3) on support bracket (17) with two washers (2), screw (16), and locknut (1).
15. Install left splash shield (3) on plate (22) with four washers (24), lockwashers (20), and screws (19).
16. Install fuel filter drain valve (24) on left splash shield (3) with nut (23).
17. Install access cover (18) on left splash shield (3) with three washers (15) and screws (14).
3-84. DIFFERENTIAL COOLER LINES REPLACEMENT (SERIAL NUMBERS 188974 AND BELOW (Cont'd))

18. Install relief valve (32) on splash shield (3) with reinforcement (41), two washers (35), and bolts (36).
19. Install O-ring (42) and union (29) on side of relief valve (32).
20. Install O-ring (34) and union (33) on top of relief valve (32).
21. Install hood prop rod (43) and bracket (44) on left splash shield (3) and airlift bracket (4) with four lockwashers (45) and screws (46).
22. Connect bypass hose (30) to union (29).
23. Connect bypass hose (31) to union (33).
24. Connect bypass hose (30) and return hoses (39) and (40) to tee (38) with three clamps (37).
25. Install clamp (49) on bypass hose (30).
26. Secure clamps (49) and (50) together with bolt (51), washer (48), and locknut (47).

FOLLOW-ON TASKS:
- Install rear propeller shaft [para. 6-4].
- Connect battery ground cables [para. 4-68].
- Install rear brake protection guards [para. 7-11].
- Bleed power steering system [para. 8-27].
- Start engine (TM 9-2320-387-10) and inspect for leaks at engine oil cooler, supply, and return lines.
3-85. DIFFERENTIAL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 188975 THROUGH 299999)

This task covers:

a. Front Hoses and Relief Valve Removal  
d. Rear Oil Cooler Hoses and Tubes Installation  
b. Oil Cooler Tubes Removal  
e. Oil Cooler Tubes Installation  
c. Drilling Hole Locations in Tunnel Support Braces  
f. Front Hoses and Relief Valve Installation

INITIAL SETUP:

Tools

- General mechanic’s tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

Materials/Parts

- Sealing compound-pipe (Appendix C, Item 62)
- Four lockwashers (Appendix G, Item 146)
- Four lockwashers (Appendix G, Item 190.2)
- Locknut (Appendix G, Item 87)
- Six locknuts (Appendix G, Item 106)
- Two O-rings (Appendix G, Item 221)
- Tiedown strap (Appendix G, Item 329)
- Two O-rings (Appendix G, Item 218)

Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition

- Rear propeller shaft removed (para. 6-4).
- Battery ground cables disconnected (para. 4-68).
- Rear brake protection guards removed (para. 7-11).

General Safety Instructions

- Allow differential to cool.
- Hood must be supported during hood prop rod and bracket removal.

Maintenance Level

Unit

NOTE

If rear steel differential oil cooler tubes have failed on vehicle serial numbers 188975 and above, perform tasks c. and d. to replace them with flexible differential oil cooler hoses.

a. Front Hoses and Relief Valve Removal

WARNING

Allow differential to cool before performing this task. Severe injury to personnel may result.

CAUTION

Cover or plug all tubes and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE

Have drainage container ready to catch oil.

1. Remove locknut (1), washer (2), and bolt (4) from clamp (3). Discard locknut (1).
2. Remove clamp (3) from bypass hose (5).
3. Loosen three clamps (12) on tee (13).
4. Disconnect bypass hose (5) and return hoses (14) and (15) from tee (13).
5. Disconnect bypass hose (6) from union (8).
6. Disconnect bypass hose (5) from union (19).
7. Remove union (8) and O-ring (9) from top of relief valve (7). Discard O-ring (9).
8. Remove union (19) and O-ring (18) from side of relief valve (7). Discard O-ring (18).
9. Remove two bolts (11), washers (10), relief valve (7), and reinforcement (16) from splash shield (17).
3-85. DIFFERENTIAL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 188975 THROUGH 299999) (Cont’d)

**WARNING**

Hood must be supported during hood prop rod and bracket removal. Failure to support hood may cause injury to personnel or damage to equipment.

10. Remove four screws (24), lockwashers (23), hood prop rod (20), and bracket (22) from left splash shield (17) and airlift bracket (21). Discard lockwashers (23).
11. Remove three screws (14), washers (15), and access cover (16) from left splash shield (3).

**NOTE**
Perform steps 13 through 18 for M1113 and steps 12 through 15 and 18 for M1114.

12. Remove nut (23) and fuel filter drain valve (24) from left splash shield (3).
13. Remove four screws (19), washers (21), and lockwashers (20) from plate (22) and left splash shield (3). Discard lockwashers (20).
14. Remove locknut (1), two washers (2), and screw (17) from support bracket (18) and left splash shield (3). Discard locknut (1).
15. Remove locknut (7), two washers (8), and screw (10) from master cylinder bracket (9) and left splash shield (3). Discard locknut (7).
16. Remove locknut (5), two washers (6), and screw (11) from left splash shield (3) and airlift bracket (4). Discard locknut (5).
17. Remove screw (12) and lockwasher (13) from left splash shield (3) and airlift bracket (4). Discard lockwasher (13).
18. Remove locknut (28), screw (25), clamp (26), and harness (27) from left splash shield (3). Discard locknut (28) and remove left splash shield (3) from vehicle.
19. Remove hose clamp (31) and hose (32) from outlet port (30) on power steering cooler (29).
20. Disconnect hose (32) from tee (36) on upper tube (37) on front intermediate crossmember (38).
21. Disconnect tee (36) from upper tube (37).
22. Disconnect tee (36) from hose (34).
23. Remove tiedown strap (33) from hose (34) and elbow (35). Discard tiedown strap (33).
NOTE
Perform steps 24 and 25 for vehicles with serial numbers 196901 and above.

24. Remove locknut (9), washer (8), screw (6), and three clamps (7) from bracket (10). Discard locknut (9).
25. Remove clamp (7) from hose (1).
26. Disconnect hose (1) from adapter (5) on hydraulic control valve (4).
27. Remove adapter (5) from hydraulic control valve (4).
28. Disconnect hose (1) from lower tube (2) on intermediate crossmember (3).
b. Oil Cooler Tubes Removal

**WARNING**
Allow differential to cool before performing this task. Severe injury to personnel may result.

**CAUTION**
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**
Have drainage container ready to catch oil.

1. Remove screw (1), washer (2), and two clamps (3) from intermediate crossmember (10).
2. Remove nut (6), washer (5), nut (6), washer (5), and screw (4) from two clamps (9).
3. Remove clamp (9) from tubes (7) and (8).
4. Remove two nuts (5), washers (6), nuts (5), washers (6), and screws (4) from four clamps (3).
5. Remove two clamps (3) from tubes (1) and (2).
6. Disconnect tubes (1) and (2) from unions (7) and (10).
7. Remove unions (7) and (10) from tubes (8) and (9).
3-85. DIFFERENTIAL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 188975 THROUGH 299999) (Cont’d)

c. Drilling Hole Locations in Tunnel Support Braces

**NOTE**

Perform task c. when replacing rear steel differential oil cooler tubes with flexible differential oil cooler lines.

1. Locate, mark, and drill a 0.201 in. (5.10 mm) diameter hole (1) (#7 drill bit) in tunnel support brace (2).

2. Using 0.250-20 UNC standard tap, thread hole (1) drilled in step 1 in front tunnel support brace (2).
3. Locate, mark, and drill two 0.201 in. (5.10 mm) diameter holes (1) (#7 drill bit) in tunnel support braces (2) and (3).
d. Rear Oil Cooler Hoses and Tubes Installation

**NOTE**
- Perform task d. when replacing rear steel differential oil cooler tubes with flexible differential oil cooler lines.
- Remove all protective caps and plugs from tubes and hoses prior to connecting.

1. Connect hose (3) to tube (4).
2. Connect hose (2) to tube (1).
3. Route hose (3) and tube (4) over rear crossmember (5).
4. Route hose (2) and tube (1) over rear crossmember (5).
3-85. DIFFERENTIAL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 188975 THROUGH 299999) (Cont’d)

NOTE
Ensure hoses have O-ring installed on ends that connect to cooler cover assembly.

5. Route hose (2) along rear differential support brace (1) and connect hose (2) and O-ring (8) to left port (7) on cooler cover assembly (5).

6. Route hose (3) along rear differential support brace (1) and connect hose (3) and O-ring (4) to right port (6) on cooler cover assembly (5).

7. Secure hoses (2) and (3) to differential support brace (1) with tiedown strap (9).
8. Route left-hand hose (10) over transfer case and connect to tube (11).
9. Route right-hand hose (13) over transfer case and connect to tube (12).
10. Connect left-hand hose (10) to tube (15).
11. Connect right-hand hose (13) to tube (14).
12. Install six clamps (8) on tubes (5) and (6).

13. Secure tubes (5) and (6) to center tunnel support brace (3) with two clamps (8), washer (7), and tapping screw (9).

14. Secure tubes (5) and (6) to rear tunnel support brace (4) with two clamps (8), washer (7), and tapping screw (9).

15. Secure tubes (5) and (6) to front tunnel support brace (2) with two spacers (1), clamps (8), washer (7), and bolt (10).

16. Secure hose (11) and (12) together with three tiedown straps (13).
3-85. DIFFERENTIAL COOLER LINES REPLACEMENT  
(SERIAL NUMBERS 188975 THROUGH 299999) (Cont’d)

**e. Oil Cooler Tubes Installation**

1. Install two clamps (18) on tubes (16) and (17) with screws (19), washers (20), and nuts (21).
2. Route tubes (16) and (17) along right-hand frame rail (14) and under idler arm (15).
3. Secure two clamps (18) on tubes (16) and (17) to two clamps on transmission cooler tube (22) with washers (20) and nuts (21).
4. Route tubes (8) and (9) along right-hand frame rail (7) and onto front intermediate crossmember (11).

5. Install two clamps (3) on tubes (8) and (9).

6. Secure tubes (8) and (9) to front intermediate crossmember (11) with washer (1) and screw (2).

7. Install clamp (3) on tubes (8) and (9).

8. Secure tubes (8) and (9) to clamp (3) on transmission oil cooler line (10) with clamp (3), washer (5), screw (4), nut (6), washer (5), and nut (6).
NOTE
Remove all protective caps and plugs from tubes and hoses prior to connecting.

1. Connect hose (1) to lower tube (2) on front intermediate crossmember (3).
2. Route hose (1) along left inner cowl (3) to adapter (4) on hydraulic control valve (2).

**NOTE**

Do not apply pipe sealing compound on first two threads of adapter.

3. Apply pipe sealing compound to threads of adapter (4) and install on hydraulic control valve (2).

4. Connect hose (1) to adapter (4) on hydraulic control valve (2).

**NOTE**

Perform steps 5 and 6 for vehicles with serial numbers 196901 and above.

5. Install clamp (6) on hose (1).

6. Install three clamps (6) on bracket (9) with screw (5), washer (7), and locknut (8).
7. Connect tee (16) to hose (12).
8. Connect tee (16) to upper tube (15), and route hose (12) under elbow (13) on fan shroud (14) and under brake limiter bracket (10).
9. Install tiedown strap (11) on elbow (13) and hose (12).

NOTE
Ensure that hose and tee are positioned towards fan shroud and away from moving parts when tightening.
10. Connect hose (4) to tee (5) on upper tube (7) on front intermediate crossmember (8) and route to outlet port (2) on power steering oil cooler (1).
11. Install hose (4) on outlet port (2) with hose clamp (3).
12. Install left splash shield (11) on vehicle and install harness (35) and clamp (34) on left splash shield (11) with screw (33) and locknut (36).

**NOTE**
Perform steps 14 through 17 and 19 for M1113 and steps 16 through 19 for M1114.

13. Install screw (20) and lockwasher (21) on left splash shield (11) and airlift bracket (12).

14. Install screw (19), two washers (14), and locknut (13) on left splash shield (11) and airlift bracket (12).

15. Install left splash shield (11) on master cylinder bracket (17) with two washers (16), screw (18), and locknut (15).

16. Install left splash shield (11) on support bracket (26) with two washers (10), screw (25), and locknut (9).

17. Install left splash shield (11) on plate (30) with four washers (29), lockwashers (28), and screws (27).

18. Install fuel filter drain valve (32) on left splash shield (11) and nut (31).

19. Install access cover (24) on left splash shield (11) with three washers (23) and screws (22).
20. Install relief valve (3) on splash shield (14) with reinforcement (13), two washers (6), and bolts (7).
21. Install hood prop rod (17) and bracket (19) on left splash shield (14) and airlift bracket (18) with four lockwashers (20) and screws (21).
22. Install O-ring (15) and union (16) on side of relief valve (3).
23. Install O-ring (5) and union (4) on top of relief valve (3).
24. Connect bypass hose (1) to union (16).
25. Connect bypass hose (2) to union (4).
26. Connect bypass hose (1) and return hose (10) to tee (9) with two clamps (8).

**NOTE**

For vehicles with serial numbers 196901 and above, return hose is routed under fan clutch hydraulic line. For vehicles with serial numbers 188975 through 196900, return hose is routed over fan clutch hydraulic line.

27. Route return hose (11) over fan clutch hydraulic line (12) and connect return hose (11) to tee (9) with clamp (8).
28. Install clamp (19) on bypass hose (1).
29. Secure two clamps (19) together with bolt (20), washer (18), and locknut (17).
FOLLOW-ON TASKS:
- Install rear propeller shaft [para. 6-4].
- Connect battery ground cables [para. 4-68].
- Install rear brake protection guards [para. 7-11].
- Bleed power steering system [para. 8-27].
- Start engine (TM 9-2320-387-10) and inspect for leaks at all differential cooler supply hoses and return line connections.
3-85.1. TRANSFER CASE COOLER LINES MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal  
b. Disassembly  
c. Assembly  
d. Installation

INITIAL SETUP:

Tools

General mechanic’s tool kit: automotive (Appendix B, Item 1)

Materials/Parts

Two lockwashers (Appendix G, Item 144)

Manual References

TM 9-2320-387-24P

Equipment Condition

Cooling system drained (as necessary) (para. 3-61).

Maintenance Level

Unit

a. Removal

1. Remove nut (3), lockwasher (4), washer (5), capscrew (13), washer (12), and hose assembly (14) from transfer case mount (6). Discard lockwasher (4).
2. Remove hose clamps (1) and (11) and hose assembly (14) from transfer case (2).
3. Remove hose clamps (7) and (10) and remove tubes (8) and (9) from hose assembly (14).

b. Disassembly

1. Remove hose clamps (15) and (18) and tubes (16) and (17) from coolant tubes (20) and (21).
2. Remove nut (23), lockwasher (24), washer (25), capscrew (29), and washer (28) from clamps (26) and (27). Discard lockwasher (24).
3. Remove clamps (19), (22), (26), and (27) from coolant hoses (20) and (21).

c. Assembly

1. Install clamps (27), (26), (22), and (19) on coolant hoses (21) and (20).
2. Install clamp (27) on clamp (26) with washer (28), capscrew (29), washer (25), lockwasher (24), and nut (23).
3. Install tubes (17) and (16) on coolant hoses (21) and (20) with hose clamps (18) and (15).

d. Installation

1. Install hose assembly (14) on tubes (9) and (8) with hose clamps (10) and (7).
2. Install hose assembly (14) on transfer case (2) with hose clamps (11) and (1).
3. Secure hose assembly (14) to transfer case mount (6) with washer (12), capscrew (13), washer (5), lockwasher (4), and nut (3).
FOLLOW ON TASK: Fill cooling system [para. 3-61].
### CHAPTER 4
ELECTRICAL SYSTEM (UNIT) MAINTENANCE

Section I. GENERATING AND PROTECTIVE CONTROL BOX (PCB) SYSTEM MAINTENANCE

#### 4-1. GENERATING AND PROTECTIVE CONTROL BOX (PCB) SYSTEM MAINTENANCE

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<td>4-18.12</td>
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4-2. ALTERNATOR PULLEY REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)
- Mechanical puller (Appendix B, Item 157)
- Vise inserts (Appendix B, Item 160)

Materials/Parts
- Locknut (Appendix G, Item 74)
- Woodruff key (Appendix G, Item 332)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Alternator removed [para. 4-5].

Maintenance Level
- Unit

---

a. Removal

1. Clamp alternator pulley (2) in soft-jawed vise.
2. Remove locknut (5) and washer (4) from alternator shaft (3). Discard locknut (5).
3. Remove pulley (2) from soft-jawed vise.
4. Using mechanical puller, remove pulley (2) from alternator (1).
5. Remove woodruff key (6) from alternator shaft (3). Discard woodruff key (6).

---

b. Installation

**CAUTION**

Serpentine belt failure (abnormal wear or belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path. Inspect water pump pulley for proper installation and ease of rotation. Any wobble or misalignment will cause belt failure.

1. Position woodruff key (6) in alternator shaft (3) with flat side up.
2. Align pulley keyway (7) with woodruff key (6) in alternator shaft (3) and tap pulley (2) onto shaft (3).
3. Install washer (4) and locknut (5) on shaft (3). Tighten locknut (5) finger-tight.
4. Clamp pulley (2) in soft-jawed vise.
5. Tighten locknut (5) to 115-125 lb-ft (156-169 N•m).
6. Remove pulley (2) and alternator (1) from vise.
FOLLOW-ON TASK: Install alternator (para. 4-5).
This task covers:

a. Removal

b. Installation

**INITIAL SETUP:**

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<tr>
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**a. Removal**

1. Hold adapter (3) with socket and breaker bar. Place wrench on installation nut (1), turn installation nut (1) counterclockwise, and remove installation nut (1) from alternator (2).
2. Hold rear nut of alternator shaft (6) and remove adapter (3), clutch pulley (4), and woodruff key (5) from alternator (2). Discard woodruff key (5).

**b. Installation**

1. Install woodruff key (5) and clutch pulley (4) on shaft (6) of alternator (2).
2. Install adapter (3) on alternator (2). Hold rear nut on alternator shaft (6) and tighten adapter (3) to 50 lb-ft (68 N·m).
3. Install installation nut (1) on adapter (3). Using torque wrench set at 120 lb-ft (163 N·m) and socket, hold adapter (3) with socket and torque wrench. Turn installation nut (1) clockwise with wrench until torque is reached.
FOLLOW-ON TASK: Install serpentine drivebelt [para. 3-81.1].
This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Sealing compound (Appendix C, Item 60)

Manual References
TM 9-2320-387-24P

Equipment Condition
- Alternator removed (para. 4-5).
- Tensioner, idler pulleys, and mounting hardware removed (para. 3-82).
- Power steering pump removed (para. 8-23).

Maintenance Level
Unit

a. Removal

Remove two flanged-head capscrews (3), long flanged-head capscrew (2), and mounting bracket (1) from engine (4).

b. Installation

Apply sealing compound to capscrews (2) and (3), and install mounting bracket (1) on engine (4) with two flanged-head capscrews (3) and long flanged-head capscrew (2). Tighten capscrews (3) and (2) to 48 lb-ft (65 N·m).
FOLLOW-ON TASKS:  
- Install power steering pump (para. 8-23).  
- Install tensioner, idler pulleys, and mounting hardware (para. 3-82).  
- Install alternator (para 4-5).
4-3.1. ALTERNATOR/POWER STEERING MOUNTING BRACKET REPLACEMENT
(SERIAL NUMBERS 196901 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Adhesive sealant (Appendix C, Item 3.1)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition

• Hood open and secured (TM 9-2320-387-10).
• Alternator removed (para. 4-5).
• Tensioner and mounting hardware removed (para. 3-82.1).
• Idler pulleys and mounting hardware removed (para. 3-82.6).
• Power steering pump and pulley removed (para. 8-23.1).

Maintenance Level
Unit

a. Removal

1. Remove three screws (2) and alternator/power steering mounting bracket (1) from engine (3).

b. Installation

1. Apply adhesive sealant to threads of three screws (2) and install alternator/power steering mounting bracket (1) on engine (3) with screws (2).

FOLLOW-ON TASKS:
• Install alternator (para. 4-5).
• Install tensioner and mounting hardware (para. 3-82.1).
• Install idler pulleys and mounting hardware (para. 3-82.6).
• Install power steering pump and pulley (para. 8-23.1).
• Lower and secure hood (TM 9-2320-387-10).
4-4. PROTECTIVE CONTROL BOX (PCB) REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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<tr>
<td>One mechanic</td>
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<tr>
<td>One assistant</td>
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</table>

**CAUTION**

The control box must be supported from inside the vehicle during removal and installation. Failure to do this may result in damage to Protective Control Box (PCB).

**a. Removal**

1. From inside the vehicle, disconnect body wiring harness cannon plug (4) from PCB (5).
2. Working under hood, disconnect engine wiring harness cannon plug (6) from PCB connector (7).

**NOTE**

Perform step 3 for all vehicles except M1113. Perform step 4 for M1113.

3. Remove four screws (5.1) and PCB (5) from cowl (3).
4. Remove four nut and lockwasher assemblies (1) and PCB (5) from cowl (3). Discard nut and lock-washer assemblies (1).

**b. Installation**

1. Position PCB (5) under instrument panel (2) against cowl (3).

**NOTE**

Perform step 2 for all vehicles except M1113. Perform step 2.1 for M1113.

2. From under hood, install PCB (5) on cowl (3) with four screws (5.1). Tighten screws (5.1) to 6 lb-ft (8 N-m).
2.1. From under hood, install PCB (5) on cowl (3) with four nut and lockwasher assemblies (1). Tighten nut and lockwashers assemblies (1) to 6 lb-ft (8 N-m).
3. Fill cannon plug (6) and PCB connector (7) to capacity with silicone compound.
4. Connect engine wiring harness cannon plug (6) to PCB connector (7).
5. From inside vehicle, connect body wiring harness cannon plug (4) to PCB (5).
4-4. PROTECTIVE CONTROL BOX (PCB) REPLACEMENT (Cont’d)

FOLLOW-ON TASKS:  
- Connect battery ground cable [para 4-68].  
- Lower and secure hood (TM 9-2320-387-10).
### 4-5. 200-AMPERE DUAL VOLTAGE ALTERNATOR REPLACEMENT

**This task covers:**

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<th></th>
<th>a. Removal</th>
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**INITIAL SETUP:**

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Lockwasher (Appendix G, Item 180)
- Lockwasher (Appendix G, Item 181)
- Lockwasher (Appendix G, Item 182)
- Lockwasher (Appendix G, Item 144)
- Grease (Appendix C, Item 36)

**Personnel Required**
- One mechanic
- One assistant

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Voltage regulator removed (para. 4-8).

**General Safety Instructions**
- Alternator must be supported during removal and installation.

**Maintenance Level**
- Unit

---

**NOTE**

Prior to removal, tag leads for installation.

#### a. Removal

1. Remove nut (14), lockwasher (13), washer (12), and ground strap (11) from ground stud (10). Discard lockwasher (13).

2. Slide back rubber boot (15) and remove nut (1), lockwasher (2), washer (3), and alternator positive cable lead 6 (4) from positive stud (7). Discard lockwasher (2).

3. Position 3/8-in. breaker bar or, as appropriate, a 1/2-in. ratchet wrench on belt tensioner (16), move tensioner (16) clockwise, and remove drivebelt (8) from alternator pulley (9).

**WARNING**

Alternator must be supported during removal. Failure to support alternator may cause injury to personnel or damage to equipment.

4. Remove nut (29), lockwasher (28), washer (27), two screws (19), washers (17), lockwasher (18), and alternator (25) from support bracket (23) and mounting bracket (26). Discard lockwashers (28) and (18).

5. Remove three capscrews (20), washers (21), bushings (24), and fan guard assembly (22) from alternator (25).

6. Remove alternator pulley (9) (para. 4-2).
4-5. 200-AMPERE DUAL VOLTAGE ALTERNATOR REPLACEMENT (Cont’d)

b. Installation

1. Install alternator pulley (22) [para. 4-2].

2. Install fan guard assembly (6) on alternator (9) with three bushings (8), washers (5), and capscrews (4).

**WARNING**

Alternator must be supported during installation. Failure to support alternator may cause injury to personnel or damage to equipment.

3. Position alternator (9) on mounting bracket (10).

**NOTE**

Ensure terminals are clean before connections are made.

4. Install support bracket (7) on alternator (9) and alternator mounting bracket (10) with lockwasher (2), two washers (1), capscrews (3), washer (11), lockwasher (12), and nut (13).

5. Install positive cable lead 6 (17) on positive stud (20) with washer (16), lockwasher (15), and nut (14). Tighten nut (14) to 10-15 lb-ft (14-20 N•m).

6. Apply grease to positive stud (20), positive cable lead 6 (17), and inside of rubber boot (28), slide rubber boot (28) over stud (20).

7. Install ground strap (24) on ground stud (23) with washer (25), lockwasher (26), and nut (27). Tighten nut (27) to 8-12 lb-ft (11-16 N•m).

8. Position 3/8-in. breaker bar or, as appropriate, a 1/2-in. ratchet wrench on belt tensioner (29), move tensioner (29) clockwise, and install drivebelt (21) on alternator pulley (22).
FOLLOW-ON TASK: Install voltage regulator (para. 4-8).
4-6. 200-AMPERE DUAL VOLTAGE ALTERNATOR CABLE REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

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<th>Manual References</th>
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</table>

Equipment Condition

- Hood raised and secured (TM 9-2320-387-10).
- Battery ground cables disconnected (para. 4-68).
- Engine access cover removed (para. 10-22).

Maintenance Level

Unit

NOTE

Prior to removal, tag leads for installation.

a. Removal

1. Slide back rubber boot (5) and remove nut (8), lockwasher (7), washer (6), cable (4), nut (3), and washer (2) from positive stud (1). Discard lockwasher (7).
2. Remove capscrew (9) and clamp (10) from water crossover bracket (11) and separate cable (4) from cables and clamp (10).
3. Remove nut (14), lockwasher (13), and clamp (15) from stud (12) and separate cable (4) from cables and clamp (15). Discard lockwasher (13).
5. Remove screw (17) and clamp (19) from bracket (20) and remove cable (4) from clamp (19).
6. Remove nut (27), lockwasher (26), washer (25), and cable (4) from buss bar (24) on battery box (23). Discard lockwasher (26).
7. Remove cable (4) from grommet (28) and vehicle.

b. Installation

NOTE

Ensure terminals are clean before connections are made.

1. Install cable (4) through grommet (28) in battery box (23).
1.1 Install cable (4) on buss bar (24) with washer (25), lockwasher (26), and nut (27).
2. Route cable (4) through clamp (19) and install clamp (19) to bracket (20) with screw (17).
3. Route cable (4) through clamp (15) and install clamp (15) on stud (12) with lockwasher (13) and nut (14).
4. Route cable (4) through clamp (10) and install clamp (10) on water crossover bracket (11) with capscrew (9).
5. Install washer (2), nut (3), and cable (4) on positive stud (1) with washer (6), lockwasher (7), and nut (8). Tighten nut (8) to 10-15 lb-ft (14-20 N·m) and slide rubber boot (5) over nut (8).
6. Install four tiedown straps (16) on cable (4).
FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Install engine access cover (para. 10-22).
• Lower and secure hood (TM 9-2320-387-10).
• Start engine (TM 9-2320-387-10) and check operation of voltmeter gauge.
4-7. 200-AMPERE DUAL VOLTAGE UMBILICAL POWER CABLE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Applicable Models
M1113, M1152, M1152A1

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
Two lockwashers (Appendix G, Item 149)
Lockwasher (Appendix G, Item 187)
Lockwasher (Appendix G, Item 153)
Sealing compound (Appendix C, Item 64)

Personnel Required
One mechanic
One assistant

Manual References
TM 9-2320-387-24P

Equipment Condition
• Batteries removed [para. 4-74].
• Fixed rear door removed (para. 10-20).

Maintenance Level
Unit

NOTE
Prior to removal, tag leads for installation.

a. Removal

1. Remove nut (5), lockwasher (4), washer (3), and positive power cable (2) from buss bar (1).
   Discard lockwasher (4).
2. Remove capscrew (6), lockwasher (7), negative power cable (8), and two cables (9) from shunt (10).
   Discard lockwasher (7).
3. Remove five capscrews (20), two lockwashers (19), washers (18), and coverplate (17) from B-beam (12).
   Discard lockwashers (19).
4. Remove two nuts (15), washers (14), capscrews (25), washers (26), and mounting bracket (27) from coverplate (17).
5. Remove nut (28), screw (23), and cover (22) with cover chain (21) from mounting bracket (27).
6. Remove cover (22) with cover chain (21) from umbilical power cable assembly (29).
7. Remove four nuts (30), screws (24), and mounting bracket (27) from umbilical power cable assembly (29).
8. Pull umbilical power cable assembly (29) through grommet (11) and coverplate (17), and remove from vehicle (16).
9. Remove grommet (11) from battery box (13).
4-7. 200-AMPERE DUAL VOLTAGE UMBILICAL POWER CABLE REPLACEMENT (Cont'd)

b. Installation

1. Install grommet (5) on battery box (7).
2. Route umbilical power cable assembly (14) through coverplate (11) and grommet (5), and position in approximate mounting location on vehicle (10).
3. Install cover chain (17) on mounting bracket (16) with screw (19) and nut (15).
4. Install umbilical power cable assembly (14) on mounting bracket (16) with four screws (20) and nuts (4).
5. Install cover (18) on umbilical power cable assembly (14).
6. Install coverplate (11) on B-beam (6) with two washers (12), lockwashers (13), and five capscrews (3).
7. Install mounting bracket (16) on coverplate (11) with two washers (2), capscrews (1), washers (8), and nuts (9).
8. Install two cables (24) and negative power cable (23) on shunt (25) with lockwasher (22) and capscrew (21).
9. Install positive power cable (27) on buss bar (26) with washer (28), lockwasher (29), and nut (30).
10. Apply silicone compound to cable (27), coating all exposed metallic surfaces.
FOLLOW-ON TASKS: • Install fixed rear door (para. 10-20).
  • Install batteries [para. 4-74].
4-8. 200-AMPERE DUAL VOLTAGE REGULATOR REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Two lockwashers (Appendix G, Item 177)
Lockwasher (Appendix G, Item 179)
Grease (Appendix C, Item 25)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
• Battery ground cables disconnected [para. 4-68].
• Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

NOTE
Prior to removal, tag leads for installation.

a. Removal

1. Disconnect regulator plug (13) from voltage regulator (11).
2. Slide back rubber boot (3) and remove nut (2), lead 5A (1) and washer (22.1) from IGN terminal (22).
3. Slide back rubber boot (4) and remove nut (5), lead 2A (6) and washer (6.1) from yellow (AC) terminal (7).
4. Remove nut (20) and ground wire (12) from 14-volt stud (21).
5. Remove screw (8), lockwasher (9), washer (10), and ground wire (12) from voltage regulator (11).
Discard lockwasher (9).
6. Disconnect alternator connector (15) from connector (16) on voltage regulator (11).
7. Remove two screws (19), lockwashers (18), washers (17), and voltage regulator (11) from alternator (14).
Discard lockwashers (18).

b. Installation

1. Install voltage regulator (11) on alternator (14) with two washers (17), lockwashers (18), and screws (19). Tighten screws (19) to 30-34 lb-in. (3-4 N·m).
2. Connect alternator connector (15) to connector (16) on voltage regulator (11).
3. Install washer (22.1), lead 5A (1) and nut (2) on IGN terminal (22). Tighten nut (2) to 23-27 lb-in. (2.6-3.0 N·m).
4. Apply grease to IGN terminal (22), lead 5A (1), and inside of boot (3), and slide boot (3) over IGN terminal (22).
5. Install washer (6.1), lead 2A (6) and nut (5) on yellow (AC) terminal (7). Tighten nut (5) to 18-22 lb-in. (2.0-2.5 N·m).
6. Apply grease to yellow (AC) terminal (7), lead 2A (6), and inside of boot (4), and slide boot (4) over yellow (AC) terminal (7).
7. Connect regulator plug (13) to voltage regulator (11).
8. Install one end of ground wire (12) on 14-volt stud (21) on voltage regulator (11) with nut (20). Tighten nut (20) to 45-55 lb-in. (5-6 N·m).
9. Install other end of ground wire (12) on voltage regulator (11) with washer (10), lockwasher (9), and screw (8). Tighten screw (8) to 88-94 lb-in. (10-11 N·m).
FOLLOW-ON TASKS:
- Connect battery ground cables (para. 4-68).
- Lower and secure hood (TM 9-2320-387-10).
4-8.1. 400-AMPERE DUAL VOLTAGE REGULATOR REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Two lockwashers (Appendix G, Item 181)
- Lockwasher (Appendix G, Item 179)
- Grease (Appendix C, Item 36)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (TM 9-2320-387-10).

---

**NOTE**

Prior to removal, tag leads for installation.

1. Disconnect regulator plugs (12) and (13) from connectors (9) and (10) on voltage regulator (11).
2. Slide back rubber boot (5) and remove nut (4), lead 5A (6), and washer (7) from red terminal (8) on voltage regulator (11).
3. Slide back rubber boot (2) and remove nut (1), lead 2A (3), and washer (24) from yellow terminal (25) on voltage regulator (11).
4. Slide back rubber boot (20) and remove nut (19), lead 68A (18), and washer (17) from 14 volt output terminal (15) on voltage regulator (11).
5. Remove three screws (23), lockwashers (22), washers (21), voltage regulator (11), and three spacers (16) from alternator (14). Discard lockwashers (22).

---

**b. Installation**

1. Install three spacers (16) and voltage regulator (11) on alternator (14) with three washers (21), lockwashers (22), and screws (23). Tighten screws (23) to 30-34 lb-in. (3-4 N·m).
2. Install washer (7), lead 5A (6), and nut (4) on red terminal (8) of voltage regulator (11). Tighten nut (4) to 35 lb-in. (4 N·m).
3. Apply grease to red terminal (8), lead 5A (6), and inside of rubber boot (5), and slide boot (5) over red terminal (8).
4. Install washer (24), lead 2A (3), and nut (1) on yellow terminal (25) of voltage regulator (11). Tighten nut (1) to 20 lb-in. (2 N·m).
5. Apply grease to yellow terminal (25), lead 2A (3), and inside of rubber boot (2), and slide boot (2) over yellow terminal (25).
6. Install washer (17), lead 68A (18), and nut (19) on 14 volt output terminal (15) of voltage regulator (11). Tighten nut (19) to 50 lb-in. (6 N·m).
7. Apply grease to 14 volt output terminal (15), lead 68A (18), and inside of rubber boot (20), and slide boot (20) over 14 volt output terminal (15).
8. Connect regulator plugs (12) and (13) to connectors (9) and (10) on voltage regulator (11).
FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Lower and secure hood (TM 9-2320-387-10).
4-8.2. 400-AMPERE DUAL VOLTAGE ALTERNATOR CABLE REPLACEMENT

This task covers:
   a. Removal  b. Installation

INITIAL SETUP:

<table>
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<tr>
<th>Tools</th>
<th>Manual References</th>
<th>Equipment Condition</th>
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<td>TM 9-2320-387-24P</td>
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<tr>
<td>Maintenance and repair shop equipment:</td>
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<tr>
<td>Materials/Parts</td>
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</tr>
<tr>
<td>Locknut (Appendix G, Item 82)</td>
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<td>• Hood raised and secured (TM 9-2320-387-10).</td>
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<tr>
<td>Two lockwashers (Appendix G, Item 185)</td>
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<td>• Battery ground cables disconnected (para. 4-88).</td>
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<td>Three tiedown straps (Appendix G, Item 327)</td>
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<td>• Engine access cover removed (para. 10-22).</td>
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<tr>
<td>Lockwasher (Appendix G, Item 167)</td>
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<tr>
<td>Five lockwashers (Appendix G, Item 183)</td>
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</tr>
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</table>

a. Removal

NOTE
Prior to removal, tag leads for installation.
1. Remove locknut (7), washer (6), screw (3), clamp (4), and cables (2) and (11) from bracket (5). Discard locknut (7).
2. Remove screw (8), clamp (9), and cables (2) and (11) from bracket (10).
3. Remove three tiedown straps (1) from cables (2) and (11). Discard tiedown straps (1).
4. Remove nut (12), lockwasher (13), washer (14), and cable (11) from stud (22) on battery box side panel (15). Discard lockwasher (13).
5. Remove nut (19), lockwasher (20), washer (18), and cable (2) from stud (17) on buss bar (16). Discard lockwasher (20).
6. Remove grommet (21) from battery box side panel (15) and remove cable (2) through battery box side panel (15).
4-8.2. 400-AMPERE DUAL VOLTAGE ALTERNATOR CABLE REPLACEMENT (Cont’d)
7. Remove nut (6), screw (1), and cable (2) with clamp (7) from oil pan bracket (8).
8. Remove nut (3), lockwasher (4), and cable (2) from positive starter terminal (5). Discard lockwasher (4).
9. Remove nut (11), lockwasher (12), washer (13), cable (2), and clamp (9) from stud (10) on thermostat housing (14). Discard lockwasher (12).
10. Remove nut (15), washer (16), cable (2), and clamp (18) from stud (17).
11. Remove screw (23), lockwasher (22), washer (21), ground strap (24), lead (20), and cable (25) from alternator (19). Discard lockwasher (22).

12. Remove screw (26), lockwasher (27), washer (28), and cables (25) and (29) from alternator (19). Discard lockwasher (27).

13. Slide back rubber boot (35) and remove screw (31), lockwasher (32), washer (33), and cables (34) and (36) from alternator (19). Discard lockwasher (32).

14. Slide back rubber boot (40) and remove screw (30), lockwasher (39), washer (38), and cables (37) and (36) from alternator (19). Discard lockwasher (39).
b. Installation

1. Install cables (2) and (3) on rear positive terminal (14) of alternator (1) with washer (4), lockwasher (5), and screw (6), and slide rubber boot (7) over cables (2) and (4).

2. Install cables (2) and (9) on front positive terminal (8) of alternator (1) with washer (10), lockwasher (12), and screw (11), and slide rubber boot (13) over cables (2) and (9).

3. Install cable (21), lead (16), and ground strap (17) on front negative terminal (15) of alternator (1) with washer (18), lockwasher (20), and screw (19).

4. Install cables (25) and (21) on rear negative terminal (26) of alternator (1) with washer (24), lockwasher (23), and screw (22).
5. Install cable (9) and clamp (36) on stud (35) with washer (34) and nut (33).

6. Install cable (9) and clamp (27) on stud (28) of thermostat housing (32) with washer (29), lockwasher (31), and nut (30).

7. Install cable (9) on positive terminal (41) of starter (44) with lockwasher (39) and nut (40).

8. Install cable (9) and clamp (37) on oil pan bracket (38) with screw (43) and nut (42).
4-8.2. 400-AMPERE DUAL VOLTAGE ALTERNATOR CABLE REPLACEMENT (Cont’d)

9. Install grommet (12) on battery box side panel (5) and route cable (8) through grommet (12) and battery box side panel (5).

10. Install cable (8) on stud (7) of buss bar (6) with washer (9), lockwasher (10), and nut (11).

11. Install cable (4) on stud (13) of battery box side panel (5) with washer (3), lockwasher (2), and nut (1).

12. Install cables (4) and (8) on bracket (22) with clamp (21) and screw (20).

13. Install cables (4) and (8) on bracket (17) with clamp (16), screw (15), washer (18), and locknut (19).

14. Install three tiedown straps (14) on cables (4) and (8).
FOLLOW-ON TASKS: • Install engine access cover (para. 10-22).
• Connect battery ground cables (para. 4-68).
• Lower and secure hood (TM 9-2320-387-10).
# 4-8.3. 400-AMPERE DUAL VOLTAGE ALTERNATOR REPLACEMENT

This task covers:

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<thead>
<tr>
<th></th>
<th>a. Removal</th>
<th>b. Installation</th>
</tr>
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</table>

## INITIAL SETUP:

### Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

### Materials/Parts
- Lockwasher (Appendix G, Item 144)
- Lockwasher (Appendix G, Item 185)
- Lockwasher (Appendix G, Item 154)

### Personnel Required
- One mechanic
- One assistant

## Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

## Equipment Condition
- Hood raised and secured (TM 9-2320-387-10).
- Battery ground cables disconnected (para. 4-68).
- Alternator cables removed (para. 4-8.2).

## General Safety Instructions
- Alternator must be supported during removal and installation.

### a. Removal

**NOTE**

Prior to removal, tag leads for installation.

1. Position 3/8-in. breaker bar or, as appropriate, a 1/2-in. ratchet wrench on belt tensioner (4), move tensioner (4) clockwise, and remove drivebelt (1) from power steering pump pulley (3) and alternator pulley (2).

2. Remove nut (5), lockwasher (6), washer (7), ground strap (8), and washer (10) from stud (9). Discard lockwasher (6).

**WARNING**

Alternator must be supported during removal and installation. Failure to do so may cause injury to personnel or damage to equipment.

3. Remove screw (12), lockwasher (13), and washer (14) from alternator bracket (17) and alternator mounting bracket (11). Discard lockwasher (13).

4. Remove screw (15), washer (16), and bracket (17) from alternator (18).

5. Remove nut (24), lockwasher (23), washer (22), screw (19), washer (20), and alternator (18) from alternator support bracket (21) and alternator mounting bracket (11). Discard lockwasher (23).

6. Remove alternator pulley (2) (para. 4-2).

## b. Installation

1. Install alternator pulley (2) (para. 4-3).

2. Position alternator (18) on alternator mounting bracket (11).

3. Install alternator (18) on alternator mounting bracket (11) and alternator support bracket (21) with washer (20), screw (19), washer (22), lockwasher (23), and nut (24). Do not tighten nut (24).

4. Install alternator bracket (17) on alternator (18) with washer (16) and screw (15). Do not tighten screw (15).

5. Install washer (14), lockwasher (13), and screw (12) on alternator mounting bracket (11) and alternator bracket (17).

6. Tighten screw (15) to 40 lb-ft (54 N·m).

7. Tighten nut (24) to 155 lb-ft (210 N·m).
8. Install ground strap (8) on stud (9) with washers (10) and (7), lockwasher (6), and nut (5).

9. Position 3/8-in. breaker bar or, as appropriate, a 1/2-in. ratchet wrench on belt tensioner (4) and move tensioner (4) clockwise and install drivebelt (1) on power steering pump pulley (3) and alternator pulley (2).

FOLLOW-ON TASKS:
- Install alternator cables (para. 4-8.2).
- Connect battery ground cables (para. 4-68).
- Lower and secure hood (TM 9-2320-387-10).
4-10. ROTARY SWITCH REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

**Tools**

- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**

- Lockwasher (Appendix G, Item 147)
- Lockwasher (Appendix G, Item 155)

**Manual References**

- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**

- Battery ground cables disconnected (para. 4-68)

**Maintenance Level**

- Unit

**NOTE**

Prior to removal, tag leads and note position of lever for installation.

**a. Removal**

1. Remove screw (8), lockwasher (7), and switch lever (6) from switch shaft (9). Discard lockwasher (7).
2. Remove nut (5) and lockwasher (4) from switch (2) and instrument panel (3). Discard lockwasher (4).
3. Push switch (2) out of hole in panel (3).
4. Disconnect three electrical leads 11A (1), 14A (10), and 29A (11) from switch (2).

**b. Installation**

1. Connect three electrical leads 11A (1), 14A (10), and 29A (11) to switch (2).
2. Install switch (2) into hole in instrument panel (3).
3. Install lockwasher (4) and nut (5) on switch (2).
4. Place switch lever (6) on switch shaft (9) to ENGINE STOP position.
5. Secure lever (6) on switch shaft (9) with lockwasher (7) and screw (8).
FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-68).  
- Check rotary switch operation (TM 9-2320-387-10).
### 4-11. STARTER REPLACEMENT

This task covers:

- **Removal**
- **Installation**

#### INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Special Tools**
- Crowfoot, 9/16-in. (Appendix B, Item 139)
- Torque adapter, 3/4-in. (Appendix B, Item 134)
- Socket adapter, 3/8- to 1/2-in. drive (Appendix B, Item 135)

**Materials/Parts**
- Lockwasher (Appendix G, Item 144)
- Lockwasher (Appendix G, Item 148)
- Assembled locknut (Appendix G, Item 134)
- Adhesive sealant (Appendix C, Item 12)
- Sealing compound (Appendix C, Item 62)

**Personnel Required**
- One mechanic
- One assistant

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Battery ground cables disconnected [para. 4-68].
- Sealed upper converter housing cover removed [para. 5-12].

**General Safety Instructions**
- Starter must be supported during removal and installation.

**Maintenance Level**
- Unit

---

**WARNING**

Starter must be supported during removal and installation. Failure to support starter may cause injury to personnel or damage to equipment.

**NOTE**

- Illustration shown is a cutaway of the right side of vehicle.
- Prior to removal, tag leads for installation.

#### a. Removal

1. Remove assembled locknut (30), capscrew (28), and clamp (29) from oil pan bracket (27). Discard assembled locknut (30).
2. Remove adhesive sealant from positive terminal (8) on starter (1).

**NOTE**

Perform steps 3 and 4 for M1113 models only. Perform steps 5 and 6 for M1114 models only.

3. Remove nut (14), lockwasher (13), lead 6V (12), lead 81B (15), and lead 6A (20) from positive terminal (8). Discard lockwasher (13).
4. Remove nut (16), lockwasher (17), lead 7V (18), lead 3D (19), and negative cable 7A (21) from starter negative terminal (22). Discard lockwasher (17).
5. Remove nut (16), lockwasher (17), lead 3D (19), and negative cable 7A (21) from starter negative terminal (22). Discard lockwasher (17).
6. Remove nut (14), lockwasher (13), lead 81B (15), and lead 6A (20) from positive terminal (8). Discard lockwasher (13).
7. Remove screw (11), clip (10), lead 74B (9), and lead 74A (7) from solenoid (2).
8. Remove screw (25), clamp (23), and lead 6A (20) from starter (1).
9. Loosen nut (5) on stud (6) connecting starter (1) to bracket (4).
10. While supporting starter (1) from under vehicle, remove two cap screws (24) from starter (1) and engine (3).

**NOTE**
Note size of shim for installation.

11. Remove starter (1) and shim (26) from engine (3).
4-11. STARTER REPLACEMENT (Cont’d)

b. Installation

1. Install a .08-in. (2-mm) shim (26) on starter (1).
2. Position shim (26) and starter (1) on engine (3).
3. Slide front stud (6) on starter (1) in bracket (4).

**NOTE**
Some capscrews have sealing compound pre-applied. Additional sealing compound is not required.

4. Apply sealing compound to two capscrews (24). Install capscrews (24) on starter (1) and engine (3). Tighten capscrews (24) to 30-40 lb-ft (41-54 N•m).
5. Install starter (1) on bracket (4) with nut (5). Using crowfoot, tighten nut (5) to 15-19 lb-ft (20-26 N•m).
6. Install clamp (23) and positive cable 6A (20) on starter (1) with screw (25).
7. Connect lead 74B (7) and lead 74A (9) on solenoid (2) with clip (10) and screw (11). Tighten screw (11) to 20 lb-in. (2 N•m).

**NOTE**
Perform steps 8 and 9 for M1113 models only. Perform steps 10 and 11 for M1114 models only.

8. Connect lead 6A (20), lead 81B (15), and lead 6V (12) on positive terminal (8) with lockwasher (13) and nut (14).
9. Connect negative cable 7A (21), lead 3D (19), and lead 7V (18) on negative terminal (22) with lockwasher (17) and nut (16). Using torque adapter, tighten nut (16) to 15-20 lb-ft (20-27 N•m).
10. Connect lead 6A (20) and lead 81B (15) on positive terminal (8) with lockwasher (13) and nut (14).
11. Connect lead 7A (21) and lead 3D (19) on negative terminal (22) with lockwasher (17) and nut (16). Using torque adapter, tighten nut (16) to 15-20 ft-lb (20-27 N•m).
12. Seal positive terminal (8) with adhesive sealant. Apply sealant at least 1/8 in. (3 mm) thick, covering all exposed metal attached to positive terminal (8).
13. Install clamp (29) on oil pan bracket (27) with capscrew (28) and assembled locknut (30).
FOLLOW-ON TASKS:
- Install sealed upper converter housing cover (para. 5-12).
- Connect battery ground cables (para. 4-68).
- Start engine (TM 9-2320-387-10) and check for smooth starter engagement.
4-12. CIRCUIT BREAKER REPLACEMENT

This task covers:

a. Removal  
b. Installation

**INITIAL SETUP:**

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| Maintenance and repair shop equipment:  
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| Two lockwashers (Appendix G, Item 147) |
| TM 9-2320-387-10 |
| TM 9-2320-387-24P |

**Equipment Condition**

Battery ground cables disconnected (para. 4-68).

**Maintenance Level**

Unit

**NOTE**

- Replacement procedures for all circuit breakers are basically the same. This procedure covers the instrument gauge circuit breaker.
- Prior to removal, tag leads for installation.

**a. Removal**

1. Loosen nut (1) and lower steering column (2).
2. Disconnect leads 29B (8) and 29D (9) from circuit breaker (6).
3. Remove two nuts (4), lockwashers (5), screws (7), and circuit breaker (6) from column bracket (3). Discard lockwashers (5).

**b. Installation**

1. Install circuit breaker (6) on column bracket (3) with two screws (7), lockwashers (5), and nuts (4).
2. Connect leads 29B (8) and 29D (9) to circuit breaker (6).
3. Raise steering column (2) and tighten nut (1) to 31 lb-ft (42 N\(\cdot\)m).
FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
  • Check operation of circuit breaker (TM 9-2320-387-10).
## INSTRUMENTS, SENDING UNITS, SWITCHES, AND HORN MAINTENANCE TASK SUMMARY

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4-14. INSTRUMENT CLUSTER REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
Five lockwashers (Appendix G, Item 137)
Antiseize compound (Appendix C, Item 16)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected (para. 4-68)

Maintenance Level
Unit

NOTE
Prior to removal, tag leads for installation.

a. Removal

1. Remove four screws (7) and washers (6) from instrument cluster (8) and instrument panel (3). Pull instrument cluster (8) away from instrument panel (3) to allow access to speedometer cable (4).

2. Loosen driveshaft nut (5) and disconnect speedometer cable (4) from speedometer (1).

3. Disconnect harness lead 27J (26), 28A (9), 40B (13), 27H (14), 36A (15), 57L (19), 17B (20), 27G (21), 33A (22), 40C (17), and 567A (18) from instrument cluster (8).

4. Remove five nuts (12), lockwashers (11), and harness ground leads 58H (10), 58G (25), 58E (23), 58F (24), and 57G (16) from instrument cluster (8) and remove instrument cluster (8). Discard lockwashers (11).
4-14. INSTRUMENT CLUSTER REPLACEMENT (Cont’d)

b. Installation

1. Apply antiseize compound to harness ground leads 58H (10), 58G (25), 58E (23), 58F (24), and 57G (16) and install on instrument cluster (8) with five lockwashers (11) and nuts (12).

2. Connect harness leads 27J (26), 28A (9), 40B (13), 27H (14), 36A (15), 57L (19), 17B (20), 27G (21), 33A (22), 40C (17), and 567A (18) to instrument cluster (8).

3. Connect speedometer cable (4) to speedometer (1), ensuring core (2) engages with square hole in speedometer (1), and secure with driveshaft nut (5).

4. Install instrument cluster (8) in panel (3) with four washers (6) and screws (7).

FOLLOW-ON TASKS:  
- Connect battery ground cables [para. 4-68].
- Check operation of instrument cluster components (TM 9-2320-387-10).
4-14.1. INSTRUMENT CLUSTER (ELECTRONIC) REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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</table>

NOTE

Prior to removal, tag leads for installation.

a. Removal

1. Remove capscrew (12), grounds 58M (13) and 57G (14), and washer (15) from instrument cluster (18).

2. Disconnect harness leads 36A (1), 567A (2), 40C (3), 57L (5), 17B (6), 27G (7), 33A (8), 27J (22), 40W (23), 28A (21), and 27W (24) from instrument cluster (18).

3. Remove four nuts (9), (11), (17) and (20), and ground wires 58E (4), 58F (10), 58G (16), and 58H (19) from instrument cluster (18).

b. Installation

1. Install four nuts (9), (11), (17) and (20), and ground wires 58E (4), 58F (10), 58G (16), and 58H (19) on instrument cluster (18).

2. Connect harness leads 36A (1), 567A (2), 40C (3), 57L (5), 17B (6), 27G (7), 33A (8), 27J (22), 28A (21), 40W (23), and 27W (24) to instrument cluster (18).

3. Install capscrew (12), grounds 58M (13) and 57G (14) and washer (15) on instrument cluster (18).
FOLLOW-ON TASKS:

- Install speedometer/odometer (electronic) [para. 4-17.1].
- Check operation of instrument cluster components (TM 9-2320-387-10).
4-15. INSTRUMENT PANEL MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)
- Torque wrench 3/8-in. drive, 75 ft-lb (Appendix B, Item 2.1)

Equipment Condition

- Instrument cluster removed (para. 4-14 or para. 4-14.1)
- Heater control cables removed (para. 10-79)

Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P

NOTE

Prior to removal, tag leads for installation.

a. Removal

1. Loosen nut (9) and lower steering column (3).
2. Remove cannon plug (11) from main light switch (10).

NOTE

All vehicles except M1113 and M1114 are equipped with nut inserts.
Perform step 3 for M1113 and M1114 only.

3. Remove two capscrews (12) and washers (13) from instrument panel (2) and body (1).

NOTE

Perform step 3.1 for M1113 and M1114 vehicles only.

3.1 Remove two capscrews (12), washers (13) nuts (14), and washers (13) from instrument panel (2) and body (1).
4. Remove nut (16) and screw (17) from hand throttle bracket (15) and instrument panel (2).
5. Remove nut (4), washer (5), capscrew (7), washer (5), and hand throttle bracket (15) from steering column bracket (8) and instrument panel (2).
6. Remove screw (6) from instrument panel (2) and body (1).
7. Pull instrument panel (2) away from body (1).
8. Disconnect harness leads 11A (28), 14A (29), and 27A (27) from rotary switch (26).
9. Disconnect harness leads 27F (32) and 571A (31) at wait-to-start indicator light (24).
10. Disconnect harness leads 27L (30) and 67D (33) at brake warning indicator light (22).
11. Disconnect harness lead 400 D (18) from resistor (21).
12. Disconnect harness lead 27E (19) from blower switch (20) and remove instrument panel (2).
13. Disconnect hose (25) from air restriction gauge (23).

b. Inspection

Refer to para. 10-56 for nut insert inspection and replacement.

c. Installation

1. Connect hose (25) to air restriction gauge (23).
2. Connect harness lead 27E (19) to blower switch (20).
3. Connect harness lead 400D (18) to resistor (21).
4. Connect harness leads 27L (30) and 67D (33) to brake warning indicator light (22).
5. Connect harness leads 27F (32) and 571A (31) to wait-to-start indicator light (24).
4-15. INSTRUMENT PANEL MAINTENANCE (Cont’d)

6. Connect harness leads 11A (28), 14A (29), and 27A (27) to rotary switch (26).
7. Install instrument panel (2) on body (1) with screw (6).
8. Install instrument panel (2) and hand throttle bracket (15) on steering column bracket (8) with washer (5), capscrew (7), washer (5), and nut (4).
9. Install hand throttle bracket (15) on instrument panel (2) with screw (17) and nut (16).

**CAUTION**
When installing capscrews into nut inserts, use grade 5 torque value. Failure to do so may damage equipment or components.

**NOTE**
All vehicles except M1113 and M1114 are equipped with nut inserts. Perform step 10 for all vehicles except M1113 and M1114.

10. Secure instrument panel (2) to body (1) with two washers (13) and capscrews (12). Tighten capscrews (12) to 8 lb-ft (11 N•m).

**NOTE**
Perform step 10.1 for M1113 and M1114 vehicles only.

10.1. Secure instrument panel (2) to body (1) with two washers (13), capscrews (12), washers (13), and nuts (14).
11. Install cannon plug (11) on main light switch (10).
12. Raise steering column (3) and tighten nut (9) to 31 lb-ft (42 N•m).

FOLLOW-ON TASKS:  
- Install heater control cables (para. 10-79).
- Install instrument cluster\([\text{para. 4-14 or para. 4-14.1}]\).
- Check operation of instrument panel components (TM 9-2320-387-10).
4-16. ELECTRICAL GAUGE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Two lockwashers (Appendix G, Item 137)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected (para. 4-68).

Maintenance Level
Unit

NOTE

- Replacement procedures for all electrical gauges are basically the same. This procedure covers the temperature gauge.
- Prior to removal, tag all leads for installation.

a. Removal

1. Remove four screws (9) and washers (8) from instrument cluster (1) and instrument panel (6).
2. Pull instrument cluster (1) away from panel (6).
3. Disconnect leads (4) and (5) from gauge (10).
4. Remove two nuts (3), lockwashers (7), retaining bracket (2), and gauge (10) from instrument cluster (1). Discard lockwashers (7).

b. Installation

1. Install gauge (10) and retaining bracket (2) on instrument cluster (1) with two lockwashers (7) and nuts (3). Tighten nuts (3) to 8 lb-in. (1 N-m).
2. Connect leads (4) and (5) to gauge (10).
3. Install instrument cluster (1) on panel (6) with four washers (8) and screws (9).
FOLLOW-ON TASKS:  • Connect battery ground cables (para. 4-68).
               • Start engine and check operation of electrical gauge (TM 9-2320-387-10).
4-17. SPEEDOMETER/ODOMETER REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

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<th>Manual References</th>
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</table>

a. Removal

1. Remove four screws (10) and washers (9) from instrument cluster (4) and instrument panel (8).
2. Pull instrument cluster (4) away from panel (8).
3. Loosen driveshaft nut (2) on speedometer cable (7) and pull cable end out of speedometer (3).
4. Remove two nuts (6) from speedometer retaining bracket (5) and remove speedometer (3) and bracket (5) from instrument cluster (4).

b. Installation

1. Install speedometer (3) and retaining bracket (5) on instrument cluster (4) with two nuts (6).  
   Tighten nuts (6) to 8 lb-in. (1 N·m).
2. Install speedometer cable (7) into back of speedometer (3), ensuring core (1) engages in square hole in speedometer (3), and tighten driveshaft nut (2).
3. Install instrument cluster (4) on panel (8) with four washers (9) and screws (10).
FOLLOW-ON TASK: Check operation of speedometer (TM 9-2320-387-10).
## 4-17.1. SPEEDOMETER/ODOMETER (ELECTRONIC) REPLACEMENT

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### a. Removal

1. Remove four capscrews (11), washers (10), and instrument cluster (1) from instrument panel (2).
2. Remove harness assembly nut (7) from rear of speedometer (13).
3. Remove two nuts (6), washers (5), washers (4), ground wire 58M (3), and shielding ground wire (8) from retaining bracket (9) on rear of speedometer (13).
4. Remove retaining bracket (9) from two threaded studs (12) on rear of speedometer (13) and remove speedometer (13) from instrument cluster (1).

### b. Installation

1. Install retaining bracket (9) on two threaded studs (12) on rear of speedometer (13).
2. Install ground wire 58M (3) and shielding ground wire (8) on two threaded studs (12) on rear of speedometer (13) with two washers (4), washers (5), and nuts (6). Tighten nuts (6) to 5 lb-in (0.6 N.m).
3. Install harness assembly nut (7) on rear of speedometer (6).
4. Install instrument cluster (1) into instrument panel (2) with four capscrews (11) and washers (10).
FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-68).
- Check operation of speedometer/odometer (TM 9-2320-387-10).
4-18. SPEEDOMETER CABLE REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Equipment Condition
- Hood raised and secured (TM 9-2320-387-10).
- Engine access cover removed (para. 10-22).

Maintenance Level
Unit

Tools
General mechanic's tool kit:
- automotive (Appendix B, Item 1)

Materials/Parts
- Nut and lockwasher assembly
  (Appendix G, Item 197)
- Tiedown strap (Appendix G, Item 329.1)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

a. Removal

1. Remove four screws (12) and washers (13) from instrument cluster (11) and instrument panel (10) and pull instrument cluster (11) away to gain access to back of speedometer (3).
2. Remove driveshaft nut (2) from speedometer (3).
3. Push cable (5) and rubber grommet (4) through body (8).
4. Remove nut and lockwasher assembly (6), screw (9), and clamp (7) from body (8). Remove clamp (7) from cable (5). Discard nut and lockwasher assembly (6).
5. Remove tiedown strap (14) from speedometer cable (5) and harness (16). Discard tiedown strap (14).
6. Remove speedometer cable (5) from adapter (15).

b. Installation

1. Install speedometer cable (5) on adapter (15), ensuring core (1) engages in square hole of adapter (15).
2. Install tiedown strap (14) on speedometer cable (5) and harness (16).
3. Install cable (5) on body (8) with clamp (7), screw (9), and nut and lockwasher assembly (6).
4. Install cable (5) and grommet (4) on body (8).
5. Connect cable (5) to back of speedometer (3), ensuring core (1) engages in square hole in speedometer (3) and tighten driveshaft nut (2).
6. Install instrument cluster (11) on instrument panel (10) with four washers (13) and screws (12).
4-18. SPEEDOMETER CABLE REPLACEMENT (Cont'd)

FOLLOW-ON TASKS:
- Lower and secure hood (TM 9-2320-387-10).
- Install engine access cover (para. 10-22).
4-18.1. SPEEDOMETER HARNESS ASSEMBLY REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
Two tiedown straps (Appendix G, Item 324)
Two locknuts (Appendix G, Item 73.1)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
• Hood raised and secured (TM 9-2320-387-10).
• Instrument cluster (electronic) removed
para. 4-14.1.
• Sender generator (electronic) removed
para. 5-17.1.
• Engine access cover removed
(para. 10-22).

Maintenance Level
Unit

NOTE
• Prior to removal, tag leads for installation.
• Jumper wires on rear of instrument cluster can be replaced separately.
• Rotate speedometer harness under body harness to keep body harness from laying on transmission.

a. Removal

1. Remove locknut (5), capscrew (7), harnesses (3) and (4), and clamp (6) from cowl (8). Discard locknut (5).

2. Remove locknut (9), capscrew (2), clamp (1), and harnesses (3) and (4) from cowl (8). Discard locknut (9).
3. Remove three capscrews (12), tiedown strap (13), and harness (14) from three clamps (11) on vehicle (10).
4. Remove tiedown strap (6) and harness (2) from harness (1).
5. Remove capscrew (4), clamp (3), and harness (2) from engine floor pan support (5).
NOTE

Ensure any excess harness assembly is secured to existing instrument cluster harness with tiedown strap(s), as needed.

1. Install harness (8) and clamp (9) on engine floor pan support (11) with capscrew (10).
2. Secure harness (8) on harness (7) with tiedown strap (12).
4-18.1. SPEEDOMETER HARNESS ASSEMBLY REPLACEMENT (Cont’d)

3. Install harness (5) and three clamps (2) on vehicle (1) with tiedown strap (4) and three capscrews (3).
4-18.1. SPEEDOMETER HARNESS ASSEMBLY REPLACEMENT (Cont’d)

4. Install harnesses (8) and (9) and clamp (6) on cowl (13) with capscrew (7) and locknut (14).
5. Install harnesses (8) and (9) and clamp (11) on cowl (13) with capscrew (12) and locknut (10).

FOLLOW-ON TASKS:
- Install engine access cover (para. 10-22).
- Install sender generator (electronic) [para. 5-17.1].
- Install instrument cluster (electronic) [para. 4-14.1].
- Lower and secure hood (TM 9-2320-387-10).
4-19. INSTRUMENT CLUSTER LIGHT REPLACEMENT

This task covers:

a. Lamp Removal  c. Light Assembly Removal
b. Lamp Installation  d. Light Assembly Installation

INITIAL SETUP:

Equipment Condition
Battery ground cables disconnected (para. 4-68).

Maintenance Level
Unit

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

a. Lamp Removal

1. Remove light lens (1) and gasket (2) from instrument cluster (4).
2. Remove lamp (3) from instrument cluster (4).

b. Lamp Installation

1. Install lamp (3) on instrument cluster (4).
2. Install gasket (2) and lens (1) on instrument cluster (4).

2. Install gasket (2) and lens (1) on instrument cluster (4).
4-19. INSTRUMENT CLUSTER LIGHT REPLACEMENT (Cont'd)

c. Light Assembly Removal

1. Remove two light lenses (1) and gaskets (2) from light assemblies (6).
2. Remove lamp (3) from light assembly (6) being replaced.
3. Remove all electrical gauges \([\text{para. 4-16}]\) and speedometer/odometer \([\text{para. 4-17 or para. 4-17.1}]\).
4. Separate instrument cluster (4) from backing panel (7).
5. Disconnect harness lead 40B (5) from light assembly (6).
6. Remove two screws (8) and light assembly (6) from backing panel (7).

d. Light Assembly Installation

1. Install light assembly (6) on backing panel (7) with two screws (8).
2. Install backing panel (7) on instrument cluster (4).
3. Install all electrical gauges \([\text{para. 4-16}]\) and speedometer/odometer \([\text{para. 4-17 or para. 4-17.1}]\).
4. Connect harness lead 40B (5) to light assembly (6).
5. Install lamp (3) on light assembly (6).
6. Install two gaskets (2) and light lenses (1) on light assemblies (6).

FOLLOW-ON TASK: Connect battery ground cables \([\text{para. 4-68}]\).
4-20. WAIT-TO-START LAMP REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
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<tr>
<th>Tools</th>
<th>Equipment Condition</th>
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<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>• Battery ground cables disconnected (para. 4-68).</td>
</tr>
<tr>
<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>• Instrument cluster removed (para. 4-14 or para. 4-14.1).</td>
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<th>Maintenance Level</th>
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<td>Unit</td>
</tr>
<tr>
<td>TM 9-2320-387-24P</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE**

Prior to removal, tag leads and note position for installation.

### a. Removal

1. Loosen nut (14) and lower steering column (7).
2. Remove cannon plug (16) from main light switch (15).

**NOTE**

All models except M1113 and M1114 are equipped with nut inserts, not nuts and washers as indicated in steps 3 and 4.

3. Remove two capscrews (17), washers (18), nuts (20), and washers (18) from instrument panel (6) and body (19).
4. Remove nut (22) and screw (23) from hand throttle bracket (21) and instrument panel (6).
5. Remove nut (13), washer (11), capscrew (10), and washer (11) from instrument panel (6), hand throttle bracket (21), and steering column bracket (12).
6. Remove screw (8) from instrument panel (6) and cowl (9).
7. Pull instrument panel (6) away from body (19).
8. Remove two screws (5) from wait-to-start lamp (4) and instrument panel (6).
9. Disconnect leads 571 (2) and 27 (3) from wiring harness (1).
10. Remove wait-to-start lamp (4).

### b. Installation

1. Connect leads 571 (2) and 27 (3) to wiring harness (1).
2. Install wait-to-start lamp (4) on instrument panel (6) with two screws (5).
3. Install instrument panel (6) on cowl (9) with screw (8).
4. Install instrument panel (6) and hand throttle bracket (21) on steering column bracket (12) with washer (11), capscrew (10), washer (11), and nut (13).

**NOTE**

All models except M1113 and M1114 are equipped with nut inserts, not nuts and washers as indicated in steps 5 and 6.

5. Install hand throttle bracket (21) on instrument panel (6) with screw (23) and nut (22).
6. Install instrument panel (6) on body (19) with two washers (18), capscrews (17), washers (18), and nuts (20).
7. Install cannon plug (16) on main light switch (15).
8. Raise steering column (7) and tighten nut (14) to 31 lb-ft (42 N•m).
FOLLOW-ON TASKS:

- Install driver's closeout panel (para. 11-104.2).
- Install instrument cluster (para. 4-14 or para. 4-14.1).
- Connect battery ground cables (para. 4-68).
- Start engine (TM 9-2320-387-10) and check wait-to-start lamp assembly for operation.
4-21. BRAKE WARNING LAMP REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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<th>Equipment Condition</th>
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<td>General mechanic's tool kit:</td>
<td>TM 9-2320-387-10</td>
<td>Battery ground cables disconnected (para. 4-68).</td>
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<tr>
<td>automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
<td>Air restriction gauge removed (para. 3-17).</td>
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<tr>
<td>Tape (Appendix C, Item 77)</td>
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NOTE

Prior to removal, tag leads and note position for installation.

a. Removal

1. Remove two screws (2) from brake warning lamp (1) and instrument panel (5).
2. Disconnect leads 67 (7) and 27 (3) from wiring harness leads (6).
3. Slide brake warning lamp (1) down toward steering column (4) and remove brake warning lamp (1).

b. Installation

NOTE

Place tape around lead wires to keep lamp in proper position during installation.

1. Install tape (8) around lamp (1) and lead wires (7) and (3).
2. Slide brake warning lamp (1) up along steering column (4) and install brake warning lamp (1) on instrument panel (5) with two screws (2).
3. Connect leads 67 (7) and 27 (3) to wiring harness leads (6).

FOLLOW-ON TASKS:  • Install air restriction gauge (para. 3-17).
                  • Connect battery ground cables (para. 4-68).
                  • Start engine (TM 9-2320-387-10) and check brake warning lamp for operation.
4-22. HIGH-BEAM LAMP REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

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</tr>
<tr>
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<td>• Speedometer/odometer removed (para. 4-17 or para. 4-17.1).</td>
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<td>Gasket (Appendix G, Item 48)</td>
<td>Unit</td>
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</table>

Manual References  
TM 9-2320-387-24P

NOTE

Prior to removal, tag leads for installation.

a. Removal

1. Remove two light lenses (7) from instrument cluster back panel (4).
2. Remove instrument cluster (6) from instrument cluster back panel (4).
3. Disconnect harness lead 57L (2) and lead 17B (3) from high-beam lamp (5).
4. Remove two screws (1), high-beam lamp (5), and gasket (8) from instrument cluster back panel (4).

b. Installation

1. Install gasket (8) and high-beam lamp (5) on instrument cluster back panel (4) with two screws (1).
2. Connect harness lead 57L (2) and lead 17B (3) to high-beam lamp (5).
3. Install instrument cluster (6) on instrument cluster back panel (4).
4. Install two light lenses (7) on instrument cluster back panel (4).

FOLLOW-ON TASKS:  
• Install speedometer/odometer (para. 4-17 or para. 4-17.1).  
• Install electrical gauges (para. 4-16).
4-23. PARKING BRAKE SWITCH REPLACEMENT

This task covers:

a. Removal  b. Installation

INITIAL SETUP:

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<td>[para. 4-68]</td>
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<td>Unit</td>
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<tr>
<td>TM 9-2320-387-24P</td>
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</table>

**NOTE**

Prior to removal, tag leads for installation.

**a. Removal**

1. Disconnect parking brake switch leads 67C (1) and 67 (2) from wiring harness leads 67B (3) and 67E (4).
2. Remove parking brake switch (5) from parking brake lever (6).

**b. Installation**

1. Install parking brake switch (5) on parking brake lever (6).
2. Connect leads 67C (1) and 67 (2) to wiring harness leads 67B (3) and 67E (4).

**FOLLOW-ON TASKS:**

- Connect battery ground cables [para. 4-68].
- Check parking brake switch operation (TM 9-2320-387-10).
4-24. HORN SWITCH REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
Sealing compound (Appendix C, Item 63)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected (para. 4-68).

Maintenance Level
Unit

a. Removal

1. Remove snapring (5) from horn switch (4) and steering wheel (1).
2. Pull horn switch (4) out and disconnect switch (4) from lead 25A (3) in steering shaft (2).

b. Installation

1. Apply sealing compound to bushing (6).
2. Connect lead 25A (3) to horn switch (4) and push switch (4) into steering shaft (2).
3. Install snapring (5) on horn switch (4) and steering wheel (1).

FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-68).
- Test horn for operation (TM 9-2320-387-10).
4-25. HORN CONTROL BRUSH REPLACEMENT

This task covers:

a. Removal 

b. Installation

INITIAL SETUP:

Tools

General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts

Silicone compound (Appendix C, Item 74)
Grease (Appendix C, Item 32)

Manual References

TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition

Battery ground cables disconnected (para. 4-68)

Maintenance Level

Unit

a. Removal

1. Loosen nut (1) and lower steering column (5).
2. Disconnect lead 25A (3) from horn control brush (4).
3. Remove two screws (2) from horn control brush (4) and pry horn control brush (4) out of steering column (5).
4. Clean silicone compound from steering column (5).

b. Installation

1. Apply grease to brass ring (6) in steering column (5).
2. Apply silicone compound to bottom of horn control brush (4).
3. Install horn control brush (4) on steering column (5) with two screws (2).
4. Connect lead 25A (3) to horn control brush (4).
5. Raise steering column (5) and tighten nut (1) to 31 lb-ft (42 N·m).

FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Check horn for proper operation (TM 9-2320-387-10).
4-26. HORN REPLACEMENT

This task covers:

- a. Horn Replacement With EESS Removal
- b. Horn Replacement With EESS Installation
- c. Horn Replacement Without EESS Removal
- d. Horn Replacement Without EESS Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Lockwasher (Appendix G, Item 190.5)
- Two lockwashers (Appendix G, Item 172)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (TM 9-2320-387-10).

**Maintenance Level**
- Unit

**NOTE**
- Vehicles equipped with engine electrical starting system (EESS) need to perform the following procedure for the fabrication of the jumper wire and installation of the semi-conductor.
- Prior to removal, tag leads for installation reference.

**a. Horn Replacement With EESS Removal**

1. Remove end of jumper wire (3) and lead 26A (2) from horn (4).
2. Remove two capscrews (9), four lockwashers (7) and (8), and horn (4) from bracket (6). Discard four lockwashers (7) and (8).
3. Remove terminal lug (10) from horn mounting base (5).
4. Remove semi-conductor (11) and lead 25A (1) from connector (12).
4-26. HORN REPLACEMENT (Cont’d)

5. Remove two terminals (13), shells (15), and insulators (14) from both ends of jumper wire (3).

b. Horn Replacement With EESS Installation

1. Slide two shells (15) and insulators (14) over both ends of jumper wire (3) and attach two terminals (13) on insulators (14).

2. Connect lead 25A (1) and semi-conductor (11) to connector (12).

3. Install horn (4) and terminal lug (10) of semi-conductor (11) on horn mounting base (5) and bracket (6) using two capscrews (9), lockwashers (8), and lockwashers (7).

4. Connect lead 26A (2) and end of jumper wire (3) to horn (4).
4-26. HORN REPLACEMENT (Cont’d)

NOTE
Prior to removal, tag leads for installation reference.

c. Horn Replacement Without EESS Removal

1. Remove two capscrews (4), lockwashers (5), and horn (2) from bracket (3). Discard lockwashers (5).
2. Disconnect leads 25A (1) and 26A (6) from horn (2).

d. Horn Replacement Without EESS Installation

1. Connect leads 25A (1) and 26A (6) to horn (2).
2. Install horn (2) on bracket (3) with two lockwashers (5) and capscrews (4).

FOLLOW-ON TASKS: • Lower and secure hood (TM 9-2320-387-10).
• Connect battery ground cables (para. 4-68).
• Check horn for proper operation (TM 9-2320-387-10).
4-26.1. HORN REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:
  a. Removal
  b. Installation

INITIAL SETUP:

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<th>Equipment Condition</th>
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<td>(para. 4-68)</td>
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<td>Two lockwashers (Appendix G, Item 146)</td>
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<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-387-24P</td>
</tr>
</tbody>
</table>

a. Removal

1. Disconnect wires 26A (6) and 25C (5) from horn (7).
2. Remove two capscrews (4), lockwashers (3), washers (2), and horn (7) from horn bracket (1). Discard lockwashers (3).

b. Installation

1. Install horn (7) on horn bracket (1) with two washers (2), lockwashers (3), and capscrews (4).
2. Connect wires 26A (6) and 25C (5) to horn (7).

FOLLOW-ON TASK: Connect battery cables (para. 4-68).
4-27. HORN MOUNTING BRACKET REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

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<th>Manual References</th>
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<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
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<th>Maintenance Level</th>
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<tr>
<td>Two lockwashers (Appendix G, Item 144)</td>
<td>Horn removed (para. 4-26)</td>
<td>Unit</td>
</tr>
</tbody>
</table>

a. Removal

Remove two nuts (1), lockwashers (5), capscrews (4), and horn mounting bracket (2) from front crossmember (3). Discard lockwashers (5).

b. Installation

Install horn mounting bracket (2) on front crossmember (3) with two capscrews (4), lockwashers (5), and nuts (1). Tighten nuts (1) to 10 lb-ft (14 N-m).

FOLLOW-ON TASK: Install horn (para. 4-26).
4-28. ENGINE TEMPERATURE SENDING UNIT REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
Sealing compound (Appendix C, Item 61)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
• Battery ground cables disconnected (para. 4-68).
• Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

NOTE
The engine temperature sending unit is located at left front of engine.

a. Removal

1. Disconnect lead 33B (1) from engine temperature sending unit (2).
2. Remove engine temperature sending unit (2) from engine (3).

b. Installation

1. Apply sealing compound to threads of engine temperature sending unit (2).
2. Install engine temperature sending unit (2) on engine (3).
3. Connect lead 33B (1) to engine temperature sending unit (2).

FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Start engine (TM 9-2320-387-10) and check sending unit for leaks.
• Lower and secure hood (TM 9-2320-387-10).
4-29. OIL PRESSURE SENDING UNIT MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Sealing compound (Appendix C, Item 61)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Battery ground cables disconnected (para. 4-68).
- Engine access cover removed (para. 10-22).

Maintenance Level
- Unit

a. Removal

1. Disconnect lead 36A (5) from oil pressure sending unit (4).
2. Remove clamp (1) and oil pressure sending unit (4) from bracket (2).
3. Disconnect oil pressure sending unit (4) from connector (3).

b. Inspection

Inspect connector (3) for damage. Replace if damaged.

c. Installation

1. Apply sealing compound to threads of oil pressure sending unit (4).
2. Connect oil pressure sending unit (4) to connector (3).
3. Install oil pressure sending unit (4) on bracket (2) with clamp (1). Tighten clamp to 10-20 lb-in. (1-2 N-m).
4. Connect lead 36A (5) to oil pressure sending unit (4).
FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Start engine (TM 9-2320-387-10) and check sending unit for leaks.
• Install engine access cover (para. 10-22).
4-30. FUEL PRESSURE TRANSDUCER REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
Sealing compound (Appendix C, Item 61)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

NOTE
The fuel pressure transducer is a sensor unit for diagnostic testing. It is mounted on top of the fuel filter on firewall of vehicle.

a. Removal
1. Disconnect multiple connector (2) from STE/ICE-R wiring harness (3).
2. Remove fuel pressure transducer (1) from fuel filter (4).

b. Installation
1. Apply sealing compound to threads of fuel pressure transducer (1).
2. Install fuel pressure transducer (1) on fuel filter (4).
3. Connect multiple connector (2) to STE/ICE-R wiring harness (3).

FOLLOW-ON TASKS:
- Connect battery ground cables (para. 4-68).
- Start engine (TM 9-2320-387-10) and check fuel pressure transducer for leaks.
- Lower and secure hood (TM 9-2320-387-10).
4-31. COLD-ADVANCE SWITCH REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:  
automotive (Appendix B, Item 1)

Materials/Parts
Sealing compound (Appendix C, Item 61)

Manual References
TM 9-2320-387-24P

Equipment Condition

- Battery ground cables disconnected [para. 4-68].
- Engine coolant drained as necessary [para. 3-61].
- Engine access cover removed [para. 10-22].

Maintenance Level
Unit

NOTE

- The cold-advance switch is located in the right cylinder head water jacket at the rear of the cylinder head just above the exhaust manifold.
- Prior to removal, tag leads for installation.

a. Removal

1. Disconnect leads 569G (1) and 569B (3) from engine harness (2).
2. Remove cold-advance switch (5) from engine (4).

b. Installation

1. Apply sealing compound to threads of cold-advance switch (5).
2. Install cold-advance switch (5) on engine (4).
3. Connect leads 569G (1) and 569B (3) to engine harness (2).

FOLLOW-ON TASKS:

- Connect battery ground cables [para. 4-68].
- Fill cooling system [para. 3-61].
- Install engine access cover [para. 10-22].
4-32. FUEL LEVEL SENDING UNIT REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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<th>Equipment Condition</th>
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<td>Gasket (Appendix G, Item 42)</td>
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</table>

**WARNING**

Diesel fuel is highly flammable. Do not perform this procedure near fire, flame, or sparks. Severe injury or death may result.

**a. Removal**

1. Remove five screws (1) and lockwashers (2) from fuel level sending unit (3) and fuel tank (6). Discard lockwashers (2).
2. Remove fuel level sending unit (3) from inside of fuel tank (6).
3. Remove and discard gasket (4).

**b. Installation**

1. Place gasket (4) on fuel level sending unit (3).
2. Install fuel level sending unit (3) into fuel tank (6), ensuring not to bend float arm (8).
3. Align holes of fuel level sending unit (3) to tank (6) so float (7) is pointed in same direction that tank filler neck (5) points.
4. Install fuel level sending unit (3) on fuel tank (6) with five lockwashers (2) and screws (1). Tighten screws (1) to 32 lb-in. (4 N•m).
FOLLOW-ON TASKS:
- Install fuel tank (para. 3-25).
- Check fuel gauge for proper operation (TM 9-2320-387-10).
4-33. GLOW PLUG CONTROLLER REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

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<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-10</td>
</tr>
<tr>
<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>TM 9-2320-387-24P</td>
</tr>
</tbody>
</table>

Materials/Parts

- Grease (Appendix C, Item 36)
- Sealing compound (Appendix C, Item 61)

Equipment Condition

- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level

Unit

NOTE

It may be necessary to clamp surge tank-to-lower radiator tube to prevent loss of coolant.

a. Removal

1. Disconnect multiple connector (2) from glow plug controller (1).
2. Remove glow plug controller (1) from water crossover (3).

b. Installation

**CAUTION**

- Do not attempt to start engine unless controller has been mounted in engine for a minimum of 10 minutes, or if all glow plugs are disconnected. Damage to glow plugs may result.
- Do not overtighten controller. Damage to water crossover may result.

1. Apply sealing compound to threads of glow plug controller (1).
2. Install glow plug controller (1) on water crossover (3). Tighten controller (1) to 14-20 lb-ft (19-27 N•m).
3. Apply grease to pins (4) of glow plug controller (1).
4. Connect multiple connector (2) to glow plug controller (1).
FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-65).
- Lower and secure hood (TM 9-2320-387-10).
4-34. FAN TEMPERATURE SWITCH REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Equipment Condition
- Battery ground cables disconnected [para. 4-68].
- Hood raised and secured (TM 9-2320-387-10).

Materials/Parts
Sealing compound (Appendix C, Item 61)

Maintenance Level
Unit

NOTE

- The engine temperature switch is located on the top front side of the engine in the water crossover.
- Prior to removal, tag leads for installation.

a. Removal

1. Disconnect engine harness leads 458A (4) and 458B (3) from fan temperature switch (1).
2. Remove fan temperature switch (1) from water crossover (2).

b. Installation

1. Apply sealing compound to threads of fan temperature switch (1).
2. Install fan temperature switch (1) on water crossover (2).
3. Connect engine harness leads 458A (4) and 458B (3) to fan temperature switch (1).

FOLLOW-ON TASKS: • Connect battery ground cables [para. 4-68].
• Lower and secure hood (TM 9-2320-387-10).
4-35. TIME-DELAY MODULE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>General mechanic's tool kit:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>automotive (Appendix B, Item 1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Battery ground cables disconnected [para. 4-68].</td>
</tr>
<tr>
<td>• Hood raised and secured (TM 9-2320-387-10).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-387-10</td>
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<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
</tr>
</tbody>
</table>

a. Removal

1. Disconnect connector plug (3) from control valve connector (5).
2. Disconnect connector plug (2) from engine harness (4).
3. Remove two screws (1) and time-delay module (7) from cowl (6).

b. Installation

1. Install time-delay module (7) on cowl (6) with two screws (1).
2. Connect connector plug (2) to engine harness (4).
3. Connect connector plug (3) to control valve connector (5).

FOLLOW-ON TASKS:  
• Connect battery ground cables [para. 4-68].
• Lower and secure hood (TM 9-2320-387-10).
4-36. BACKUP LIGHT SWITCH REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
<th>Equipment Condition</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic’s tool kit:</td>
<td>TM 9-2320-387-24P</td>
<td>Shift controls housing removed</td>
<td>Unit</td>
</tr>
<tr>
<td>automotive (Appendix B, Item 1)</td>
<td></td>
<td>(para. 5-7).</td>
<td></td>
</tr>
<tr>
<td>Materials/Parts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tiedown strap (Appendix G, Item 328)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**a. Removal**

1. Remove boot (4) from shift controls housing assembly (1).
2. Remove two screws (5) from backup light switch (7) and housing assembly (1).
3. Remove tiedown strap (3) and backup light switch (7) from neutral start switch leads (2). Discard tiedown strap (3).

**b. Installation**

1. Install backup light switch (7) on shift controls housing assembly (1) with two screws (5).
2. Install tiedown strap (3) on leads from backup light switch (7) and neutral start switch leads (2).
3. Position neutral start switch leads (2) and backup light switch (7) leads through boot (4) and install boot (4) on housing assembly (1).
FOLLOW-ON TASK: Install shift controls housing (para. 5-7).
4-37. ENGINE RPM SENSOR REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic’s tool kit:</td>
<td></td>
</tr>
<tr>
<td>automotive (Appendix B, Item 1)</td>
<td>• Battery ground cable disconnected (para. 4-68).</td>
</tr>
<tr>
<td>Manual References</td>
<td>• Hood raised and secured (TM 9-2320-387-10).</td>
</tr>
<tr>
<td>TM 9-2320-387-10</td>
<td>Maintenance Level</td>
</tr>
<tr>
<td>TM 9-2320-387-24P</td>
<td>Unit</td>
</tr>
</tbody>
</table>

a. Removal

1. Disconnect body harness lead (1) from rpm sensor lead (2).
2. Remove screw (4) and clamp (7) from front cover (8).
3. Remove capscrew (3) and rpm sensor (6) from front cover (8).

b. Installation

1. Install rpm sensor (6) in front cover (8) with capscrew (3).
2. Install rpm sensor lead (2) on front cover (8) with clamp (7) and screw (4).
3. Connector rpm sensor lead (2) to body harness lead (1).

FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Lower and secure hood (TM 9-2320-387-10).
### Section IV. TRANSFER CASE AND TRANSMISSION ELECTRICAL MAINTENANCE

#### 4-38. TRANSFER CASE AND TRANSMISSION ELECTRICAL MAINTENANCE TASK SUMMARY

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<th>PROCEDURES</th>
<th>PAGE NO.</th>
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<td>Transmission Circuit Breakers Maintenance</td>
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<tr>
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<tr>
<td>4-47.1</td>
<td>Transmission Control Module (TCM) Capacitor Replacement</td>
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<tr>
<td>4-47.2</td>
<td>Electromagnetic Interference (EMI) Capacitor Assembly Replacement</td>
<td>4-80.2</td>
</tr>
</tbody>
</table>
4-39. TRANSFER CASE INDICATOR SWITCH REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Equipment Condition
Battery ground cables disconnected (para. 4-68)

Maintenance Level
Unit

Manual References
TM 9-2320-387-24P

a. Removal

1. Disconnect leads 511A (4) and 511B (5) from indicator switch leads (3) on transfer case (1).

2. Remove indicator switch (2) from transfer case (1).

b. Installation

1. Install indicator switch (2) on transfer case (1).

2. Connect leads 511A (4) and 511B (5) to indicator switch leads (3).

FOLLOW-ON TASK: Connect battery ground cables (para. 4-68).
This task covers:

a. Removal
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
</thead>
</table>
| General mechanic's tool kit: | • Battery ground cables disconnected (para. 4-68).
| automotive (Appendix B, Item 1) | • Engine access cover removed (para. 10-22). |

<table>
<thead>
<tr>
<th>Manual References</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-387-24P</td>
<td>Unit</td>
</tr>
</tbody>
</table>

**a. Removal**

1. Disconnect lead 511A (8) from lamp assembly lead (7).
2. Remove nut (9), washer (6), ground lead (5), and washer (4) from stud (3).
3. Remove two screws (2) and lamp assembly (10) from body (1).

**b. Installation**

1. Install lamp assembly (10) on body (1) with two screws (2).
2. Install ground lead (5) on stud (3) with washers (4) and (6), and nut (9).
3. Connect lead 511A (8) to lamp assembly lead (7).

**FOLLOW-ON TASKS:**

• Install engine access cover (para. 10-22).
• Connect battery ground cables (para. 4-68).
4-41. TRANSMISSION INDICATOR LAMP ASSEMBLY REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools:
General mechanic’s tool kit:
automotive (Appendix D, Item 1)

Equipment Condition:
• Battery ground cables disconnected (para. 4-68).
• Engine access cover removed (para. 10-22).

Manual References:
TM 9-2320-387-24P

Maintenance Level:
Unit

a. Removal

1. Disconnect lead 657 (4) from lamp assembly lead (5).
2. Remove two screws (2) and lamp assembly (1) from body (3).

b. Installation

1. Install lamp assembly (1) on body (3) with two screws (2).
2. Connect lead 657 (4) to lamp assembly lead (5).

FOLLOW-ON TASKS:
• Install engine access cover (para. 10-22).
• Connect battery ground cables (para. 4-68).
4-42. FAN CUT-OFF SWITCH REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
<th>Maintenance Level</th>
</tr>
</thead>
</table>
| General mechanic’s tool kit: automotive (Appendix B, Item 1) | • Battery ground cables disconnected[(para. 4-68)]  
• Hood raised and secured (TM 9-2320-387-10) | Unit |
| Materials/Parts            |                                          |                   |
| Two locknuts (Appendix G, Item 89) |                                          |                   |
| Manual References          |                                          |                   |
| TM 9-2320-387-10           |                                          |                   |
| TM 9-2320-387-24P          |                                          |                   |

NOTE

Prior to removal, tag leads for installation.

a. Removal

1. Disconnect harness leads 315A/315B (4) from leads 315 (5).
2. Remove two locknuts (1), washers (2), and switch (6) from bracket (3). Discard locknuts (1).

b. Installation

1. Install switch (6) on bracket (3) with two washers (2) and locknuts (1).
2. Connect harness leads 315A/315B (4) to leads 315 (5).

FOLLOW-ON TASKS:

• Connect battery ground cables[(para. 4-68)]
• Lower and secure hood (TM 9-2320-387-10)
4-43. TRANSMISSION CIRCUIT BREAKERS MAINTENANCE

This task covers:

a. Removal

  a.1. Inspection

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
  automotive (Appendix B, Item 1)
  Torque wrench 3/8-in. drive, 75 ft-lb (Appendix B, Item 2.1)

Materials/Parts

Two lockwashers (Appendix G, Item 146)

Manual References

TM 9-2320-387-24P

Equipment Condition

Battery ground cables disconnected (para. 4-68).

Maintenance Level

Unit

NOTE

Prior to removal, tag leads for installation.

a. Removal

NOTE

- Perform steps 1, 2 and 3 for M1113, M1165 (S/N 248731 and below), and M1165A1 (S/N 248731 and below) vehicles only.
- Perform steps 3.1, 3.2 and 3.3 for M1152 and M1152A1 vehicles only.
- Perform steps 4 and 5 for M1114, M1151, M1151A1, M1165, M1165A1 (S/N 248732 and above), and M1167 vehicles only.

1. Remove three capscrews (1) from coverplate (2) and B-beam (3).
2. Remove two nuts (4), washers (5), capscrews (11), and washers (10) from coverplate (2) and B-beam (3).
3. Remove two capscrews (9), lockwashers (8), washers (7), and coverplate (2) from battery box (6). Discard lockwashers (8).
3.1. Remove three capscrews (11.1), lockwashers (11.2), and washers (11.3) from coverplate (2) and B-beam (3). Discard lockwashers (11.2).
3.2. Remove two nuts (4), washers (5), capscrews (11), and washers (10) from coverplate (2) and B-beam (3).
3.3. Remove three capscrews (11.6), washers (11.5), and coverplate (2) from vehicle floor (11.4).
4. Remove two capscrews (15) from coverplate (2) and B-beam (3).
5. Remove two capscrews (14), lockwashers (13), washers (12), and coverplate (2) from battery box (6). Discard lockwashers (13).
6. Disconnect two leads (17) from circuit breaker (18).
7. Remove two nuts (16), circuit breaker (18), and screws (19) from coverplate (2).
4-43. TRANSMISSION CIRCUIT BREAKERS MAINTENANCE (Cont’d)
4-43. TRANSMISSION CIRCUIT BREAKERS MAINTENANCE (Cont’d)

a.1. Inspection

Refer to para. 10-56 for nut insert (20) inspection and replacement.

b. Installation

1. Install circuit breaker (4) on coverplate (1) with two screws (5) and nuts (2).
2. Connect two leads (3) to circuit breaker (4).

**NOTE**
- Perform steps 2.1, 2.2, and 2.3 for M1152, M1152A1 vehicles only.
- Perform steps 3, 4, and 5 for M1113, M1165 (S/N 248731 and below), and M1167 (S/N 248731 and below) vehicles only.
- Perform steps 6 and 7 for M1114, M1151, M1151A1, M1165, M1165A1 (S/N 248732 and above), and M1167 vehicles only.

2.1. Install coverplate (1) on vehicle floor (11.4) with three washers (11.5) and capscrews (11.6).
2.2. Install coverplate (1) on B-beam (3) with two washers (10), capscrews (11), washers (5), and nuts (4).
2.3. Secure coverplate (1) to B-beam (8) with three lockwashers (18), capscrews (17) and washers (19).
3. Install coverplate (1) on battery box (11) with two washers (12), lockwashers (13), and capscrews (14).
   Tighten capscrews (14) to 8 lb-ft (11 N•m).
4. Install coverplate (1) on B-beam (8) with three capscrews (7).
5. Install coverplate (1) on B-beam (8) with two washers (15), capscrews (16), washers (10), and nuts (9).
   Tighten capscrews (16) to 17 lb-ft (23 N•m).
6. Install coverplate (1) on battery box (11) with two washers (24), lockwashers (25), and capscrews (26).
   Tighten capscrews (26) to 8 lb-ft (11 N•m).
7. Secure coverplate (1) to B-beam (8) with two capscrews (27).
FOLLOW-ON TASK: Connect battery ground cables [para. 4-68].
4-44. TRANSMISSION RELAY MAINTENANCE

This task covers:

a. Removal

a.1. Inspection

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Torque wrench 3/8-in. drive, 75 ft-lb
(Appendix B, Item 2.1)

Materials/Parts
Two lockwashers (Appendix G, Item 146)

Manual References
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected
(para. 4-68).

Maintenance Level
Unit

NOTE
Prior to removal, tag leads for installation.

a. Removal

NOTE

- Perform steps 1, 2, and 3 for M1113, M1165 (S/N 248731 and below), and M1165A1 (S/N 248731 and below) vehicles only.
- Perform steps 3.1, 3.2, and 3.3 for M1152 and M1152A1 vehicles only.
- Perform steps 4 and 5 for M1114, M1151, M1151A1, M1165, M1165A1, (S/N 248732 and above), M1167 vehicles only.

1. Remove three capscrews (1) from coverplate (2) and B-beam (3).
2. Remove two nuts (4), washers (5), capscrews (11), and washers (10) from coverplate (2) and B-beam (3).
3. Remove two capscrews (9), lockwashers (8), washers (7), and coverplate (2) from battery box (6). Discard lockwashers (8).
4. Remove three capscrews (11.1), lockwashers (11.2), and washers (11.3) from coverplate (2) and B-beam (3). Discard lockwashers (11.2).
5. Remove three capscrews (11.4), lockwashers (11.5), and washers (11.6) and cover plate (2) from vehicle floor (11.4).
6. Remove two capscrews (15) from coverplate (2) and B-beam (3).
7. Remove two capscrews (14), lockwashers (13), washers (12), and coverplate (2) from battery box (6). Discard lockwashers (13).
8. Disconnect four leads (16) from relay leads (17).

NOTE

M1113 vehicles may be equipped with plusnuts instead of nuts as indicated in step 7.

7. Remove two nuts (20), washers (21), capscrews (18), and relay (19) from coverplate (2).

a.1. Inspection

Refer to para. 10-56 for nut insert (2.1) inspection and replacement.
b. Installation

NOTE

M113 vehicles may be equipped with plusnuts instead of nuts as indicated in step 1.

1. Install relay (19) on coverplate (2) with two capscrews (18), washers (21), and (if removed) nuts (20).
2. Connect four relay leads (17) to leads (16).

NOTE

- Perform steps 2.1, 2.2, and 2.3 for M1152 and M1152A1 vehicles only.
- Perform steps 3, 4, and 5 for M1113, M1165 (S/N 248731 and below), and M1165A1 (S/N 248731 and below) vehicles only.
- Perform steps 6 and 7 for M1114, M1151, M1151A1, M1165, M1165A1, (S/N 248732 and above), M1167 vehicles only.

2.1. Install coverplate (2) on vehicle floor (11.4) with three washers (11.5) and capscrews (11.6).
2.2. Install coverplate (2) on B-beam (3) with two washers (10), capscrews (11), washers (5), and nuts (4).

CAUTION

When installing capscrews into nut inserts, use grade 5 torque value. Failure to do so may damage equipment or components.

2.3 Secure coverplate (2) to B-beam (3) with three lockwashers (11.2), capscrews (11.1) and washers (11.3).
3. Install coverplate (2) on battery box (6) with two washers (7), lockwashers (8), and capscrews (9).
   Tighten capscrews (9) to 8 lb-ft (11 N•m).
4. Install coverplate (2) on B-beam (3) with three capscrews (1).
5. Install coverplate (2) on B-beam (3) with two washers (10), capscrews (11), washers (5), and nuts (4).
   Tighten capscrews (11) to 17 lb-ft (23 N•m).
6. Install coverplate (2) on battery box (6) with two washers (12), lockwashers (13), and capscrews (14).
   Tighten capscrews (14) to 8 lb-ft (11 N•m).
7. Secure coverplate (2) to B-beam (3) with two capscrews (15).
FOLLOW-ON TASK: Connect battery ground cables (para. 4-68).
4-45. TRANSMISSION CONTROL MODULE (TCM) REPLACEMENT

This task covers:  

a. Removal  
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>General mechanic’s tool kit: automotive (Appendix B, Item 1)</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials/Parts</td>
<td>Four lockwashers (Appendix G, Item 145)</td>
</tr>
<tr>
<td>Manual References</td>
<td>TM 9-2320-387-24P</td>
</tr>
</tbody>
</table>
| Equipment Condition | Battery ground cables disconnected  
para. 4-68. |
|                      | Remove left rear passenger seat  
para. 10-45. |
|                      | Remove fixed rear door access panel  
para. 10-21.1. |
| Maintenance Level | Unit |

CAUTION

Ensure ignition switch is OFF before disconnecting or reconnecting Transmission Control Module (TCM). Failure to do this may cause internal damage to TCM.

a. Removal

1. Disconnect harness connector (1) from TCM (5).
2. Remove four screws (2), washers (4), lockwashers (3), and TCM (5) from floor (6). Discard lockwashers (3).

b. Installation

1. Install TCM (5) on floor (6) with four washers (4), lockwashers (3), and screws (2).
2. Connect harness connector (1) to TCM (5).
FOLLOW-ON TASKS:  
• Install fixed rear door access panel (para. 10-21.1)  
• Install left rear passenger seat (para. 10-45).  
• Connect battery ground cables [para. 4-68].
4-45.1. E-PROM REPLACEMENT

This task covers:

| a. Removal                                                                 | b. Installation |

**INITIAL SETUP:**

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- RTV sealant (Appendix C, Item 10)

**Manual References**
- TM 9-2320-387-24P

---

**CAUTION**

Ensure that ignition switch is OFF before replacing E-PROM or disconnecting or reconnecting the Transmission Control Module (TCM). Failure to do this may cause internal damage to TCM.

**NOTE**

For proper calibration of E-PROM to transmission, ensure E-PROM is the same production year as the transmission installed in the vehicle.

---

**a. Removal**

**NOTE**
- Perform step 1 for old configuration.
- Perform step 2 for new configuration.

1. Loosen four screws (1) and remove cover (2) and foam insulation (4) from TCM box (8).
2. Loosen ten screws (1) and remove cover (2), gasket (11), and foam insulation (4) from TCM box (8).
3. Remove two screws (5) and access panel (6) from terminal box (9).
4. Remove E-PROM (10) from circuit board (7).

---

**b. Installation**

**NOTE**
- Perform steps 3 thru 5 for old configuration.
- Perform steps 6 and 7 for new configuration.

1. Install E-PROM (10) on circuit board (7) by pushing it down firmly to ensure it is well seated.
2. Install access panel (6) on terminal box (9) with two screws (5).
3. Clean sealant from TCM box (8) and cover (2).
4. Apply 0.125 in. (3.175 mm) bead of RTV adhesive sealant in groove (3) on cover (2).
5. Install foam insulation (4) and cover (2) on TCM box (8) and tighten four screws (1) to 30 lb-in. (3 N·m).
6. Install gasket (11) on cover (2).
7. Install foam insulation (4) and cover (2) on TCM box (8) and tighten ten screws (1) to 30 lb-in. (3 N·m).
4-45.1. E-PROM REPLACEMENT (Cont’d)

FOLLOW-ON TASKS: • Install fixed rear door access panel (para. 10-20.1).
• Install left rear passenger seat (para. 10-45).
• Connect battery cables (para. 4-73).
4-46. THROTTLE POSITION (TP) SENSOR MAINTENANCE

This task covers:
- a. Removal
- b. Installation
- c. Adjustment

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)

Test Equipment
- Multimeter (Appendix B, Item 155)
- Jumper wire (Appendix B, Item 79)
- Valve gauge block (Appendix B, Item 45)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Air horn removed (para. 3-14).
- Battery ground cables disconnected (para. 4-68).

Maintenance Level
- Unit

a. Removal

CAUTION

The TP sensor is an electrical component and must not be soaked in any liquid cleaner or solvent, or damage may result.

1. Disconnect engine wiring harness connector (3) from TP sensor connector (4).
2. Remove two screws (7), washers (6), and TP sensor (5) from fuel injection pump (1).

b. Installation

1. Ensure throttle is closed, and place TP sensor (5) on throttle shaft (2) of fuel injection pump (1).
2. Rotate TP sensor (5) counterclockwise to align screw holes in sensor (5) with holes in injection pump (1).
3. Install TP sensor (5) on injection pump (1) with two washers (6) and screws (7). Do not tighten screws (7).
4. Adjust TP sensor (5).

c. Adjustment

1. Disconnect engine harness (12) and body harness connectors (11).
2. Install jumper wires between TP sensor connector (4) and body wiring harness connector (11).
3. Connect battery ground cables (para. 4-68).
4. Rotate ignition switch to RUN position (TM 9-2320-387-10).
5. Using a digital multimeter, measure voltage between terminals A and C of TP sensor connector (4). This voltage should be between 4.5 - 5.8 volts. Multiply by 0.33 to obtain the desired TP sensor voltage, and use this figure to adjust TP sensor.

NOTE

For example, 5.00 volts x 0.33 = 1.65 volts (±1% or 0.02 volts tolerance).

5. Install .646 side of valve gauge block between injection pump throttle lever stop screw (8) and housing boss (9) on the injection pump (1).
6. Rotate injection pump throttle lever (10) so that stop screw (8) holds valve gauge block against housing boss (9).
4-46. THROTTLE POSITION (TP) SENSOR MAINTENANCE (Cont’d)

**NOTE**

Keep throttle lever in this position during remainder of adjustment steps.

7. Measure voltage between terminals B and C of TP sensor connector (4).
   a. If measured voltage is within calculated specification, as indicated in step 4, remove jumper wire and connect engine harness connector (3) to TP sensor connector (4).
   b. If voltage is not within calculated specification, go to next step.

8. Loosen TP sensor mounting screws (7) and rotate TP sensor (5) toward rear of vehicle (counterclockwise direction).

9. With voltmeter connected to terminals B and C of TP sensor connector (4), rotate TP sensor (5) slowly toward front of vehicle (clockwise direction) until voltmeter indicates voltage as determined in step 4.

10. Tighten TP sensor mounting screws (7) and confirm that adjustment did not change.

11. Remove jumper wire.

12. Remove valve gauge block.

13. Connect engine wiring harness connector (3) to TP sensor connector (4).

14. Connect body harness connector (11) and engine harness connector (12).

FOLLOW-ON TASK: Install air horn (para. 3-14).
4-47. TRANSMISSION INPUT SPEED SENSOR (TISS) AND OUTPUT SPEED SENSOR (TOSS) MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

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<th>Manual References</th>
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**NOTE**
Replacement procedure for input and output speed sensors are basically the same. This procedure covers the output speed sensor.

### a. Removal

1. Disconnect speed sensor harness connector (5) from sensor (7).
2. Remove nut (10), capscrew (1), washer (2), and harness clip (4) from sensor bracket (8).
3. Remove capscrew (9) from sensor (7) and transmission (3). Slide bracket (8) off sensor (7).
4. Using a twisting motion, remove sensor (7) from transmission (3).

### b. Inspection

Inspect O-ring seal (6) and replace if damaged.

### c. Installation

1. Lubricate O-ring seal (6) with hydraulic fluid and install on sensor (7) if removed.
2. Using a twisting motion, install sensor (7) on transmission (3).
3. Slide bracket (8) over sensor (7) and install capscrew (9).
4. Install harness clip (4) on sensor bracket (8) with washer (2), capscrew (1), and nut (10).
5. Install connector (5) on sensor (7).
FOLLOW-ON TASKS:

- Connect battery ground cables (para. 4-68).
- Start engine (TM 9-2320-387-10) and check operation of transmission.
4-47.1. TRANSMISSION CONTROL MODULE (TCM) CAPACITOR REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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<td>Battery ground cables disconnected (para. 4-68)</td>
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### a. Removal

1. Disconnect TCM capacitor connector (8) from body wiring harness connectors (7).
2. Remove nut (6), screw (1), washer (2), body wiring harness clamp (3), TCM capacitor clamp (4), and TCM capacitor (9) from body wiring harness bracket (5).
3. Remove TCM capacitor (9) from TCM capacitor clamp (4).

### b. Installation

1. Install TCM capacitor (9) on body wiring harness bracket (5) with TCM capacitor clamp (4), body wiring harness clamp (3), washer (2), screw (1), and nut (6).
2. Connect TCM capacitor connector (8) to body wiring harness connector (7).
FOLLOW-ON TASK: Connect battery ground cables (para. 4-68).
4-47.2. ELECTROMAGNETIC INTERFERENCE (EMI) CAPACITOR ASSEMBLY REPLACEMENT

This task covers:
   a. Removal  b. Installation

INITIAL SETUP:

   Tools
   General mechanic’s tool kit: automotive (Appendix B, Item 1)

   Materials/Parts
   Lockwasher

   Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

   Equipment Condition
   Battery ground cable disconnected (para. 4-68).

   Maintenance Level
   Unit

a. Removal

1. Remove screw (1), lockwasher (2), nut (6), and ground terminal (3) from loop clamp (14) and harness clamp (4). Discard lockwasher (2).
2. Remove clamp (14) from capacitor assembly (7).
3. Disconnect plug (8) from connector adapter (9).
4. Disconnect plug (13) from connector adapter (12).
5. Disconnect transmission harness plug (10) and capacitor jumper assembly plug (11) from connector adapter (12).

b. Installation

1. Connect transmission harness plug (10) and capacitor jumper assembly plug (11) to connector adapter (12).
2. Connect plug (13) to connector adapter (12).
3. Connect plug (8) to connector adapter (9).
4. Install clamp (14) on capacitor assembly (7).
5. Secure clamp (14), harness clamp (4), and ground terminal (3) to sensor bracket (5) with screw (1), lockwasher (2), and nut (6).
FOLLOW-ON TASKS: Connect battery ground cable (para. 4-68).
### Section V. LIGHTING SYSTEM MAINTENANCE

#### 4-48. LIGHTING SYSTEM MAINTENANCE TASK SUMMARY

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4-49. SERVICE HEADLIGHT LAMP MAINTENANCE

This task covers:

a. Removal
b. Installation
c. Adjustment

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Personnel Required
One mechanic
Once assistant

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected (para. 4-68).

Maintenance Level
Unit

NOTE
Prior to removal, tag leads for installation.

a. Removal

1. Loosen three screws (1) on retaining ring (2) and remove retaining ring (2) from headlight housing (5).
2. Disconnect leads 17 (4), 18 (6), and 91 (7) from headlight housing (5) and remove lamp (3).

b. Installation

NOTE
Circuit numbers are marked on housing.

1. Connect leads 17 (4), 18 (6), and 91 (7) to headlight housing (5).
2. Install lamp (3) on housing (5) with retaining ring (2) and tighten three screws (1).
3. Connect battery ground cables (para. 4-68).
c. Adjustment

**NOTE**
- Headlamp alignment is basically the same for both headlamps.
- Inflate tires on vehicle before starting procedure. (Refer to TM 9-2320-387-10.)
- Measured height (H) varies depending on model of vehicle and load configuration.

1. Position vehicle on level ground 25 ft. from and facing a vertical wall.
2. Measure height (H) from ground up to center of headlamp (3).
3. Using chalk, draw a horizontal line across vertical wall at center height (H) of headlamp.
4. Draw a vertical line through horizontal line for center position (C) of vehicle.
5. Measure distance from center to center of headlamp (D) and divide measurement in half.
6. Draw two vertical lines (D) at equal distance from center position line (C).
7. Measure down one-twelfth from horizontal line (H) and mark horizontal lines through headlamp vertical lines (D).
8. Turn headlamps on low beam and block out one headlamp.
9. Adjust headlamp (3) using vertical adjusting screw (8) and/or horizontal adjusting screw (9) until center of headlamp beam is aligned with lower horizontal and vertical lines.
10. Repeat steps 8 and 9 for other headlamp.

FOLLOW-ON TASK: Check headlight lamp for proper operation (TM 9-2320-387-10).
4-50. SERVICE HEADLIGHT ASSEMBLY REPLACEMENT

This task covers:

- a. Removal
- b. Installation

INITIAL SETUP:

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**NOTE**

- Prior to removal, tag leads for installation.
- Note position of circuit 91 for installation.

---

**a. Removal**

1. Remove three nuts (4) and washers (5) from headlight assembly (1) and hood (6).
2. Remove leads 17 (2), 18 (3), and 91 (7) from headlight assembly (1).
3. Remove headlight assembly (1) from hood (6).

---

**b. Installation**

**NOTE**

Circuit numbers are marked on headlight next to respective connectors.

1. Connect leads 17 (2), 18 (3), and 91 (7) to headlight assembly (1).
2. Install headlight assembly (1) on hood (6) with three washers (5) and nuts (4).
FOLLOW-ON TASKS:  
- Connect battery ground cables [para. 4-68].
- Lower and secure hood (TM 9-2320-387-10).
- Check adjustment of headlight lamp [para. 4-49].
4-51. BLACKOUT DRIVE LIGHT ASSEMBLY REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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</table>

a. Removal

1. Remove nut (5), lockwasher (6), and special washer (7) from blackout drive light (1) and hood (9). Discard lockwasher (6).
2. Disconnect lead 198 (4) from blackout drive light (1).
3. Remove blackout drive light (1) and coned mounting washer (3) from swivel bracket (11).
4. Disconnect lead 92C (2) from blackout drive light (1).
5. Remove four nut and lockwasher assemblies (8), swivel bracket (11), and plate (10) from hood (9). Discard nut and lockwasher assemblies (8).

b. Installation

1. Install swivel bracket (11) on outside of hood (9), and plate (10) to inside of hood (9) with four nut and lockwasher assemblies (8). Tighten nut and lockwasher assemblies (8) to 16-30 lb-in. (2-3 N-m).
2. Connect lead 92C (2) to blackout drive light (1).
3. Place coned mounting washer (3) and blackout drive light (1) through hole in swivel bracket (11).
4. Connect lead 198 (4) to blackout drive light (1).
5. Install blackout drive light (1) on hood (9) with special washer (7), lockwasher (6), and nut (5).
FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-68).  
- Lower and secure hood (TM 9-2320-387-10).  
- Check blackout drive light for proper operation (TM 9-2320-387-10).
4-52. BLACKOUT DRIVE LIGHT LAMP REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
Gasket (Appendix G, Item 38)
Adhesive (Appendix C, Item 12)
Three gaskets (Appendix G, Item 43)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected (para. 4-68)

Maintenance Level
Unit

a. Removal

1. Loosen three retaining screws (2) on light door (6) and remove light door (6), gasket (3), and three gaskets (5.1) from light body (5). Discard gasket (3) and gaskets (5.1).
2. Remove lamp (4) from light body (5).
3. Clean adhesive from mating surfaces of light door (6) and light body (5).

b. Installation

1. Install lamp (4) on light body (5).
2. Install three gaskets (5.1), gasket (3), and light door (6) on light body (5) with lens hood (1) at top.  

   NOTE
   To prevent moisture from entering light assembly, tighten all screws evenly.
3. Secure light door (6) by tightening three screws (2).
4. Apply thin coat of adhesive to seam between light body (5) and light door (6).
FOLLOW-ON TASKS:  • Connect battery ground cables (para. 4-68).
• Check blackout drive light for proper operation (TM 9-2320-387-10).
4-53. FRONT COMPOSITE LIGHT ASSEMBLY REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Materials/Parts
- Adhesive sealant (Appendix C, Item 12)

Equipment Condition
- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
- Unit

NOTE
- Replacement procedures for right and left front composite light assemblies are basically the same. Left front composite light has four screws securing access cover; right front composite light has three screws. This procedure covers the left front composite light.
- Prior to removal, tag leads for installation.

a. Removal

1. Remove four screws (1), washers (2), and access cover (3) from hood (4).
2. Disconnect leads 20 (5), 461 (12), and 491 (11) from hood wiring harness (6).
3. Remove two capscrews (9), washers (8), ground 92 (7), buss bar (10), and composite light (13) from hood (4).

NOTE
To prevent water from accumulating between composite light access cover and hood, general purpose RTV adhesive sealant should be applied to the inside of cover. Clean and reapply RTV when removing and reinstalling cover.

b. Installation

1. Install composite light (13), buss bar (10), and ground 92 (7) on hood (4) with two washers (8) and capscrews (9).
2. Connect leads 20 (5), 461 (12), and 491 (11) to hood wiring harness (6).
3. Install access cover (3) on hood (4) with four washers (2) and screws (1).
FOLLOW-ON TASKS:

- Connect battery ground cables (para. 4-68).
- Lower and secure hood (TM 9-2320-387-10).
- Check front composite light for proper operation (TM 9-2320-387-10).
4-54. FRONT COMPOSITE LIGHT LAMP REPLACEMENT

This task covers:
 a. Removal
 b. Installation

INITIAL SETUP:

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</table>

a. Removal

1. Loosen five retaining screws (1) and remove light door (2) and O-ring (4) from light body (5). Discard O-ring (4).
2. Remove lamps (3), (6), and (7) from light body (5).
3. Clean adhesive from mating surfaces of light door (2) and light body (5).

b. Installation

1. Install lamps (3), (6), and (7) on light body (5).

**NOTE**

To prevent moisture from entering light assembly, tighten all screws evenly.

2. Install O-ring (4) and light door (2) on light body (5) with five retaining screws (1).
3. Apply thin coat of adhesive to seam between light body (5) and light door (2).

FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Check front composite light for proper operation (TM 9-2320-387-10).
4-55. REAR COMPOSITE LIGHT LAMP REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

**Tools**
- General mechanic’s tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- O-ring (Appendix G, Item 227)
- Adhesive (Appendix C, Item 12)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Battery ground cables disconnected (para. 4-68)

**Maintenance Level**
- Unit

**a. Removal**

1. Loosen six retaining screws (4) and remove composite light door (5) and O-ring (6) from composite light (1). Discard O-ring (6).
2. Remove lamps (2), (3), (7), and (8) from composite light (1).
3. Clean adhesive from mating surfaces of light door (5) and composite light (1).

**b. Installation**

1. Install lamps (2), (3), (7), and (8) on composite light (1).

**NOTE**

To prevent moisture from entering light assembly, tighten all screws evenly.

2. Install O-ring (6) and composite light door (5) on composite light (1) and tighten six screws (4).
3. Apply a thin coat of adhesive to seam between composite light (1) and composite light door (5).

FOLLOW-ON TASKS:
- Connect battery ground cables (para. 4-68).
- Check rear composite light for proper operation (TM 9-2320-387-10).
4-56. SIDE MARKER LIGHT ASSEMBLY REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
- Four locknuts (Appendix G, Item 95) (front only)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (front side marker only) (TM 9-2320-387-10).

Maintenance Level
- Unit

NOTE
Replacement procedures for front and rear side marker light assemblies are basically the same. Front marker lights have locknuts; rear marker lights have plain nuts. This procedure covers the left front side marker.

a. Removal

1. Remove four screws (1), washers (2), and closeoff cover (3) from hood (4).
2. Disconnect lead 489 (15) from hood wiring harness (14).
3. Remove two screws (13), lens (11), and door (12) from side marker light (9).
4. Remove four locknuts (5), washers (6), ground lead 92 (7), screws (10), side marker light (9), and gasket (8) from hood (4). Discard locknuts (5).

b. Installation

1. Install gasket (8), side marker light (9), and ground lead 92 (7) on hood (4) with four screws (10), washers (6), and locknuts (5), ensuring ground lead 92 (7) is under washer (6).
2. Install lens (11) and door (12) on side marker light (9) with two screws (13).
3. Connect lead 489 (15) to hood wiring harness (14).
4. Install closeoff cover (3) on hood (4) with four washers (2) and screws (1).
FOLLOW-ON TASKS:  
- Connect battery ground cables \((\text{para. 4-68})\).
- Lower and secure hood (front side marker only) \((\text{TM 9-2320-387-10})\).
- Check side marker light for proper operation \((\text{TM 9-2320-387-10})\).
4-57. REAR COMPOSITE LIGHT ASSEMBLY REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
   Two lockwashers (Appendix G, Item 146)
   Nut and lockwasher assembly (Appendix G, Item 197)

Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

Equipment Condition
   Battery ground cables disconnected (para. 4-68)

Maintenance Level
   Unit

NOTE
   Prior to removal, tag leads for installation.

a. Removal
   1. Remove two capscrews (3), washers (4), ground lead 95B (5), and ground strap (6) from housing (17).
   2. Remove two capscrews (15) and lockwashers (16) and pull shield (1) away from D-beam (14). Discard lockwashers (16).
   3. Remove nut and lockwasher assembly (12), screw (2), and clamp (11) from shield (1). Discard nut and lockwasher assembly (12).
   4. Disconnect leads 21 (7), 23 (8), 24 (9), and 22-461 (10) from body harness (13).
   5. Remove composite light (18) from housing (17).

b. Installation
   1. Install composite light (18) on housing (17).
   2. Connect leads 21 (7), 23 (8), 24 (9), and 22-461 (10) to body harness (13).
   3. Install clamp (11) on shield (1) with screw (2) and nut and lockwasher assembly (12).
   4. Install shield (1) on D-beam (14) with two lockwashers (16) and capscrews (15).
   5. Install ground strap (6) and ground lead 95B (5) on housing (17) with two washers (4) and capscrews (3).
FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-68).  
- Check rear composite light for proper operation (TM 9-2320-387-10).
4-58. MAIN LIGHT SWITCH REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
  automotive (Appendix B, Item 1)

Materials/Parts
Lockwasher (Appendix G, Item 147)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected (para. 4-68).

Maintenance Level
Unit

a. Removal

1. Disconnect cannon plug (1) from main light switch (8).
2. Remove screw (6), lockwasher (5), single-position lever (4), and washer (7) from lever shaft (9) on switch (8). Discard lockwasher (5).

**NOTE**
Lower right lever must be raised to remove screw.

3. Remove four screws (3) from instrument panel (2) and switch (8).
4. Remove switch (8) from behind instrument panel (2).

b. Installation

**NOTE**
Lower right lever must be raised to install screw.

1. With lever shaft (9) at top of switch (8), install switch (8) on instrument panel (2) with four screws (3).
2. Install washer (7) and single position lever (4) on lever shaft (9) with lockwasher (5) and screw (6).
3. Connect cannon plug (1) to rear of switch (8).

FOLLOW-ON TASKS:
- Connect battery ground cables (para. 4-68).
- Check main light switch for proper operation (TM 9-2320-387-10).
This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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<td>Three assembled washer screws (Appendix G, Item 278.1)</td>
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<td>Four rivets (Appendix G, Item 271.1)</td>
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**NOTE**

- Prior to removal, tag leads for installation.
- Pull back floor insulation for access to beam selector switch and bracket.

1. Remove three assembled washer screws (6), switch (3), and shield (5) from bracket (4). Discard assembled washer screws (6).
2. Disconnect leads 16A (2), 17A (1), and 18A (9) from switch (3).
3. Remove four rivets (7) and bracket (4) from floor (8).

**b. Installation**

1. Install bracket (4) on floor (8) with four rivets (7).
2. Connect leads 16A (2), 17A (1), and 18A (9) to switch (3).
3. Install switch (3) and shield (5) on bracket (4) with three assembled washer screws (6).

FOLLOW-ON TASKS:

- Connect battery ground cables (para. 4-68).
- Check headlight beam selection switch for proper operation (TM 9-2320-387-10).
4-60. STOPLIGHT/TORQUE CONVERTER CLUTCH BRAKE SWITCH MAINTENANCE

This task covers:

a. Removal
b. Installation
c. Adjustment

INITIAL SETUP:

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<th>Materials/Parts</th>
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NOTE
Prior to removal, tag leads for installation.

a. Removal

1. Disconnect leads 75A (1), 75B (16), and connector 810A/810B (15) from switch leads (2).
2. Remove two assembled locknuts (6), washers (4), capscrews (5), washers (4), and switch (3) from mounting bracket (7). Discard assembled locknuts (6).
3. Remove pushnut (14), stoplight switch arm (13), and washer (12) from actuating rod (11). Discard pushnut (14).
4. Remove pushnut (9), actuating rod (11), and washer (10) from brake pedal (8). Discard pushnut (9).

b. Installation

1. Install washer (10) and actuating rod (11) on bracket (8) with pushnut (9).
2. Install washer (12) and stoplight switch arm (13) on actuating rod (11) with pushnut (14).
3. Install switch (3) on mounting bracket (7) with two washers (4), capscrews (5), washers (4), and assembled locknuts (6).
4. Connect leads 75A (1), 75B (16), and connector 810A/810B (15) to switch leads (2).

c. Adjustment

1. Disconnect leads 75A (1), 75B (16), and connector 810A/810B (15) from switch leads (2) and connect multimeter to leads on switch (3) to check continuity. Multimeter should indicate open. Depress brake pedal; multimeter should indicate continuity within approximately 1/4 in. (6 mm) of pedal travel. If not, go to step 2.
2. Loosen two capscrews (5) to allow movement of switch (3).
3. Position switch (3) so that continuity is present when installed. Slide switch forward until no continuity (open) is indicated (approximately 1/4 in. (6 mm)).
4. Tighten two capscrews (5).
5. Connect leads 75A (1), 75B (16), and connector 810A/810B (15) to switch leads (2).
6. Connect battery ground cables (para. 4-68).
7. Turn selector lever to service drive; stoplights should not illuminate. Depress brake pedal; stoplights should illuminate within 1/4 in. (6 mm) of pedal travel.
4-61. DIRECTIONAL SIGNAL FLASHER MAINTENANCE

This task covers:

a. Removal
   a.1. Inspection

b. Installation

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NOTE

The flasher is located under the instrument panel to the left of the steering column.

a. Removal

1. Disconnect cannon plug (8) from main light switch (7).
2. Disconnect connector plug (6) from flasher (5).

   NOTE

   All models except M1113 and M1114 are equipped with nut inserts, not nuts and washers as indicated in step 3.

3. Remove two nuts (4), washers (3), screws (1), and flasher (5) from cowl (2).

a.1. Inspection

Refer to para. 10-56 for nut insert inspection and replacement.

b. Installation

CAUTION

When installing capscrews into nut inserts, use grade 5 torque value. Failure to do so may damage equipment or components.

NOTE

All models except M1113 and M1114 are equipped with nut inserts, not nuts and washers as indicated in step 1.

1. Install flasher (5) on cowl (2) with two screws (1), washers (3), and nuts (4).
2. Apply sealing compound to threads of connector plug (6) and connect connector plug (6) to flasher (5).
3. Connect cannon plug (8) to main light switch (7).

FOLLOW-ON TASKS: • Connect battery ground cables [para. 4-68].
                  • Check directional signal flasher for proper operation (TM 9-2320-387-10).
4-62. DIRECTIONAL SIGNAL CONTROL INDICATOR LAMP REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected (para. 4-68).

Maintenance Level
Unit

a. Removal

1. Push lever (1) to four-way flasher position (TM 9-2320-387-10).
2. Remove light lens (3) from directional control unit (4).
3. Remove lamp (2) from directional control unit (4).

b. Installation

1. Install lamp (2) in directional control unit (4).
2. Install light lens (3) in directional control unit (4).

FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Check directional signal control lamp for proper operation (TM 9-2320-387-10).
4-63. DIRECTIONAL SIGNAL CONTROL REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Equipment Condition**
- Battery ground cables disconnected (para. 4-68).

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Maintenance Level**
- Unit

### a. Removal

1. Loosen connector nut (6) and remove connector plug (7) from directional signal control (4).
2. Remove four screws (2) and directional signal control (4) from bracket (1).

### b. Installation

1. Place lever (5) to HAZARD position.
2. Install directional signal control (4) on bracket (1) with four screws (2). Do not tighten screws (2).
3. Rotate steering wheel, ensuring gauge post (3) mates with directional signal control (4), and tighten screws (2) to 22-26 (30-35 N·m).
4. Install connector plug (7) on directional signal control (4) and tighten connector nut (6).

**FOLLOW-ON TASKS:**
- Connect battery ground cables (para. 4-68).
- Check directional signal control for proper operation (TM 9-2320-387-10).
4-64. DIRECTIONAL SIGNAL CONTROL CANCELLING RING REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

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<td>TM 9-2320-387-24P</td>
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a. Removal

Remove three screws (5) and cancelling ring (4) from steering wheel (6).

b. Installation

**WARNING**

Cancelling pin must be positioned 90° ± 5°. Ensure front wheels of vehicle point straight ahead. Failure to position pin properly could cause loss of steering, causing injury to personnel or damage to equipment.

1. Install cancelling ring (4) on steering wheel (6) with pin (2) 90° ± 5° from directional signal control (1).
2. Rotate steering wheel (6), ensuring pin (2) mates with directional signal control (1) and secure cancelling ring (4) on steering wheel (6) with three screws (5).

**NOTE**

Gauge posts found on a new cancelling ring are there to ensure proper installation only. Gauge posts must be removed after installation of cancelling ring to permit proper operation of directional signal control.

3. Cut gauge posts (3) off within 1/4 in. (6 mm) of base.

**FOLLOW-ON TASK:** Check directional signal control for proper operation (TM 9-2320-387-10).
4-65. SERVICE HEADLIGHT AND BLACKOUT DRIVE LIGHT ELECTRICAL CONNECTOR AND GROMMET REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit: automotive (Appendix B, Item 1)

Equipment Condition
Service headlight lamp removed (para. 4-49).

Manual References
TM 9-2320-387-24P

Maintenance Level
Unit

NOTE

Replacement procedures for connector and grommet from service headlight and blackout drive light are basically the same. The following procedure covers the service headlight.

a. Removal

Remove connector (3) from grommet (1) and remove grommet (1) from headlight housing (2).

b. Installation

Install grommet (1) on headlight housing (2) and install connector (3) on grommet (1).

FOLLOW-ON TASK: Install service headlight lamp (para. 4-49).
# Section VI. BATTERY SYSTEM MAINTENANCE

## 4-66. BATTERY SYSTEM MAINTENANCE TASK SUMMARY

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4-67. BATTERY CABLE TERMINAL CLAMP REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

| Tools | General mechanic’s tool kit: 
automotive (Appendix B, Item 1) |
<table>
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<td>Equipment Condition</td>
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**WARNING**

- Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing battery maintenance. Severe injury will result if acid contacts eyes or skin.
- Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry or disconnected battery ground cable contact battery terminal, a direct short can result, causing instant heating of tools, severe injury to personnel, or damage to equipment.
- When removing battery cable clamps, disconnect both ground cables first. Do not allow tools to come in contact with vehicle when disconnecting cable clamps. A direct short can result, causing instant heating of tools, tool damage, battery damage, or battery explosion.

**NOTE**

The replacement procedure for all four battery cable terminal clamps is basically the same. This procedure covers one battery cable terminal clamp.

**a. Removal**

1. Remove cap (4) from battery terminal boot (8).
2. Clean lubricating oil from battery terminal boot (8).
3. Loosen screw (6) and nut (7) and remove terminal clamp (3) from terminal post (9).
4. Remove screw (2) and nut (5) from cable (1) and terminal clamp (3).
5. Remove cable (1) from terminal clamp (3) and battery terminal boot (8).
6. Remove terminal clamp (3) from battery terminal boot (8).

**b. Installation**

1. Push battery terminal boot (8) onto cable (1).
2. Place terminal clamp (3) into battery terminal boot (8) and install cable (1) on terminal clamp (3) with screw (2) and nut (5).
3. Apply lubricating oil to battery post pad (10). Do not allow lubricating oil to coat terminal post (9).
4. Secure terminal clamp (3) to terminal post (9) by tightening screw (6) and nut (7).
5. Apply lubricating oil to terminal clamp (3).
6. Install cap (4) on battery terminal boot (8).
FOLLOW-ON TASK: Install battery box cover (para. 10-43).
This task covers:

a. Cleaning and Inspection  
b. Ground Cables Disconnection  
c. Ground Cables Reconnection  
d. Ground Cable Removal  
e. Ground Cable Installation  
f. Interconnecting Cable Removal  
g. Interconnecting Cable Installation  
h. Positive Cable Removal  
i. Positive Cable Installation

INITIAL SETUP:

**Tools**
General mechanic’s tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Two lockwashers (Appendix G, Item 153)
- Sodium bicarbonate (Appendix C, Item 76)
- Lubricating oil (Appendix C, Item 46)
- Sealing compound (Appendix C, Item 64)

**Manual References**
TM 9-2320-387-24P

**Equipment Condition**
Battery box cover removed (para. 10-43).

**General Safety Instructions**
- Wear safety goggles and rubber gloves and do not smoke when performing battery maintenance.
- Remove all jewelry.
- When removing battery cables, disconnect ground cables first. Ensure all switches are in OFF position before disconnecting.

**Maintenance Level**
Unit

**WARNING**
- Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing battery maintenance. Severe injury will result if acid contacts eyes or skin.
- Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry or disconnected battery ground cable contact battery terminal, a direct short can result, causing instant heating of tools, severe injury to personnel, or damage to equipment.
- When removing battery cable clamps, disconnect both ground cables first. Ensure all switches are in OFF position before disconnecting. Do not allow tools to come in contact with vehicle when disconnecting cable clamps. A direct short can result, causing instant heating of tools, severe injury to personnel or damage to equipment.

**NOTE**
- If performing transmission diagnostics, record fault codes stored in TCM before disconnecting battery cables.
- When battery cables are disconnected, all stored fault codes in TCM will be lost.
- Secure all cables to head side of mounting capscrews.
- Use this procedure for disconnecting all battery cables.

**a. Cleaning and Inspection**

1. Inspect cables (1), (2), and (11) for corrosion and cracks.
2. Remove defective cables (1), (2), and (11), or clean with wire brush and sodium bicarbonate solution.

4-110  Change 2
4-68. BATTERY CABLE MAINTENANCE (Cont’d)

b. Ground Cables Disconnection

1. Remove nut (12), screw (14), and cable (1) from terminal clamp (13).
2. Remove cap (5) from battery terminal boot (8).
3. Clean lubricating oil from battery terminal boot (8).
4. Loosen nut (7) and remove terminal clamp (4) from terminal (9).
5. Remove nut (3) and screw (6) from cable (2) and terminal clamp (4).
6. Remove cable (2) from terminal clamp (4) and battery terminal boot (8).

c. Ground Cables Reconnection

1. Push battery terminal boot (8) onto cable (2) and secure cable (2) to terminal clamp (4) with screw (6) and nut (3).
2. Apply a 1/16-in. (1.6-mm) bead of lubricating oil to battery post pad (10). Do not allow oil to coat terminal post (9).
3. Install terminal clamp (4) on terminal (9) and tighten nut (7).
4. Fill battery terminal boot (8) with lubricating oil.
5. Install cap (5) on battery terminal boot (8).
6. Install cable (1) on terminal clamp (13) with screw (14) and nut (12).
4-68. BATTERY CABLE MAINTENANCE (Cont’d)

d. Ground Cable Removal

Remove screw (2), lockwasher (6), ground cable (5), and slave cable (4) from shunt (1) and battery box (3). Discard lockwasher (6).

e. Ground Cable Installation

Install slave cable (4) and ground cable (5) on shunt (1) and battery box (3) with lockwasher (6) and screw (2).
4-68. BATTERY CABLE MAINTENANCE (Cont’d)

f. Interconnecting Cable Removal

1. Remove caps (10) and (17) from battery terminal boots (20).
2. Clean lubricating oil from battery terminal boots (20).
3. Loosen nut (19) and remove terminal clamp (16) from battery post (21).
4. Remove nut (15), cable (14), and screw (18) from terminal clamp (16).
5. Remove battery terminal boot (20) from terminal clamp (16).
6. Loosen nut (27) and remove terminal clamp (13) from battery post (25).
7. Remove nut (11) and clamp (12) from holddown rod (23).
8. Remove nut (26), screw (8), cable (14), lead (9), and cable (7) from terminal clamp (13).

g. Interconnecting Cable Installation

1. Push battery terminal boot (20) onto cable (14) and install cable (14) on terminal clamp (16) with screw (18) and nut (15).
2. Install clamp (12) on holddown rod (23) with nut (11).
3. Apply a 1/16-in. (1.6-mm) bead of lubricating oil to battery post pads (22) and (24). Do not allow oil to coat terminal posts (21) and (25).
4. Install battery terminal clamp (16) on battery post (21) and tighten nut (19).
5. Push terminal boot (20) onto cable (7) and install cable (7), lead (9), and cable (14) on battery terminal clamp (13) with screw (8) and nut (26).
6. Install battery terminal clamp (13) on battery post (25) and tighten nut (27).
7. Fill battery terminal boots (20) with lubricating oil.
8. Install caps (10) and (17) on battery terminal boots (20).
h. Positive Cable Removal

1. Disconnect ground cable (task b.).
2. Remove cap (8) from battery terminal boot (11).
3. Clean lubricating oil from battery terminal boot (11).
4. Loosen nut (10) and remove terminal clamp (7) from terminal post (12).
5. Remove screw (6), nut (9), and positive cable (2) from terminal clamp (7) and battery terminal boot (11).
6. Remove nut (5), lockwasher (4), washer (3), and battery positive cable (2) from buss bar (1). Discard

i. Positive Cable Installation

1. Install battery positive cable (2) on buss bar (1) with washer (3), lockwasher (4), and nut (5). Apply silicone compound on cable (2), coating all exposed metallic surfaces.
2. Push battery terminal boot (11) onto positive cable (2) and install cable (2) on terminal clamp (7) with screw (6) and nut (9).
3. Apply a 1/16-in. (1.6-mm) bead of lubricating oil to battery post pad (13). Do not allow oil to coat terminal post (12).
4. Install terminal clamp (7) on terminal post (12) and tighten nut (10).
5. Fill battery terminal boot (11) with lubricating oil.
6. Install cap (8) on terminal boot (11).
7. Connect battery ground cable (task c.).
FOLLOW-ON TASK: Install battery box cover (para. 10-43).
# 4-69. POWER FEED-THROUGH STUD REPLACEMENT

This task covers:

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## a. Removal

1. Slide rubber boot (5) from power feed-through stud (9) and remove nut (1), lockwasher (2), washer (3), lead 6B/6C (4), and starter cable (6) from feed-through stud (9). Discard lockwasher (2).
2. Remove nut (7) and feed-through stud (9) from battery box (8).

## b. Installation

1. Install power feed-through stud (9) on battery box (8) with nut (7).
2. Install starter cable (6) and lead 6B/6C (4) on feed-through stud (9) with washer (3), lockwasher (2), and nut (1). Tighten nut (1) to 18-22 lb-ft (24-30 N·m).
3. Apply sealing compound to feed-through stud (9), starter cable (6), and lead 6B/6C (4), coating all exposed metallic surfaces.
4. Slide rubber boot (5) over feed-through stud (9).
FOLLOW-ON TASK: Install buss bar [para. 4-71].
4-70. 12-VOLT REGULATOR CABLE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts

Four tiedown straps (Appendix G, Item 326)
Lockwasher (Appendix G, Item 185)
Lubricating oil (Appendix C, Item 46)

Manual References

TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition

• Battery ground cables disconnected (para. 4-68).
• Hood raised and secured (TM 9-2320-387-10).
• Engine access cover removed (para. 10-22).

Maintenance Level

Unit

Prior to removal, tag leads for installation.

a. Removal

1. Slide back rubber boot (3) and remove nut (1), washer (2), and cable (4) from regulator (5).
2. Remove four tiedown straps (10) from cable (4). Discard tiedown straps (10).
3. Remove nut (7), lockwasher (8), clamp (9), and cable (4) from stud (6). Discard lockwasher (8).
4. Remove screw (11), clamp (13), and cable (4) from bracket (14).
5. Remove cap (23) from battery terminal boot (22).
6. Clean lubricating oil from battery terminal boot (22).
7. Remove nut (20), screw (17), cable (4), lead (18), and cable (19) from terminal clamp (21). Remove cable (4) from battery box (24).
4-70. 12-VOLT REGULATOR CABLE REPLACEMENT (Cont’d)

b. Installation

1. Position cable (4) in approximate mounting location on stud (6) and through hole in battery box (24).
2. Install cable (19), lead (18), and cable (4) on terminal clamp (21) with screw (17) and nut (20).
3. Fill battery terminal boot (22) with lubricating oil.
4. Install cap (23) on terminal boot (22).
5. Install cable (4) and clamp (13) on bracket (14) with screw (11).
6. Install clamp (9) and cable (4) on stud (6) with lockwasher (8) and nut (7).
7. Install cable (4) on regulator (5) with washer (2) and nut (1). Tighten nut (1) to 18-22 lb-in. (2.0-2.5 N•m). Slide rubber boot (3) over nut (1).
8. Install four tiedown straps (10) on cable (4).

FOLLOW-ON TASKS: • Lower and secure hood (TM 9-2320-387-10).
• Connect battery ground cables (para. 4-68).
• Install engine access cover (para. 10-22).
4-71. BUSS BAR REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Materials/Parts
Five lockwashers (Appendix G, Item 187)
Lockwasher (Appendix G, Item 144)
Lockwasher (Appendix G, Item 167)
Sealing compound (Appendix C, Item 64)

Equipment Condition
Batteries removed (para. 4-74).

Maintenance Level
Unit

a. Removal

1. Remove five nuts (9), lockwashers (8), washers (7), engine harness cable (6), alternator cable (11), battery cable (10), umbilical power cable (12), and slave receptacle cable (13) from buss bar (2). Discard lockwashers (8).

2. Remove nut (5), lockwasher (4), washer (3), capscrew (14), washer (16), lockwasher (15), and buss bar (2) from power feed-through stud (1) and battery box (17). Discard lockwashers (4) and (15).

b. Installation

1. Install buss bar (2) on battery box (17) and power feed-through stud (1) with lockwasher (15), washer (16), capscrew (14), washer (3), lockwasher (4), and nut (5).

2. Install engine harness cable (6), alternator cable (11), battery cable (10), umbilical power cable (12), and slave receptacle cable (13) on buss bar (2) with five washers (7), lockwashers (8), and nuts (9).

3. Apply sealing compound to buss bar (2), coating all exposed metallic surfaces.

FOLLOW-ON TASK: Install batteries (para. 4-74).
### 4-71.1. ADDITIONAL TERMINAL BOARDS REPLACEMENT

This task covers:

a. Removal  
b. Installation

#### INITIAL SETUP:

**Tools**
- General mechanic's tool kit:  
  - automotive (Appendix B, Item 1)  
  - Riveter tool kit (Appendix B, Item 123)

**Materials/Parts**
- Three lockwashers (Appendix G, Item 146)
- Four locknuts (Appendix G, Item 77)
- Five locknuts (Appendix G, Item 133.28)
- Five locknuts (Appendix G, Item 197.2)
- Locknut (Appendix G, Item 197)
- Two rivets (Appendix G, Item 262)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Battery ground cables disconnected (para. 4-68).
- 12-volt auxiliary power outlet removed (para. 4-76.1).

**Maintenance Level**
- Unit

#### a. Removal

1. Remove three self-tapping screws (3) from panel (2) and B-beam (1).
2. Remove two capscrews (4), lockwashers (5), washers (6), and panel (2) from battery box (7). Discard lockwashers (5).
3. Remove four capscrews (10), three 24-volt fuse holders (9), and 12-volt fuse holder assembly (8) from B-beam (1).
4. Remove nut (17), lockwasher (16), and 24-volt terminal board cable (15) from buss bar (14). Discard lockwasher (16).
5. Remove capscrew (11) and ground cable (13) from shunt (12).
4-71.1. ADDITIONAL TERMINAL BOARDS REPLACEMENT (Cont’d)
4-71.1. ADDITIONAL TERMINAL BOARDS REPLACEMENT (Cont’d)

6. Remove panel (3) from battery box (6) and B-beam (11).
7. Remove nut (7), capscrew (10), and 12-volt fuse wire (9) from rear positive battery clamp (8).
8. Remove four locknuts (4), washers (2), capscrews (1), and three relays (5) from panel (3).
   Discard locknuts (4).
4-71.1. ADDITIONAL TERMINAL BOARDS REPLACEMENT (Cont’d)
4-71.1. ADDITIONAL TERMINAL BOARDS REPLACEMENT (Cont’d)

9. Remove two terminal board covers (5) and (6), four locknuts (4), three 24-volt fuse holder wires (3), and 24-volt power cable (9) from 24-volt terminal board (2). Discard locknuts (4).

10. Remove locknut (8) and ground cable assembly (10) from ground terminal board (7). Discard locknut (8).

11. Remove terminal board cover (12), locknut (13), 12-volt fuse wire (11), and link (14) from 12-volt terminal board (15).

12. Remove two locknuts (23), capscrews (20), washers (21), and 12-volt terminal board (22) from panel (1). Discard locknuts (23).

13. Remove three locknuts (19), capscrews (25), washers (24), and 24-volt terminal board (18) from panel (1). Discard locknuts (19).

14. Remove two rivets (17) and ground terminal board (16) from panel (1).

b. Installation

1. Install ground terminal board (16) on panel (1) with two rivets (17).

2. Install 24-volt terminal board (18) on panel (1) with three washers (24), capscrews (25), and nuts (19).

3. Install 12-volt terminal board (22) on panel with two washers (21), capscrews (20), and locknuts (23).

4. Install link (14) and 12-volt fuse wire (11) on 12-volt terminal board (15) with nuts (13) and terminal board cover (12).

5. Install ground cable assembly (10) on ground terminal board (7) with nut (8).

6. Install 24-volt power cable (9) and three 24-volt fuse holder wires (3) on 24-volt terminal board with four nuts (4) and two terminal board covers (6) and (5).
7. Install three relays (5) on panel (3) with four washers (2), capscrews (1), and nuts (4).
8. Install 12-volt fuse wire (9) on rear positive battery clamp (8) with capscrew (10) and nut (7).
9. Install panel (3) on B-beam (11) and battery box (6).
4-71.1. ADDITIONAL TERMINAL BOARDS REPLACEMENT (Cont’d)

10. Install ground cable (13) on shunt (12) with capscrew (11).
11. Install 24-volt terminal board cable (15) on buss bar (14) with lockwasher (16) and nut (17).
12. Install three 24-volt fuse holders (9) and 12-volt fuse holder (8) on B-beam (1) with four capscrews (10).
13. Install panel (2) on battery box (7) with three washers (6), lockwashers (5), and capscrews (4).
14. Install panel (2) on B-beam (1) with three self-tapping screws (3).
FOLLOW-ON TASKS:

- Install 12-volt auxiliary power outlet [para. 4-76.1].
- Install battery ground cables [para. 4-68].
4-72. STARTER POWER CABLES REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit: automotive (Appendix B, Item 1)

Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts

Lockwasher (Appendix G, Item 174)

Tiedown strap (Appendix G, Item 326)

Adhesive sealant (Appendix C, Item 12)

Lockwasher (Appendix G, Item 167)

Lockwasher (Appendix G, Item 187)

Materials/Parts (Cont’d)

Lockwasher (Appendix G, Item 144)

Lockwasher (Appendix G, Item 148)

Assembled locknut (Appendix G, Item 134)

Manual References

TM 9-2320-387-24P

Equipment Condition

Battery ground cables disconnected (para. 4-68).

Maintenance Level

Unit

NOTE

Prior to removal, tag all leads for installation.

a. Removal

1. Slide back rubber boot (1) on starter cable 6A (3) and remove nut (8), lockwasher (9), washer (10), lead 6B/6C (11), and starter cable (3) from power stud (2). Discard lockwasher (9).

2. Remove nut (7), lockwasher (6), and ground cable (5) from ground stud (4). Discard lockwasher (6).

3. Remove nut (16), lockwasher (15), washer (14), and engine harness cable (12) from buss bar (13). Discard lockwasher (15).

4. Remove screw (28), two clamps (30), starter cable (3), and ground cable (5) from starter (22) and remove clamps (30) from cables (3) and (5).

**NOTE**

Perform steps 5 and 6 for M1113 winch equipped vehicles only.

5. Remove nut (31), lockwasher (32), lead 7W (33) (winch vehicles only), STE/ICE-R lead 3D (34), and lead 7A (35) from negative post (41) on starter (22). Discard lockwasher (32).

6. Remove nut (26), lockwasher (25), starter cable (3), positive accessory cable 6W (24), and STE/ICE-R lead 81B (42) from positive post (23). Discard lockwasher (25).

7. Remove screw (36), clip (37), and leads 74A (38) and 74B (39) from solenoid (40).

8. Remove assembled locknut (19), cable (17), and clamp (18) from screw (20). Discard assembled locknut (19).

9. Remove tiedown straps (21) as required. Discard tiedown straps (21).

10. Remove cable (3), ground cable (5), STE/ICE-R harness (27), and coil (29) from vehicle.
b. Installation

1. Install coil (15) on starter cable (10) and ground cable (19). Route STE/ICE-R harness (13) through coil (15), and place cables (10) and (19) and STE/ICE-R harness (13) in approximate mounting locations.

2. Install engine harness cable (29), washer (31), and lockwasher (32) on buss bar (30) with nut (33).

3. Install starter cable (10) and lead 6B/6C (42) on power stud (35) with washer (41), lockwasher (40), and nut (39). Tighten nut (39) to 26 lb-ft (35 N•m). Slide rubber boot (34) over power stud (35).

4. Install ground cable (19) on ground stud (36) with lockwasher (37) and nut (38). Tighten nut (38) to 75 lb-ft (102 N•m).

NOTE

Perform step 5 on M1113 winch equipped vehicles only.

5. Install STE/ICE-R lead 81B (8), positive accessory cable 6V (9), and starter cable (10) on positive post (7) with lockwasher (11) and nut (12). Tighten nut (12) to 25-30 lb-ft (34-41 N•m).

6. Apply sealant to positive post (7) and cable terminals, coating exposed metallic surfaces. The sealant should be evenly applied with a minimum thickness of 0.12 in. (3 mm).

NOTE

Perform step 7 on M1114 vehicles only.

7. Install lead 7V (20) (winch vehicles only), lead (22), and STE/ICE-R 3C lead (21) on negative post (24) with lockwasher (18) and nut (17). Tighten nut (17) to 15-20 lb-ft (20-27 N•m).

8. Install leads 74A (27) and 74B (26) on solenoid (28) with clip (25) and screw (23).

9. Install two clamps (16) on starter cable (10) and ground cable (19) and secure to starter (6) with screw (14).

10. Install cable (1) and clamp (2) on screw (4) with assembled locknut (3).

11. Install tiedown straps (5) as required.
FOLLOW-ON TASK: Connect battery ground cables (para. 4-68).
4-73. BATTERY HOLDDOWN REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Manual References

TM 9-2320-387-24P

Equipment Condition

- Battery box cover removed (para. 10-43).
- Battery ground cables removed (para. 4-68).
- Battery interconnecting cable removed (para. 4-68).
- Battery positive cable removed (para. 4-68).

General Safety Instructions

- Wear safety goggles and rubber gloves, and do not smoke when performing battery maintenance.
- Remove all jewelry.

Maintenance Level

Unit

WARNING

- Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing battery maintenance. Severe injury will result if acid contacts eyes or skin.
- Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry or disconnected battery ground cable contact battery terminal, a direct short can result, causing instant heating of tools, severe injury to personnel, or damage to equipment.

a. Removal

Remove four nuts (2), battery holddown (3), and four holddown rods (1) from batteries (5) and brackets (4).

b. Installation

Install battery holddown (3) on batteries (5) and brackets (4) with four holddown rods (1) and four nuts (2).
FOLLOW-ON TASKS:

- Install battery positive cable (para. 4-68).
- Install battery interconnecting cable (para. 4-68).
- Install battery ground cables (para. 4-68).
- Install battery box cover (para. 10-43).
4-74. BATTERY REPLACEMENT AND SERVICING

This task covers:
a. Removal  
b. Servicing  
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:  
automotive (Appendix B, Item 1)

Manual References
TM 9-6140-200-14
TM 9-2320-387-24P

Equipment Condition
Battery holddown removed (para. 4-73).

GENERAL SAFETY INSTRUCTIONS

- Wear safety goggles and rubber gloves, and do not smoke when performing battery maintenance.
- Remove all jewelry.

MAINTENANCE LEVEL

Unit

WARNING

- Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing battery maintenance. Severe injury will result if acid contacts eyes or skin.
- Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry or disconnected battery ground cable contacts battery terminal, a direct short can result, causing instant heating of tools, severe injury to personnel, or damage to equipment.

a. Removal

Remove two batteries (1) from battery box (2).

b. Servicing

NOTE

For battery testing and servicing instructions, refer to TM 9-6140-200-14.

c. Installation

NOTE

Ensure negative terminal posts are correctly located. Cables must reach their respective terminals without stretching.

Install two batteries (1) in battery box (2).
FOLLOW-ON TASK: Install battery holddown (para. 4-73).
4-75. BATTERY TRAY MAINTENANCE

This task covers:

a. Removal
b. Cleaning and Inspection
c. Preventive Modification
d. Installation

c.1. Inspection

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Four locknuts (Appendix G, Item 77)
- Sodium bicarbonate (Appendix C, Item 76)

Manual References
- TM 9-6140-200-14
- TM 9-2320-387-24P

Equipment Condition
- Batteries removed (para. 4-74)

Maintenance Level
- Unit

a. Removal

NOTE
All vehicles except M1113 and M1114 are equipped with nut inserts, not nuts and washers as indicated.

Remove four locknuts (6), washers (2), capscrews (1), washers (2), and battery tray (3) from battery box (5). Discard locknuts (6).

b. Cleaning and Inspection

NOTE
For additional information on battery box tray cleaning, refer to TM 9-6140-200-14.
1. Clean battery tray (3) with sodium bicarbonate solution.
2. Inspect battery tray (3) for damage. Replace if damaged.
3. Inspect battery cable protectors (4) and battery compartment seals (7) for damage. Replace if damaged.

NOTE
The following step will prevent water from accumulating in the battery tray.
- Refer to hole diagram for location of holes.

Locate, mark, and drill four 1/2-in. holes in battery tray (3).

c. Preventive Modification

NOTE
- The following step will prevent water from accumulating in the battery tray.
- Refer to hole diagram for location of holes.

Refer to para. 10-56 for nut insert inspection and replacement.

d. Installation

CAUTION
When installing capscrews into nut inserts, use grade 5 torque value. Failure to do so may damage equipment or components.

NOTE
All vehicles except M1113 and M1114 are equipped with nut inserts, not nuts and washers as indicated.

Install battery tray (3) on battery box (5) with four washers (2), capscrews (1), washers (2), and locknuts (6). Tighten locknuts (6) to 6 lb-ft (8 N•m).
FOLLOW-ON TASK: Install batteries (para. 4-74).
4-76. SLAVE RECEPTACLE AND CABLE MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

Tools

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Materials/Parts

| Two lockwashers (Appendix G, Item 135) | |
| Lockwasher (Appendix G, Item 153) | |
| Two lockwashers (Appendix G, Item 187) | |
| Silicone compound (Appendix C, Item 75) | |

a. Removal

Prior to removal, tag leads for installation.

1. Remove capscrew (8), lockwasher (9), slave negative cable (10), and battery negative cable (11) from shunt (1). Discard lockwasher (9).
2. Remove two nuts (6), lockwashers (5), washers (4), battery positive cable (7), and slave positive cable (3) from buss bar (2). Discard lockwashers (5).
3. Remove four nuts (15), capscrews (17), and cover (18) from receptacle (16) and battery box (12).
4. Loosen compression nut (22) on backshell (21).
5. Remove backshell (21) from receptacle (16).
6. Remove capscrew (13), lockwasher (14), and slave negative cable (10) from receptacle (16). Discard lockwasher (14).
7. Remove capscrew (19), lockwasher (20), and slave positive cable (3) from receptacle (16). Discard lockwasher (20).
8. Remove receptacle (16) from battery box (12).

b. Inspection

Cover and/or receptacle do not require replacement if dust cover cable is broken. To replace dust cover cable, crimp a terminal ring (NSN 5940-00-143-4794) to each end of a 9-in. (22.9-cm) piece of nylon cord (NSN 4020-00-246-0688).

1. Inspect cover (18) for breaks and cracks. Replace if damaged.
2. Inspect cables (3) and (10) for damage. Replace if damaged.

c. Installation

Slave receptacle cover cord is secured under upper left capscrew.

1. Install receptacle (16) and cover (18) on battery box (12) with four capscrews (17) and nuts (15).
2. Install slave positive cable (3) and battery positive cable (7) on buss bar (2) with two washers (4), lockwashers (5), and nuts (6). Tighten nuts (6) to 26 lb-ft (35 N·m).
3. Install battery negative cable (11) and slave negative cable (10) on shunt (1) with lockwasher (9) and capscrew (8). Tighten capscrew (8) to 8 lb-ft (11 N·m).

4. Install slave positive cable (3) through compression nut (22) and backshell (21) on receptacle (16) with lockwasher (20) and capscrew (19).

5. Install slave negative cable (10) on receptacle (16) with lockwasher (14) and capscrew (13).

6. Apply silicone compound on receptacle (16) terminals, all exposed metal on rear of receptacle (16), and area under cover (18) on front of receptacle (16).

7. Install backshell (21) on receptacle (16).

8. Tighten compression nut (22) on backshell (21).

FOLLOW-ON TASK: Install battery tray [para. 4-75].
4-76.1. 12-VOLT AUXILIARY POWER OUTLET REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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<td>Two lockwashers (Appendix G, Item 145)</td>
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a. Removal

1. Remove terminal board cover (10), nut (11), and 12-volt positive wire (12) from 12 volt terminal board stud (13).
2. Remove nut (8) and 12-volt negative wire (9) from negative terminal board stud (14).
3. Remove four capscrews (1), outlet cap (2), and auxiliary power outlet (7) from bracket (3).
4. Remove two capscrews (6), lockwashers (5), washers (4), bracket (3), and spacer (16) from B-beam (15). Discard lockwashers (5).

b. Installation

1. Install spacer (16) and bracket (3) on B-beam (15) with two washers (4), lockwashers (5), and capscrews (6).
2. Install auxiliary power outlet (7) and outlet cap (2) on bracket (3) with four capscrews (1).
3. Install 12-volt negative wire (9) on negative terminal board stud (14) with nut (8).
4. Install 12-volt positive wire (12) on 12-volt positive terminal board stud (13) with nut (11) and terminal board cover (10).
FOLLOW-ON TASK: Connect battery ground cables (para. 4-68).
4-77. WINCH POWER CABLE REPLACEMENT

This task covers:

a. Front Power Cable Removal
b. Front Power Cable Installation
    c. Rear Power Cable Removal
    d. Rear Power Cable Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Assembled locknut (Appendix G, Item 134)
Lockwasher (M1114) (Appendix G, Item 144)
Lockwasher (M1114) (Appendix G, Item 187)
Lockwasher (M1114) (Appendix G, Item 167)
Five tiedown straps (Appendix G, Item 325)
Five tiedown straps (M1114)
(Appendix G, Item 322)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Batteries removed (M1114 only) [para. 4-74].

Maintenance Level
Unit

a. Front Power Cable Removal

1. Remove capscrew (5) and lead 7 (4) from winch (8).
2. Remove nut (7) and lead 6W (6) from solenoid (3).
3. Remove screw (1) and clamp (9) from lead 7 (4), lead 6W (6), and lower radiator mount (2).
4. Remove screw (11) and clamp (10) from lead 7 (4), lead 6W (6), and bracket (12).
5. Remove two screws (13) and clamps (14) from lead 7 (4), lead 6W (6), and airlift bracket (15).
6. Remove assembled locknut (16), capscrew (18), and clamp (19) from lead 7 (4), lead 6W (6), and bracket (17). Discard assembled locknut (16).
7. Remove nut (23) and lead 7 (4) from starter negative stud (22).
8. Remove nut (20) and lead 6W (6) from starter positive stud (21).

b. Front Power Cable Installation

1. Install lead 6W (6) on starter positive stud (21) with nut (20). Tighten nut (20) to 25-30 lb-ft (34-41 N-m).
2. Install lead 7 (4) on starter negative stud (22) with nut (23). Tighten nut (23) to 15-20 lb-ft (20-27 N-m).
3. Install lead 7 (4) and lead 6W (6) on bracket (17) with clamp (19), capscrew (18), and assembled locknut (16).
4. Install lead 7 (4) and lead 6W (6) on airlift bracket (15) with two clamps (14) and screws (13).
5. Install lead 7 (4) and lead 6W (6) on bracket (12) with clamp (10) and screw (11).
6. Install lead 7 (4) and lead 6W (6) on lower radiator mount (2) with clamp (9) and screw (1).
7. Install lead 6W (6) on solenoid (3) with nut (7).
8. Install lead 7 (4) on winch (8) with capscrew (5).
4-77. WINCH POWER CABLE REPLACEMENT (Cont'd)
4-77. WINCH POWER CABLE REPLACEMENT (Cont’d)

c. Rear Power Cable Removal

1. Remove capscrew (8), lockwasher (7), ground lead (6), and lead 7 (5) from winch (4). Discard lockwasher (7).
2. Remove nut (1) and lead 6W (3) from solenoid (2).
3. Remove nine screws (13), clamps (12), five tiedown straps (11), harness (10), and leads 7 (5) and 6W (3) from body (9). Discard tiedown straps (11).
4. Remove nut (18), lockwasher (19), washer (20), and lead 6W (3) from buss bar (17). Discard lockwasher (19).
5. Remove nut (15), lockwasher (14), and lead 7 (5) from capscrew (16). Discard lockwasher (14).

d. Rear Power Cable Installation

1. Install lead 7 (5) on capscrew (16) with lockwasher (14) and nut (15). Tighten nut (15) to 15-20 lb-ft (20-27 N-m).
2. Install lead 6W (3) on buss bar (17) with washer (20), lockwasher (19), and nut (18). Tighten nut (18) to 15-20 lb-ft (20-27 N-m).
3. Install leads 7 (5), 6W (3), and harness (10) on body (9) with nine clamps (12), screws (13), and five tiedown straps (11).
4. Install lead 6W (3) on solenoid (2) with nut (1).
5. Install lead 7 (5) and ground lead (6) on winch (4) with lockwasher (7) and capscrew (8).
FOLLOW-ON TASKS:  • Install batteries (M1114 only) [para. 4-74].
  • Test winch for proper operation (TM 9-2320-387-10).
4-78. SHUNT REPLACEMENT

This task covers:

  a. Removal  b. Installation

INITIAL SETUP:

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<th>Personnel Required</th>
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<td>One mechanic</td>
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<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>One assistant</td>
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<tr>
<td>Unit</td>
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</table>

**NOTE**

Prior to removal, tag leads for installation.

### a. Removal

1. Remove two screws (11), washers (8), and lockwashers (9) and disconnect leads 7B and 7D (15), 9A (16), and 8A (6) from shunt (17). Discard lockwashers (9).
2. Remove nut (1), lockwasher (2), and starter cable (3) from capscrew (10). Discard lockwasher (2).
3. Remove nut (19), lockwasher (18), and capscrew (10) from shunt (17). Discard lockwasher (18).
4. Remove capscrew (12), lockwasher (13), and two negative cables (14) from shunt (17). Discard lockwasher (13).
5. Remove two assembled locknuts (7), washers (5), capscrews (4), washers (5), and shunt (17) from battery box (20). Discard assembled locknuts (7).

### b. Installation

1. Install shunt (17) on battery box (20) with two washers (5), capscrews (4), washers (5), and assembled locknuts (7). Tighten assembled locknuts (7) to 8 lb-ft (11 N-m).
2. Install two negative cables (14) on shunt (17) with lockwasher (13) and capscrew (12). Tighten capscrew (12) to 8 lb-ft (11 N-m).
3. Install capscrew (10) on shunt (17) with lockwasher (18) and nut (19). Tighten nut (19) to 75 lb-ft (102 N-m).
4. Install starter cable (3) on capscrew (10) with lockwasher (2) and nut (1). Tighten nut (1) to 18-22 lb-ft (24-30 N-m).
5. Install leads 9A (16), 7B and 7D (15), and 8A (6) on shunt (17) with two lockwashers (9), washers (8), and screws (11).
FOLLOW-ON TASK: Install batteries (para. 4-74).
4-79. HOOD JUMPER WIRING HARNESS REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
Lockwasher (Appendix G, Item 144)
Antiseize compound (Appendix C, Item 16)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Side marker light assembly removed (para. 4-56).

Maintenance Level
Unit

CAUTION
Use care when removing harness from vehicle. Failure to do so may cause damage to equipment.

NOTE
Prior to removal, tag leads for installation.

a. Removal

1. Disconnect left and right hood jumper wiring harness connector (1) from body harness connector (2).
4-79. HOOD JUMPER WIRING HARNESS REPLACEMENT (Cont'd)

2. Remove nut (7), lockwasher (8), and special washer (9) from blackout drive light (3) and hood (10). Discard lockwasher (8).

3. Disconnect lead 19B (5) from blackout drive light (3).

4. Remove blackout drive light (3), ground lead 92C (4), and coned mounting washer (6) from swivel bracket (11).

5. Disconnect harness leads 20E (12), 461B (21), and 491C (19) from left composite light terminals (20).

6. Remove capscrew (14), washer (13), and left composite light ground 92B (15) from buss bar (16).

7. Remove rubber grommet (18) from hood (10).

8. Remove hood jumper wiring harness (17) from hood (10).
9. Disconnect harness leads 20F (3), 460B (5), and 491D (6) from right composite light terminals (4).
10. Remove capscrew (2), washer (1), and right composite light ground lead 92A (11) from buss bar (7).
11. Remove rubber grommet (8) from hood (10).
12. Remove hood jumper wiring harness (9) from hood (10).
Use care when installing harness. Failure to do so may cause damage to harness.

1. Position left side hood jumper wiring harness (14) in approximate mounting position.
2. Install rubber grommet (15) on hood (7).
3. Connect ground lead 92C (2) to blackout drive light (1).
4. Place coned mounting washer (9), ground lead 19B (3), and blackout drive light (1) through hole in swivel bracket (8).
5. Install blackout drive light (1) on hood (7) with special washer (6), lockwasher (5), and nut (4).
6. Apply antiseize compound to left composite light ground lead 92C (12) and install on buss bar (13) with washer (10) and capscrew (11).
7. Connect harness leads 20E (19), 461B (18), and 491B (16) to left composite light terminals (17).
8. Position right side jumper wiring harness (9) in approximate mounting position.
9. Install rubber grommet (8) on hood (10).
10. Apply antiseize compound to right composite light ground 92C (11) and install on buss bar (7) with washer (1) and cap screw (2).
11. Connect harness leads 20F (3), 60B (5), and 491B (6) to left composite light terminals (4).
12. Connect left and right side hood jumper wiring harness connector (12) to body harness connector (13).

FOLLOW-ON TASKS:
- Install side marker light assembly (para. 4-56).
- Check front lights for proper operation (TM 9-2320-387-10).
4-80. WIRING HARNESS CONNECTOR REPAIR

This task covers:

a. Terminal-Type Cable Connector Repair  
b. Male Cable Connector Repair  
c. Female Cable Connector Repair  
d. Connector Assembly Repair  
e. Receptacle Assembly Repair  
f. Protective Control Box Lower Cannon Plug Assembly Repair

INITIAL SETUP:

Tools

- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Connector repair kit (Appendix B, Item 154)

Manual References

- TB SIG-222
- TM 9-2320-387-24P

Equipment Condition

Battery ground cables disconnected (para. 4-65).

General Safety Instructions

Remove all jewelry.

Maintenance Level

Unit

WARNING

Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry or disconnected battery ground cable contact battery terminal, a direct short can result, causing instant heating of tools, severe injury to personnel, or damage to equipment.

a. Terminal-Type Cable Connector Repair

1. Strip cable insulation (1) from cable (2) to equal depth of terminal well (4).
2. Slide insulator (3) over cable insulation (1).
3. Insert cable (2) into terminal well (4) and crimp.
4. Slide insulator (3) over crimped end of terminal (5) and apply heat to shrink insulator (3).

b. Male Cable Connector Repair

1. Strip cable insulation (6) from cable (7) to equal depth of terminal well (10).
2. Slide shell (8) over cable insulation (6).
3. Insert cable (7) into terminal well (10) and crimp.
4. Place slotted washer (9) over crimped junction at terminal (11).
5. Slide shell (8) over slotted washer (9) and terminal (11).

4-146
4-80. WIRING HARNESS CONNECTOR REPAIR (Cont'd)

c. Female Cable Connector Repair

1. Strip cable insulation (12) from cable (13) to equal depth of terminal well (16).
2. Slide shell (14) and sleeve (15) over cable insulation (12).
3. Insert cable (13) into terminal well (16) and crimp.
4. Slide shell (14) and sleeve (15) over terminal (17).

\[\text{Diagram of female cable connector repair}\]

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\[\text{Diagram of female cable connector repair}\]

\[\text{Diagram of female cable connector repair}\]

\[\text{Diagram of female cable connector repair}\]

d. Connector Assembly Repair

\textbf{NOTE}

Refer to TB SIG-222 for soldering instructions.

1. Strip cable insulation (18) to depth of solder wells (21) on inserts (22).
2. Slide cable ends (25) through grommet retaining nut (19) and grommet (20).
3. Place cable ends (25) into solder wells (21) and solder.
4. Slide grommet (20) over inserts (22) and press into shell assembly (23) and coupling nut (24) until seated.
5. Screw grommet retaining nut (19) into shell assembly (23) until seated.

\[\text{Diagram of connector assembly repair}\]

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\[\text{Diagram of connector assembly repair}\]

\[\text{Diagram of connector assembly repair}\]

\[\text{Diagram of connector assembly repair}\]
4-80. WIRING HARNESS CONNECTOR REPAIR (Cont’d)

e. Receptacle Assembly Repair

**NOTE**
Refer to TB SIG-222 for soldering instructions.

1. Strip cable insulation (1) to depth of solder wells (5) on inserts (6).
2. Slide cable ends (3) through grommet retaining nut (2) and grommet (4).
3. Place cable ends (3) into solder wells (5) and solder.
4. Slide grommet (4) over inserts (5) and press into receptacle (7) until seated.
5. Screw grommet retaining nut (2) into receptacle (7) until seated.

![Diagram of Receptacle Assembly Repair](image)

f. Protective Control Box Lower Cannon Plug Assembly Repair

1. Strip cable insulation (8) to depth of solder wells (16) on inserts (14).
2. Slide cable ends (10) through grommet retaining nut (9) and grommet (11).
3. Slide insulation sleeving (17) over lead 67A (18).
4. Place cable ends (10) into solder wells (16) and solder.

**NOTE**
Ensure insulation sleeving passes through grommet to provide a water-tight fit.

5. Slide insulation sleeving (17) up to solder well end (15), and heat-shrink insulation sleeving (17).
6. Slide grommet (11) over inserts (14) and press into shell assembly (12) and coupling nut (13) until seated.
7. Install grommet retaining nut (9) into shell assembly (12) until seated.

![Diagram of Protective Control Box Lower Cannon Plug Assembly Repair](image)

**FOLLOW-ON TASK:** Connect battery ground cables (para. 4-68).
# CHAPTER 5
TRANSMISSION AND TRANSFER CASE (UNIT) MAINTENANCE

Section I. TRANSMISSION MAINTENANCE

## 5-1. TRANSMISSION MAINTENANCE TASK SUMMARY

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5-2. TRANSMISSION SERVICE

This task covers:

a. Draining Fluid
b. Transmission Filter Removal
c. Transmission Filter Installation
d. Replenishing Fluid

INITIAL SETUP:

Tools
General mechanic's tool kit:
  automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
  automotive (Appendix B, Item 2)

Materials/Parts
Filter assembly (Appendix G, Item 201)
  (1996 only)
Filter assembly (Appendix G, Item 201.1)
  (1997 and above)
Transmission oil pan gasket
  (Appendix G, Item 47)
Two locknuts (Appendix G, Item 102)
Transmission fluid (Appendix C, Item 37)
Drycleaning solvent (Appendix C, Item 26)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

General Safety Instructions
Drycleaning solvent is flammable and will not be used near an open flame.

Maintenance Level
Unit

a. Draining Fluid

NOTE
- Do not shift through driving gear ranges when warming transmission fluid for removal. Shifting through driving gear ranges is a procedure used only when refilling transmission fluid.
- Transmission should be warm when draining fluid.
- Have drainage container ready to catch fluid.
- Transmission uses two different filter assemblies based on model year. Ensure correct model year for proper filter application.

1. Remove drainplug (1) and gasket (2) from oil pan (3). Allow fluid to drain.

NOTE
Inspect fluid for grit, foaminess, and/or milkiness. If present, refer to DS maintenance (chapter 14).

2. Install gasket (2) and drainplug (1) in oil pan (3) and tighten drainplug (1) to 20 lb-ft (27 N•m).
5-2. TRANSMISSION SERVICE (Cont’d)

b. Transmission Filter Removal

**CAUTION**
Transfer case must be supported during removal and installation of crossmember for access to oil pan capscrew and to prevent damage to equipment.

1. Place support under transfer case and remove two locknuts (3), washers (2), capscrews (6), and crossmember (4) from support brackets (1) and (5). Discard locknuts (3).

**NOTE**
Oil pan gasket is reusable. Discard only if damaged.

2. Remove seventeen capscrews (12), oil pan (11), and gasket (10) from transmission (7).

3. Remove magnet (9) from oil pan (11). Remove filter (8) from transmission (7).

**WARNING**
Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

4. Clean oil pan (11) thoroughly with drycleaning solvent.

c. Transmission Filter Installation

1. Install filter (8) in transmission (7). Install magnet (9) in oil pan (11).

2. Install gasket (10) and oil pan (11) on transmission (7) with seventeen capscrews (12). Tighten capscrews (12) to 18 lb-ft (24 N•m).

3. Install crossmember (4) on support brackets (1) and (5) with two capscrews (6), washers (2), and locknuts (3). Tighten locknuts (3) to 90 lb-ft (122 N•m).

4. Remove support from transfer case.

d. Replenishing Fluid

1. Remove transmission oil dipstick (14) from dipstick tube (13).

2. Check transmission fluid and fill to proper level (TM 9-2320-387-10).

3. Install transmission oil dipstick (14) in dipstick tube (13).
FOLLOW-ON TASK: Start engine (TM 9-2320-387-10) and check for leaks.
5-3. TRANSMISSION OIL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Rear Lines Removal
c. Front Lines Removal
b. Rear Lines Installation
d. Front Lines Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
Three locknuts (Appendix G, Item 77)
Two locknuts (Appendix G, Item 106)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
- Right splash shield removed (front lines)
  (para. 10-24).
- Hood removed (para. 10-7).

General Safety Instructions
Allow transmission to cool before performing this task.

Maintenance Level
Unit

WARNING
Allow transmission to cool before performing this task. Severe injury to personnel may result.

CAUTION
Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

a. Rear Lines Removal

1. Remove two locknuts (32), washers (33), capscrews (4), and washers (5) from four retaining clamps (6) and cooler lines (7) and (31). Discard locknuts (32).
2. Loosen two clamps (1) and disconnect hoses (2) from transfer case (34).

NOTE
Have drainage container ready to catch fluid.

3. Loosen clamps (16) and (19) and disconnect hoses (15) and (20) from lines (17) and (18) and allow fluid to drain.
4. Loosen clamps (22) and (24) and disconnect hoses (21) and (29) from bypass valve (23).
5. Disconnect lines (7) and (8) from transmission (30).
6. Remove lines and hoses as an assembly from vehicle.
7. Loosen two clamps (3) and remove hoses (2) from lines (7) and (31). Remove two clamps (1) and (3) from hoses (2).
8. Loosen hose clamps (12), (14), (25), (26), (27), and (28).
9. Remove hose (9) from line (31) and tee (10). Remove two clamps (28) from hose (9).
10. Remove hose (11) from line (8) and tee (13). Remove clamps (12) from hose (11).
11. Remove hoses (15) and (20) from tees (10) and (13). Remove clamps (14), (16), (19), and (26) from hoses (15) and (20).
12. Remove hoses (21) and (29) from tees (10) and (13). Remove clamps (22), (24), (25), and (27) from hoses (21) and (29).
5-3. TRANSMISSION OIL COOLER LINES REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW) (Cont’d)
5-3. TRANSMISSION OIL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

b. Rear Lines Installation

1. Install clamps (22), (24), (25), and (27) on hoses (21) and (29). Install hoses (21) and (29) on tees (10) and (13).
2. Install clamps (14), (16), (19), and (26) on hoses (15) and (20). Install hoses (15) and (20) on tees (10) and (13).
3. Install two clamps (12) on hose (11). Install hose (11) on line (8) and tee (13).
4. Install two clamps (28) on hose (9). Install hose (9) on line (31) and tee (10).
5. Install two clamps (1) and (3) on two hoses (2). Install hoses (2) on lines (7) and (31).
6. Install lines and hoses as an assembly on vehicle and connect lines (7) and (8) to transmission (30).
7. Connect lines (8) to transfer case (34).
8. Connect hoses (21) and (29) to bypass valve (23).
9. Connect hoses (15) and (20) to lines (17) and (18).
10. Install two washers (5), capscrews (4), washers (33), and locknuts (32) on four retaining clamps (6) and cooler lines (7) and (31).
5-3. TRANSMISSION OIL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)
5-3. TRANSMISSION OIL COOLER LINES REPLACEMENT  
(SERIAL NUMBERS 299999 AND BELOW)

c. Front Lines Removal

1. Remove two locknuts (15), washers (16), capscrews (21), and washers (20) from right radiator support (2) and airlift bracket (22). Discard locknuts (15).
2. Loosen locknut (1) and swing up radiator support (2).
3. Remove locknut (14), washer (13), capscrew (9), washer (10), and capscrews (18) and (27) from clamps (11) and (12), two clamps (17), bracket (19), four clamps (26), and frame (23).
4. Loosen two clamps (25) and disconnect hoses (24) from lines (7) and (8).
5. Loosen two clamps (4) and (6) and remove hoses (5) from oil cooler (3) and lines (7) and (8).
6. Remove clamps (4) and (6) from hoses (5).
7. Remove cooler lines (7) and (8) from vehicle.

d. Front Lines Installation

1. Install cooler lines (7) and (8) on vehicle.
2. Install two clamps (4) and (6) on hoses (5) and install hoses (5) on lines (7) and (8).
3. Connect hoses (5) to oil cooler (3).
4. Connect two hoses (24) to lines (7) and (8) and tighten clamps (25).
5. Install four clamps (26) and cooler lines (7) and (8) on frame (23) with two capscrews (27).
6. Install two clamps (17) and lines (7) and (8) on bracket (19) with capscrew (18).
7. Install clamps (11) and (12) on cooler lines (7) and (8) with washer (10), capscrew (9), washer (13), and locknut (14).
8. Swing radiator support (2) down and install on airlift bracket (22) with two washers (20), capscrews (21), washers (16), and locknuts (15).
9. Tighten locknut (1).
5-3. TRANSMISSION OIL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

FOLLOW-ON TASKS:
- Fill transmission to proper level (TM 9-2320-387-10).
- Start engine (TM 9-2320-387-10) and check for leaks.
- Install right splash shield (front lines) (para. 10-24).
- Install hood (para. 10-7).
5-3.1. TRANSMISSION OIL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Front Lines Removal
b. Front Lines Installation
c. Rear Lines Removal
d. Rear Lines Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Lockwasher (Appendix G, Item 144)
- Locknut (Appendix G, Item 106)

Materials/Parts
- Lockwasher (Appendix G, Item 144)
- Locknut (Appendix G, Item 106)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Engine right splash shield removed (front lines) (para. 10-24.1).

General Safety Instructions
- Allow transmission to cool before performing this task.

Maintenance Level
- Unit

WARNING

Allow transmission to cool before performing this procedure. Severe injury to personnel may occur.

CAUTION

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection. Failure to comply may result in equipment damage.

NOTE

Geared fan vent tube may need to be removed before removing front transmission oil cooler lines.

a. Front Lines Removal

1. Remove hose clamp (22) from hose (21) and line (15).
2. Remove capscrew (25), lockwasher (24), clamps (23) and (26), and lines (14) and (15) from bracket (18). Discard lockwasher (24).
3. Remove capscrew (30), washer (29), clamps (28) and (27), and lines (14) and (15) from bracket (17).
4. Remove capscrew (34), washer (33), clamps (32) and (31), and lines (14) and (15) from bracket (16).
5. Remove locknut (13), washers (12) and (41), capscrew (10), and clamps (11) and (40) from lines (14) and (15). Discard locknut (13).
6. Remove hose clamp (42) and hose (43) from line (15).
7. Remove hose clamps (36) and (44) and tube (37) from hoses (35) and (43).
8. Remove hose clamp (39) and hose (35) from adapter (38).
9. Remove adapter (38) from oil cooler connector (1).
10. Remove hose clamp (6) and hose (5) from line (14).
11. Remove hose clamps (4) and (45) and tube (3) from hoses (5) and (9).
12. Remove hose clamp (8) and hose (9) from adapter (7).
13. Remove adapter (7) from oil cooler connector (2).
14. Remove hose clamp (19) from hose (20) and line (14).

b. Front Lines Installation

1. Install hose (21) on line (15) with hose clamp (22).
2. Install hose (20) on line (14) with hose clamp (19).
3. Install clamps (23) and (26) and lines (14) and (15) on bracket (18) with capscrew (25) and lockwasher (24).
4. Install clamps (28) and (27) and lines (14) and (15) on bracket (17) with capscrew (30) and washer (29).
5. Install clamps (32) and (31) and lines (14) and (15) on bracket (16) with capscrew (34) and washer (33).
6. Install adapter (7) on oil cooler connector (2).
7. Install adapter (7) on hose (9) with hose clamp (8).
8. Install hoses (5) and (9) on tube (3) with hose clamps (4) and (45).
9. Install hose (5) on line (14) with hose clamp (6).
10. Install adapter (38) on oil cooler connector (1).
11. Install hose (35) on adapter (38) with hose clamp (39).
12. Install hoses (35) and (43) on tube (37) with hose clamps (36) and (44).
13. Install hose (43) on line (15) with hose clamp (42).
14. Install clamps (11) and (40) on lines (14) and (15) with capscrew (10), washers (12) and (41), and locknut (13).
5-3.1. TRANSMISSION OIL COOLER LINES REPLACEMENT  
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

c. Rear Lines Removal

1. Remove fitting cover (30), clamp (32), and tube (29) from adapter (31).
2. Remove fitting cover (4), clamp (2), and tube (5) from adapter (3).
3. Remove hose clamps (13) and (17) and hoses (12) and (18) from bypass valve (16).
4. Remove hose clamps (19) and (22) and hoses (20) and (21) from lines (14) and (15).
5. Remove hose clamps (8), (10), and (11) and hoses (7), (12), and (21) from tee (9).
6. Remove hose clamp (6) and hose (7) from tube (5).
7. Remove adapter (3) from transmission (1).
8. Remove hose clamps (23), (25), and (26) and hoses (18), (20), and (27) from tee (24).
9. Remove hose clamp (28) and hose (27) from tube (29).
10. Remove adapter (31) from transmission (1).

d. Rear Lines Installation

1. Install adapter (31) on transmission (1).
2. Install clamp (32), tube (29), and sitting cover (30) on adapter (31).
3. Install hose (27) on tube (29) with hose clamp (28).
4. Install hoses (18), (20), and (27) on tee (24) with hose clamps (23), (25), and (26).
5. Install adapter (3) on transmission (1).
6. Install clamp (2), tube (5), and sitting cover (4) on adapter (3).
7. Install hose (7) on tube (5) with hose clamp (6).
8. Install hoses (7), (12), and (21) on tee (9) with hose clamps (8), (10), and (11).
9. Install hoses (12) and (18) on bypass valve (16) with hose clamps (13) and (17).
10. Install hoses (20) and (21) on lines (14) and (15) with hose clamps (19) and (22).
5-3.1. TRANSMISSION OIL COOLER LINES REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASKS:
- Install engine right splash shield (front lines) (para. 10-24.1).
- Refill transmission and check for leaks (TM 9-2320-387-10).
5-4. TRANSMISSION BYPASS VALVE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Locknut (Appendix G, Item 102)

Manual Reference
- TM 9-2320-387-10
- TM 9-2320-387-24P

General Safety Instructions
- Allow transmission to cool before performing this task.

Maintenance Level
- Unit

WARNING
Allow transmission to cool before performing this task. Severe injury to personnel may result.

CAUTION
Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

a. Removal

1. Loosen hose clamps (1) and (8) on rubber hoses (2) and (9).

   NOTE
   Have drainage container ready to catch fluid.

2. Disconnect rubber hoses (2) and (9) from bypass valve (3).

3. Remove locknut (7), washer (5), capscrew (4), washer (5), and bypass valve (3) from transmission crossmember (6). Discard locknut (7).

b. Installation

1. Install bypass valve (3) on transmission crossmember (6) with washer (5), capscrew (4), washer (5), and locknut (7). Tighten locknut (7) to 90 lb-ft (122 N-m).

2. Connect rubber hoses (2) and (9) to bypass valve (3) and tighten clamps (1) and (8).
FOLLOW-ON TASKS:  • Fill transmission to proper level (TM 9-2320-387-10).
  • Start engine (TM 9-2320-387-10) and check for leaks.
5-5. TRANSMISSION OIL DIPSTICK TUBE REPLACEMENT

This task covers:

   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
      automotive (Appendix B, Item 2)

Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

Equipment Condition
   • Hood raised and secured (TM 9-2320-387-10).
   • Engine access cover removed (para. 10-22).

Maintenance Level
   Unit

NOTE

   • Plug open transmission port to prevent contamination. Remove plug prior to installation of oil dipstick tube.
   • Have drainage container ready to catch fluid.

a. Removal

   1. Remove transmission oil dipstick (5) from dipstick tube (6).
   2. Remove capscrew (11) from dipstick tube (6) and right rear heat shield (9).
   3. Deleted.
   4. Remove nut (2), washer (3), dipstick tube (6), and washer (3) from manifold stud (4).
   5. Remove dipstick tube (6) from transmission (10).

b. Installation

   1. Install O-ring seal (12) on dipstick tube (6).
   2. Install dipstick tube (6) into transmission (10).
   3. Install washer (3) and dipstick tube (6) on manifold stud (4) with washer (3) and nut (2).
   4. Install dipstick tube (6) on right rear heat shield (9) with capscrew (11). Tighten capscrew (11) to 25-37 lb-ft (34-50 N•m).
   5. Install transmission oil dipstick (5) into dipstick tube (6).
FOLLOW-ON TASKS:
- Install engine access cover (para. 10-22).
- Fill transmission to proper level (TM 9-2320-387-10).
- Lower and secure hood (TM 9-2320-387-10).
- Start engine (TM 9-2320-387-10) and check for leaks.
5-6. NEUTRAL START SWITCH REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>Shift controls housing assembly removed (para. 5-7).</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Manual References</th>
<th>Maintenance Level</th>
</tr>
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<td>TM 9-2320-387-10</td>
<td>Unit</td>
</tr>
<tr>
<td>TM 9-2320-387-24P</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE**

Prior to removal, tag leads for installation.

**a. Removal**

1. Remove boot (5) from shift controls housing (1).
2. Remove two screws (3) and neutral start switch (2) from housing (1).

**b. Installation**

1. Install neutral start switch (2) on shift controls housing (1) with two screws (3).
2. Position neutral start switch leads 14 (4) and selector indicator lead 17J (6) through boot (5), and install boot (5) on housing (1).
FOLLOW-ON TASKS:  
- Install shift controls housing assembly [para. 5-7].  
- Check neutral start switch for proper operation (TM 9-2320-387-10).
5-7. SHIFT CONTROLS HOUSING ASSEMBLY REPLACEMENT

This task covers:

a. Removal
   b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
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<tbody>
<tr>
<td>General mechanic's tool kit:</td>
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<tr>
<td>automotive (Appendix B, Item 1)</td>
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</tr>
<tr>
<td>Maintenance and repair shop equipment:</td>
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<tr>
<td>automotive (Appendix B, Item 2)</td>
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<tr>
<td>Two cotter pins (Appendix G, Item 19)</td>
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<tr>
<td>Four locknuts (Appendix G, Item 77)</td>
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<tbody>
<tr>
<td>One mechanic</td>
<td></td>
</tr>
<tr>
<td>One assistant</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE**

If shift controls housing assembly is to be reinstalled, tape trunnions to shift rod to prevent loss of adjustment. Transfer case shift rod trunnion is removed from shift rod only if damaged or shift rods are replaced.

a. Removal

1. Remove cotter pin (5), washer (6), trunnion (9), and rub strip (8) from transmission shift lever arm (10). Discard cotter pin (5).

2. Remove cotter pin (2), washer (3), trunnion (4), and rub strip (7) from transfer case shift arm (1). Discard cotter pin (2).

**NOTE**

Tag leads for installation.

3. Disconnect two body harness leads 14A/14B (14) from neutral start switch leads 14 (19).

4. Disconnect body harness lead (17) from shift selector indicator lead 17J (18).

5. Remove four locknuts (15), washers (16), capscrews (20), and shift controls housing assembly (12) from body (13). Discard locknuts (15).

b. Installation

1. Position shift controls housing assembly (12) in body (13) with transmission lever (11) on right, and install with four capscrews (20), washers (16), and locknuts (15). Tighten locknuts (15) to 6 lb-ft (8 N·m).

2. Connect two body harness leads 14A/14B (14) to neutral start switch leads 14 (19).

3. Connect body harness lead (17) to shift selector indicator lead 17J (18).

4. Install rub strip (7) and trunnion (4) on transfer case shift arm (1) with washer (3) and cotter pin (2).

5. Install rub strip (8) and trunnion (9) on transmission shift lever arm (10) with washer (6) and cotter pin (5).
FOLLOW-ON TASK:
- Connect battery ground cables (para. 4-68).
- Start engine (TM 9-2320-387-10) and check shift controls for proper operation. Adjust as needed (paras. 5-9 and 5-16).
5-8. SHIFT CONTROLS HOUSING ASSEMBLY MAINTENANCE

This task covers:

a. Disassembly
b. Assembly

INITIAL SETUP:

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<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
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<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>Shift controls housing assembly removed (para. 5-7).</td>
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<table>
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<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-387-24P</td>
<td>Unit</td>
</tr>
</tbody>
</table>

a. Disassembly

1. Remove pin (4) and knob (3) from transfer case shift tube (2).
2. Remove pin (6) and knob (5) from transmission shift tube (7).
3. Remove neutral start switch leads (9) from openings in boot (8).
4. Remove shift indicator lead (10) from opening in boot (8).
5. Slide boot (8) off shift controls housing assembly (11).
6. Remove two transmission selector lens covers (1) from shift controls housing assembly (11).
7. Remove two fiber optic indicator strips (17) from bulbs (16).
8. Remove two bulbs (16) from sockets (15).
9. Remove four screws (14), cover plate (13), and gasket (12) from shift controls housing assembly (11).

b. Assembly

1. Install gasket (12) and cover plate (13) on shift controls housing assembly (11) with four screws (14).
2. Install two bulbs (16) in sockets (15).
3. Install two fiber optic indicator strips (17) on bulbs (16).
4. Install two transmission selector lens covers (1) on shift controls housing assembly (11).
5. Install boot (8) on shift controls housing assembly (11), placing neutral start switch and shift indicator leads (9) and (10) through openings in boot (8).
6. Complete sliding boot (8) onto shift controls housing assembly (11), ensuring mounting screw holes align.
7. Install knob (5) on transmission shift tube (7) with pin (6).
8. Install knob (3) on transfer case shift tube (2) with pin (4).
FOLLOW-ON TASK: Install shift controls housing assembly [para. 5-7].
5-9. TRANSMISSION SHIFT ROD MAINTENANCE

This task covers:
  a. Removal
  b. Installation
  c. Adjustment

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
<th>Maintenance Level</th>
</tr>
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<tbody>
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<td>General mechanic’s tool kit:</td>
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<td>Unit</td>
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<td>TM 9-2320-387-24P</td>
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<tr>
<td>Materials/Parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three cotter pins (Appendix G, Item 19)</td>
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</tr>
</tbody>
</table>

a. Removal

1. Place transmission shift lever (7) in neutral.
2. Remove cotter pin (6), washer (5), trunnion (2), and rub strip (4) from shift arm (3). Discard cotter pin (6).
3. Remove cotter pin (13) and washer (12) from rear trunnion (9). Remove trunnion (9) and shift rod (8) from relay lever (11). Discard cotter pin (13).

NOTE
Mark position of rear trunnion on shift rod for installation.
4. Remove cotter pin (10) and trunnion (9) from shift rod (8). Discard cotter pin (10).

b. Installation

1. Install trunnion (9) on shift rod (8) to marked position with cotter pin (10).
2. Install trunnion (9) on relay lever (11) with washer (12) and cotter pin (13). Do not spread cotter pin (13).
3. Install rub strip (4) and trunnion (2) on shift arm (3) with washer (5) and cotter pin (6). Do not spread cotter pin (6).
4. Check shift rod (8) adjustment (task c.).

C A U T I O N

If the manual control linkage is not in proper detent for selector lever position, transmission will be damaged.

NOTE
Proper adjustment makes end of shift rod movement parallel to relay lever movement.

1. Move transmission shift lever (7) to 1 position and ensure lever (1) is in forward detent position 1 or LOW. If not, remove cotter pin (13) and washer (12). Turn trunnion (9) until trunnion (9) aligns with relay lever (11).
2. When adjustment is correct, spread cotter pins (6) and (13).
FOLLOW-ON TASK: Operate vehicle (TM 9-2320-387-10) and test transmission shift lever for proper operation.
### 5-10. TRANSMISSION VENT LINE REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

<table>
<thead>
<tr>
<th></th>
<th>a. Removal</th>
<th>b. Installation</th>
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**INITIAL SETUP:**

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<th>Maintenance Level</th>
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</thead>
<tbody>
<tr>
<td>Silicone compound (Appendix C, Item 74)</td>
<td>Unit</td>
</tr>
</tbody>
</table>

**NOTE**

Insulation may need to be removed to access vent lines.

#### a. Removal

1. Remove vent line (2) from transmission (3) and tee fitting (1).
2. Remove vent line (12) from tee fittings (1) and (11).
3. Remove capscrew (5), clamp (7), and vent line (10) from engine mount bracket (6).
4. Remove capscrew (4), clamp (8), and vent line (10) from bracket (9).
5. Remove vent line (10) from tee fittings (11) and (13).
6. Remove clamps (7) and (8) from vent line (10).

#### b. Installation

1. Install clamps (7) and (8) on vent line (10).
2. Apply RTV silicone compound to tee fittings (11) and (13), and install vent line (10) on tee fittings (11) and (13).
3. Install vent line (10) and clamp (7) on engine mount bracket (6) with capscrew (5).
4. Install vent line (10) and clamp (8) on bracket (9) with capscrew (4).
5. Apply RTV silicone compound to tee fittings (11) and (1), and install vent line (12) on tee fittings (11) and (1).
6. Apply RTV silicone compound to tee fitting (1) and transmission (3) and install vent line (2) on tee fitting (1) and transmission (3).
7. Install insulation if removed.
5-10.1. TRANSMISSION VENT LINE REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
<th>Maintenance Level</th>
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<td>General mechanic's tool kit:</td>
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<tr>
<td>automotive (Appendix B, Item 1)</td>
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<tr>
<th>Materials/Parts</th>
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</thead>
<tbody>
<tr>
<td>Three cable ties (Appendix G, Item 329.5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Removal

1. Disconnect vent line (2) from transmission vent tube (3) and tee fitting (1).
2. Disconnect vent line (4) from tee fittings (1) and (18).
3. Remove cable ties (5), (14), and (16) from vent lines (7) and (17). Discard cable ties (5), (14), and (16).
4. Remove capscrew (10), clamp (9), and vent line (7) from engine mount bracket (6).
5. Remove capscrew (13), clamp (12), and vent line (7) from bracket (11).
6. Disconnect vent line (7) from tee fittings (18) and (8).
7. Remove vent line (7) from heat sleeve (15).

b. Installation

1. Insert vent line (7) into heat sleeve (15).
2. Install vent line (7) on tee fittings (8) and (18).
3. Install vent line (7) and clamp (12) on bracket (11) with capscrew (13).
4. Install vent line (7) and clamp (9) on engine mount bracket (6) with capscrew (10).
5. Install vent line (4) on tee fittings (18) and (1).
6. Install vent line (2) on tee fitting (1) and transmission vent tube (3).
7. Secure vent line (7) to vent lines (17) with cable ties (16), (14), and (5).
5-10.1. TRANSMISSION VENT LINE REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont'd)
5-11. SEALED LOWER CONVERTER HOUSING COVER MAINTENANCE

This task covers:

a. Removal

b. Inspection

c. Installation

INITIAL SETUP:

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<th>Tools</th>
<th>General mechanic’s tool kit: automotive (Appendix B, Item 1)</th>
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<tbody>
<tr>
<td>Materials/Parts</td>
<td>Gasket (Appendix G, Item 51) Adhesive (Appendix C, Item 6) Drycleaning solvent (Appendix C, Item 26)</td>
</tr>
<tr>
<td>Manual References</td>
<td>TM 9-2320-387-24P</td>
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<tr>
<td>Equipment Condition</td>
<td>• Exhaust pipe removed [para. 3-50].</td>
</tr>
<tr>
<td></td>
<td>• Sealed upper converter housing cover removed [para. 5-12].</td>
</tr>
<tr>
<td>General Safety Instructions</td>
<td>Drycleaning solvent is flammable and will not be used near an open flame.</td>
</tr>
<tr>
<td>Maintenance Level</td>
<td>Unit</td>
</tr>
</tbody>
</table>

a. Removal

1. Remove three capscrews (5) and converter housing cover (4) from transmission (2).

2. Remove gasket (3) from converter housing cover (4). Discard gasket (3).

b. Inspection

1. Inspect converter housing cover (4) for pitting, cracking, and excessive wear. Replace if pitted, cracked, or excessively worn.

   **WARNING**

   Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

   2. Remove gasket material and sealant from converter housing cover (4) and transmission (2) with drycleaning solvent.

   **NOTE**

   Gasket must be bent over edge of converter housing cover to ensure gasket seats properly.

   1. Apply adhesive to gasket (3) and install on converter housing cover (4).

   **CAUTION**

   Ensure converter housing cover is seated on oil pan flange to prevent converter housing cover from hitting flywheel and damaging converter housing cover.

   2. Install converter housing cover (4) on flange (1) and transmission (2) with three capscrews (5).
FOLLOW-ON TASKS: • Install exhaust pipe (para. 3-50).  
• Install sealed upper converter housing cover (para. 5-12).
5-12. SEALED UPPER CONVERTER HOUSING COVER (2-PIECE) MAINTENANCE

This task covers:

a. Removal  
b. Inspection  
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
  automotive (Appendix B, Item 1)

Materials/Parts
Gasket (Appendix G, Item 40)  
Adhesive (Appendix C, Item 6)  
Drycleaning solvent (Appendix C, Item 26)  
Adhesive, RTV (Appendix C, Item 10)

Manual References
TM 9-2320-387-24P

Equipment Condition
Battery ground cables disconnected [para. 4-68].

General Safety Instructions
Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

Maintenance Level
Unit

a. Removal

1. Remove two capscrews (4) and converter housing cover (3) from transmission (1).
2. Remove gasket (2) from converter housing cover (3). Discard gasket (2).

b. Inspection

1. Inspect converter housing cover (3) for pitting, cracking, and excessive wear. Replace if pitted, cracked, or excessively worn.

WARNING
Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

2. Remove gasket material and sealant from converter housing cover (3) and transmission (1) with drycleaning solvent.

NOTE
Gasket may require bending over edge of converter housing cover to ensure gasket seats properly.

1. Apply adhesive to gasket (2) and install on converter housing cover (3).
2. Apply RTV adhesive to edge (3.1) of converter housing cover (3) and install converter housing cover (3) on transmission (1) with two capscrews (4).
3. Apply RTV adhesive to fill any gaps between converter housing (3), transmission (1), and starter housing (1.1).
FOLLOW-ON TASK: Connect battery ground cables [para. 4-68].
5-13. TRANSMISSION MOUNT REPLACEMENT

This task covers:

<table>
<thead>
<tr>
<th>a. Removal</th>
<th>b. Installation</th>
</tr>
</thead>
</table>

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Two lockwashers (Appendix G, Item 174)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Transmission mount crossmember removed (para. 9-10)

**Maintenance Level**
- Unit

---

**a. Removal**

Remove two capscrews (4), lockwashers (3), and transmission mount (2) from adapter (1). Discard lockwashers (3).

**b. Installation**

Install transmission mount (2) on adapter (1) with two lockwashers (3) and capscrews (4). Tighten capscrews (4) to 65–70 lb-ft (88–90 N·m).

---

FOLLOW-ON TASK: Install transmission mount crossmember (para. 9-10).
5-14. TRANSMISSION ROAD TEST

This task covers:

Road Test

INITIAL SETUP:

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<th>Tools</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>• Transmission fluid at proper level (TM 9-2320-387-10).</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Manual References</th>
<th>• Adjust transmission shift linkage [para. 5-9].</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-387-10</td>
<td>Maintenance Level</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Road Test</th>
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<tbody>
<tr>
<td>1. Position shift lever in (\text{\textcopyright}) (overdrive), and accelerate vehicle. A 1-2, 2-3, and 3-4 shift should occur at all throttle openings. Allow vehicle to coast down to about 0 mph; 4-3, 3-2, and 2-1 shifts should occur.</td>
</tr>
<tr>
<td>2. Position shift lever in D (drive) and accelerate vehicle. A 1-2 and 2-3 shift should occur at all throttle openings. Allow vehicle to coast down to about 0 mph; 3-2 and 2-1 shifts should occur.</td>
</tr>
<tr>
<td>3. Position shift lever in 2 (low two), and accelerate vehicle. A 1-2 shift should occur at all throttle openings. No 2-3 shift can be obtained in this range. A 1-2 shift in 2 is somewhat firmer than in D. This is normal.</td>
</tr>
<tr>
<td>4. Position shift lever in 1 and accelerate vehicle. No upshifts should occur in this range.</td>
</tr>
<tr>
<td>5. Position shift lever in (\text{\textcopyright}), and with vehicle speed at approximately 45 mph, close throttle and move lever to 3. Transmission should downshift to 3rd gear. An increase in engine rpm and engine braking effect should be noticed.</td>
</tr>
<tr>
<td>6. Position shift lever in D and, with vehicle speed at approximately 35 mph, close throttle and move lever to 2. Transmission should downshift to 2nd gear. An increase in engine rpm and engine braking effect should be noticed.</td>
</tr>
<tr>
<td>7. Position shift lever in 2 and, with vehicle speed at approximately 25 mph, close the throttle and move lever to 1. Transmission should downshift to 1st gear. An increase in engine rpm and engine braking effect should be noticed.</td>
</tr>
<tr>
<td>8. Position shift lever in R, and check for reverse operation.</td>
</tr>
<tr>
<td>9. Hard shifting may indicate an underfilled or clogged system.</td>
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</tbody>
</table>

Section II. TRANSFER CASE MAINTENANCE

5-15. TRANSFER CASE MAINTENANCE TASK SUMMARY

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<td>5-32</td>
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<td>5-17</td>
<td>Speedometer Driven Gear Replacement</td>
<td>5-34</td>
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<tr>
<td>5-17.1</td>
<td>Sender Generator (Electronic) Replacement</td>
<td>5-34.2</td>
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<tr>
<td>5-17.2</td>
<td>Speedometer Driven Gear Replacement (Electronic)</td>
<td>5-34.4</td>
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<td>5-18</td>
<td>Transfer Case Oil Seals Replacement (Serial Numbers 299999 and Below)</td>
<td>5-36</td>
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<tr>
<td>5-18.1</td>
<td>Transfer Case Oil Seals Replacement (Serial Numbers 300000 and Above)</td>
<td>5-38.2</td>
</tr>
<tr>
<td>5-19</td>
<td>Transfer Case Vent Line Replacement (Serial Numbers 299999 and Below)</td>
<td>5-39</td>
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<tr>
<td>5-20</td>
<td>Transfer Case Vent Line Replacement (Serial Numbers 300000 and Above)</td>
<td>5-40</td>
</tr>
</tbody>
</table>
5-16. TRANSFER CASE SHIFT ROD MAINTENANCE

This task covers:

- a. Removal
- b. Installation
- c. Adjustment

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Two cotter pins (Appendix G, Item 21)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Maintenance Level**
- Unit

### a. Removal

1. Remove cotter pin (9) and washer (8) from transfer case shift rod (6) and transfer case range lever (7). Discard cotter pin (9).
2. Remove cotter pin (3), washer (4), shift rod trunnion (1), and rub strip (5) from bearing and arm assembly (2). Discard cotter pin (3).
3. Remove shift rod trunnion (1) from shift rod (6).

### b. Installation

1. Install shift rod trunnion (1) on shift rod (6).
2. Install shift rod (6) into transfer case range lever (7) with washer (8) and cotter pin (9).
3. Adjust shift rod (6) (task c.).

### c. Adjustment

**NOTE**

The shift rod must be adjusted so that the detents of the transfer case lever correspond with the positions on the transfer case name plate.

1. Ensure parking brake lever (10) is engaged and place transmission shift lever (12) in D (drive) position.
2. Place transfer case shift lever (13) all the way forward in HL (high lock) position.
3. Place long screwdriver in front of parking brake lever (10) and transmission shift lever (12), and behind knob (11) on transfer case shift lever (13) to hold transfer case shift lever (13) forward.
4. Place transfer case range lever (7) in the rearward position, HL.
5. Install rub strip (5) on arm assembly (2).
6. Turn shift rod trunnion (1) so that it slips easily into hole in bearing and arm assembly (2).
7. Secure shift rod trunnion (1) to bearing and arm assembly (2) with washer (4) and cotter pin (3).
8. Remove screwdriver from transfer case shift lever (13) and place transmission shift lever (12) in N (neutral) position.
FOLLOW-ON TASK: Operate vehicle (TM 9-2320-387-10) and check for proper shifter operation.
This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Special Tools
- Mirror, inspection (Appendix B, Item 84)

Materials/Parts
- O-ring (Appendix G, Item 219)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Maintenance Level
- Unit

a. Removal

1. Disconnect flex driveshaft (1) from correction adapter (2).
2. Loosen nut (3) and remove correction adapter (2) from pinion adapter (6).
3. Remove capscrew (4) and clamp (5) from pinion adapter (6) and transfer case (8).
4. Pull pinion adapter (6) out of transfer case (8).
6. Remove driven gear (9) from transfer case (8).

b. Installation

1. Install O-ring (7) on pinion adapter (6).

   **NOTE**
   
   Note number stamped on driven gear.

2. Install driven gear (9) into pinion adapter (6).

   **NOTE**
   
   Numbers on pinion adapter represent numbers stamped on driven gear. When installing adapter, numbers on adapter must match numbers on transfer case housing.

3. Install and align pinion adapter (6) into transfer case (8) with clamp (5) and capscrew (4). Tighten capscrew (4) to 15 lb-ft (20 N·m).
4. Install correction adapter (2) on pinion adapter (6) and tighten nut (3).
5. Connect flex driveshaft (1) to correction adapter (2).
FOLLOW-ON TASK: Operate vehicle (TM 9-2320-387-10) and check speedometer for proper operation.
5-17.1. SENDER GENERATOR (ELECTRONIC) REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
automotive (Appendix B, Item 1)

Materials/Parts

Two tiedown straps (Appendix G, Item 324)

Manual References

TM 9-2320-387-24P

Equipment Condition

Battery cables disconnected (para. 4-68).

Maintenance Level

Unit

a. Removal

1. Remove tiedown strap (9) and shielding sleeve (10) from sender generator (4). Discard tiedown strap (9).

2. Remove tiedown strap (8) and excess wiring (3) from sender generator (4). Discard tiedown strap (8).

3. Disconnect speedometer harness connector (1) from sender generator harness connector (2).

4. Remove sender generator (4) from pinion adaptor (5) on transfer case (6).

NOTE

Sender generator drive tang can be removed if necessary to replace.

5. Remove sender generator drive tang (7) from sender generator (4).

b. Installation

NOTE

Place any excess wiring inside sender generator shielding sleeve.

1. Install sender generator tang (7) in sender generator (4).

2. Install sender generator (4) on pinion adapter (5) on transfer case (6).

3. Connect speedometer harness connector (1) to sender generator harness connector (2).

4. Install excess wiring (3) on sender generator (4) with tiedown strap (8).

5. Install shielding sleeve (10) on sender generator (4) with tiedown strap (9).
5-17.1. SENDER GENERATOR (ELECTRONIC) REPLACEMENT (Cont’d)

FOLLOW-ON TASK: Connect battery cables (para. 4-68).
5-17.2. SPEEDOMETER DRIVEN GEAR (ELECTRONIC) REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment
  - automotive (Appendix B, item 2)

Materials/Parts
- O-ring (Appendix G, Item 219)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Sender generator (electronic) removed (para. 5-17.1).

Maintenance Level
- Unit

a. Removal

1. Remove capscrew (2) and clamp (3) from pinion adapter (1) and transfer case (6).
2. Pull pinion adapter (1) out of transfer case (6).
4. Remove driven gear (5) from transfer case (6).

b. Installation

1. Install O-ring (4) on pinion adapter (1).
2. Install driven gear (5) into pinion adapter (1).
3. Install and align pinion adapter (1) into transfer case (6) with clamp (3) and capscrew (2). Tighten capscrew (2) to 15 lb-ft (20 N•m).
FOLLOW-ON TASKS:

- Install sender generator (para. 5-17.1).
- Check speedometer for proper operation (TM 9-2320-387-10).
5-18. TRANSFER CASE OIL SEALS REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

- a. Front Oil Seal Removal
- b. Front Oil Seal Installation
- c. Rear Oil Seal Removal
- d. Rear Oil Seal Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Materials/Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic’s tool kit: automotive (Appendix B, Item 1)</td>
<td>Seal, lockwasher (Appendix G, Item 298)</td>
</tr>
<tr>
<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>Manual References</td>
</tr>
<tr>
<td>Special Tools</td>
<td></td>
</tr>
<tr>
<td>Front seal installer (Appendix B, Item 96)</td>
<td>TM 9-2320-387-10</td>
</tr>
<tr>
<td>Rear seal installer (Appendix B, Item 95)</td>
<td>TM 9-2320-387-24P</td>
</tr>
<tr>
<td>Drive handle (Appendix B, Item 60)</td>
<td>Maintenance Level</td>
</tr>
<tr>
<td></td>
<td>Unit</td>
</tr>
</tbody>
</table>

a. Front Oil Seal Removal

1. Remove four capscrews (4), two straps (3), and front propeller shaft (1) from output yoke (2).

   **NOTE**
   Have drainage container ready to catch fluid.

2. Remove nut (5), lockwasher seal (6), and output yoke (2) from transfer case (8). Discard lockwasher seal (6).

3. Remove output oil seal (7) from transfer case (8).

b. Front Oil Seal Installation

   **NOTE**
   Ensure rubber surface of seal faces front seal installer.

1. Using front seal installer and drive handle, install oil seal (7) on transfer case (8).

2. Install lockwasher seal (6) and output yoke (2) on transfer case (8) with nut (5). Tighten nut (5) to 110 lb-ft (149 N•m).

3. Connect front propeller shaft (1) to output yoke (2) with two straps (3) and four capscrews (4). Tighten capscrews (4) to 13-18 lb-ft (18-24 N•m).
5-18. TRANSFER CASE OIL SEALS REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW) (Cont’d)
5-18. TRANSFER CASE OIL SEALS REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW)

**c. Rear Oil Seal Removal**
1. Remove rear propeller shaft (para. 6-4).
2. Remove oil seal (1) from transfer case extension (2).

**d. Rear Oil Seal Installation**
1. Using rear seal installer, install oil seal (1) on transfer case extension (2).
2. Install rear propeller shaft (para. 6-4).

FOLLOW-ON TASK: Fill transfer case fluid to proper level (TM 9-2320-387-10).
5-18.1. TRANSFER CASE OIL SEALS REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Front Oil Seal Removal
b. Front Oil Seal Installation
c. Rear Oil Seal Removal
d. Rear Oil Seal Installation

INITIAL SETUP:

**Tools**
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Special Tools**
- Front seal installer (Appendix B, Item 96)
- Rear seal installer (Appendix B, Item 95)
- Drive handle (Appendix B, Item 60)

**Materials/Parts**
- Four lockwashers (Appendix A, Item 145)
- Seal, lockwasher (Appendix A, Item 298)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Rear propeller shaft removed (para. 6-4).

**Maintenance Level**
- Unit

---

**a. Front Oil Seal Removal**

1. Remove four nuts (3), lockwashers (2), two U-bolts (5), and front propeller shaft (1) from output yoke (4). Discard lockwashers (2).

   **NOTE**
   Have drainage container ready to catch fluid.

2. Remove nut (6), lockwasher seal (7), output yoke (4), and output seal (8) from transfer case (9). Discard lockwasher seal (7).

**b. Front Oil Seal Installation**

1. Using front seal installer and drive handle, install output seal (8) on transfer case (9).

2. Install output yoke (4) on transfer case (9) with lockwasher seal (7) and nut (6). Tighten nut (6) to 110 lb-ft (149 N·m).

3. Install front propeller shaft (1) on output yoke (4) with two U-bolts (5), four lockwashers (2), and nuts (3). Tighten nuts (3) to 13–18 lb-ft (12–24 N·m).

**c. Rear Oil Seal Removal**

Remove oil seal (10) from transfer case extension (11).

**d. Rear Oil Seal Installation**

Using rear seal installer, install oil seal (10) on transfer case extension (11).
FOLLOW-ON TASKS:

- Install rear propeller shaft (para. 6-4).
- Fill transfer case fluid to proper level (TM 9-2320-387-10).
5-19. TRANSFER CASE VENT LINE REPLACEMENT
(SErial NUMBERS 299999 AND BELOW)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Maintenance Level
Unit

a. Removal

1. Disconnect vent line (2) from elbow (1) on transfer case (4).
2. Remove vent line (2) from tee fitting (3).

b. Installation

1. Install vent line (2) on tee fitting (3).
2. Connect vent line (2) to elbow (1) on transfer case (4).
5-20. TRANSFER CASE VENT LINE REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
       automotive (Appendix B, Item 1)

Manual References
   TM 9-2320-387-24P

Maintenance Level
   Unit

a. Removal

1. Disconnect vent line (2) from tee fitting (1) and vent line adapter (4).
2. Remove vent line adapter (4) from transfer case (3).

b. Installation

1. Install vent line adapter (4) on transfer case (3).
2. Connect vent line (2) to vent line adapter (4) and tee fitting (1).
### 6-1. PROPELLER SHAFTS MAINTENANCE TASK SUMMARY

<table>
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</tbody>
</table>
# 6-2. FRONT PROPELLER SHAFT ASSEMBLY MAINTENANCE

This task covers:

- **a. Removal**
- **b. Inspection**
- **c. Installation**

## INITIAL SETUP:

### Tools

General mechanic's tool kit:
- automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
- automotive (Appendix B, Item 2)

### Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P

### Maintenance Level

Unit

### Materials/Parts

- Cotter pin (Appendix G, Item 21)
- Two locknuts (Appendix G, Item 128)
- Four lockwashers (Appendix G, Item 145)
  (Serial numbers 300000 and above)

## NOTE

Propeller shaft bearing caps should be taped together to prevent loss of bearings.

### a. Removal

1. Remove four capscrews (3) and two bearing straps (2) from front propeller shaft assembly (4) and differential pinion yoke (1).

2. Remove four nuts (7), lockwashers (8), and two U-bolts (11) from front propeller shaft assembly (4) and transfer case output yoke (9). Discard lockwashers (8).

3. Remove cotter pin (14), washer (13), and transfer case shift rod (12) from transfer case shift lever (6). Discard cotter pin (14).

4. Remove two locknuts (15), washers (16), capscrews (18), washers (16), and center bearing (17) from engine mount (19). Discard locknuts (15).

5. Move front propeller shaft assembly (4) forward, then rearward, over top of transfer case (5) and exhaust pipe (10), and remove front propeller shaft assembly (4).

### b. Inspection

1. Inspect driveshaft (21) and coupling shaft (22) for cracks and damage. Replace either if cracked or damaged (para. 6-3).

2. Inspect grease fittings (23) and universal joints (20) for serviceability. Replace universal joints (20) or grease fittings (23) if unserviceable (para. 6-3).

3. Inspect center bearing (17) for roughness or damage. Replace coupling shaft (22) if center bearing (17) is rough or damaged (para. 6-3).
6-2. FRONT PROPELLER SHAFT ASSEMBLY MAINTENANCE (Cont’d)

c. Installation

1. Position front propeller shaft assembly (4) over exhaust pipe (10) and over top of transfer case (5).
2. Install front propeller shaft assembly (4) on differential pinion yoke (1) with two bearing straps (2) and four capscrews (3). Tighten capscrews (3) to 13-18 lb-ft (18-24 N·m).
3. Install center bearing (17) on engine mount (19) with two washers (16), capscrews (18), washers (16), and locknuts (15). Tighten capscrews (18) to 60 lb-ft (81 N·m).
4. Install transfer case shift rod (12) on transfer case shift lever (6) with washer (13) and cotter pin (14).
5. Install front propeller shaft assembly (4) on transfer case output yoke (9) with two U-bolts (11), four lockwashers (8), and nuts (7). Tighten nuts (7) to 13-18 lb-ft (18-24 N·m).
FOLLOW-ON TASK: Lubricate propeller shaft assembly (TM 9-2320-387-10).
6-3. FRONT PROPELLER SHAFT ASSEMBLY REPAIR

This task covers:

a. Disassembly  
b. Cleaning and Inspection  
c. Assembly

INITIAL SETUP:

Tools
General mechanic's tool kit:
  automotive (Appendix B, Item 1)  
Maintenance and repair shop equipment:
  automotive (Appendix B, Item 2)

Materials/Parts
Dust cap (Appendix G, Item 31)  
Grease (Appendix C, Item 34)  
Drycleaning solvent (Appendix C, Item 26)

Main Reference
TM 9-2320-387-24P

a. Disassembly

NOTE
Prior to disassembly, mark slip yoke and coupling shaft for assembly.

1. Place slip yoke (2) in vise.
2. Pull coupling shaft (4) apart from slip yoke (2).
3. Pry dust cap (3) off slip yoke (2). Discard dust cap (3).

b. Cleaning and Inspection

WARNING
Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

CAUTION
Do not allow drycleaning solvent to come into contact with U-joint. Damage to equipment may result.

1. Use drycleaning solvent to clean all metallic parts.
2. Inspect driveshaft (1), coupling shaft (4), and slip yoke (2) for cracks or dents. Replace if cracked or dented.
3. Inspect splined end of coupling shaft (4) and slip yoke (2) for damage. Replace either if damaged.
4. Inspect center bearing (5) for looseness, vibration damage, rubber separation from bearing surface, and abnormal wear. If damaged, replace coupling shaft (4).
c. Assembly

**NOTE**

Ensure grease fitting on dust cap is aligned with wide spline in slip yoke.

1. Install dust cap (3) on coupling shaft (4).
2. Coat splines on coupling shaft (4) and slip yoke (2) with grease.

**NOTE**

Ensure wide spline on coupling shaft is aligned with grease fitting on slip yoke.

3. Install coupling shaft (4) and dust cap (3) on slip yoke (2).

FOLLOW-ON TASK: Install front propeller shaft assembly (para. 6-2).
6-4. REAR PROPELLER SHAFT MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit:</td>
<td>TM 9-2320-387-10</td>
</tr>
<tr>
<td>automotive (Appendix B, Item 1)</td>
<td></td>
</tr>
<tr>
<td>Maintenance and repair shop equipment:</td>
<td>TM 9-2320-387-24P</td>
</tr>
<tr>
<td>automotive (Appendix B, Item 2)</td>
<td></td>
</tr>
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a. Removal

2. Remove four capscrews (6), two straps (5), and disconnect propeller shaft (3) from differential pinion yoke (4).
3. Slide propeller shaft end yoke (1) out of transfer case extension (2) and remove propeller shaft (3).

b. Inspection

1. Inspect propeller shaft (3) for cracks and dents. Replace if cracked or dented.
2. Inspect grease fittings and universal joints for serviceability. Replace universal joints (para. 6-5) or grease fittings if unserviceable.
3. Inspect splined end of end yoke (1) for damage. Replace end yoke (1) if damaged (para. 6-5).

c. Installation

1. Slide propeller shaft end yoke (1) on transfer case extension (2) and install propeller shaft (3).
2. Connect propeller shaft (3) to differential pinion yoke (4) with two straps (5) and four capscrews (6). Tighten capscrews (6) to 30-35 lb-ft (41-47 N-m).
3. Apply parking brake (TM 9-2320-387-10) and remove wheel chocks.
FOLLOW-ON TASK: Lubricate propeller shaft (TM 9-2320-387-10).
6-5. UNIVERSAL JOINT REPAIR

This task covers:

a. Disassembly

b. Assembly

INITIAL SETUP:

Tools
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)
- Universal joint bearing kit (Appendix B, Item 19)

Materials/Parts
- Journal and bearing kit (Appendix G, Item 72)

Personnel Required
- One mechanic
- One assistant

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Propeller shaft removed (para. 6-2 or 6-4).

Maintenance Level
- Unit

NOTE

All universal joint replacement procedures are basically the same. This procedure covers the rear universal joint.

a. Disassembly

CAUTION

Do not drop bearing cups. Needle bearings can be easily lost.

1. Remove grease fitting (7) from cross (5).
2. Remove two bearing cups (4) from cross (5).
3. Remove two snaprings (2) from yoke (6).
4. Position propeller shaft (3) in vise with 1-1/8 in. socket between vise jaw and bearing cup (1) being removed. Ensure open end of socket is facing bearing cup (1).
5. Place 11/16-in. socket between opposite bearing cup (1) and vise jaw. Ensure open end of socket is facing vise jaw.
6. Press bearing cup (1) out of yoke (6) and remove bearing cup (1) from cross (5).
7. Reverse position of sockets and press remaining bearing cup (1) out of yoke (6).
8. Remove cross (5) from yoke (6).

b. Assembly

CAUTION

Ensure grease fitting on cross faces yoke. Damage to equipment will result if improperly installed.

1. Install cross (5) into yoke (6).
2. Install bearing cup (1) into yoke (6).

CAUTION

Ensure bearing cup is aligned with yoke before pressing in with vise. Damage to cross and bearing cups will result if forced into yoke.

3. Place yoke (6) in vise with 11/16-in. socket between vise jaw and bearing cup (1).
4. Press bearing cup (1) into yoke (6) far enough to install snapring (2) and install snapring (2) into yoke (6).
5. Install bearing cup (1) into yoke (6).
6. Place yoke (6) in vise with 11/16-in. socket between bearing cup (1) and vise jaw.
7. Press bearing cup (1) into yoke (6) far enough to install snapring (2) and install snapring (2) into yoke (6).
8. Install two bearing cups (4) on cross (5).
9. Install grease fitting (7) into cross (5).
FOLLOW-ON TASK: Install propeller shaft (para. 6-2 or 6-4).
## Section II. FRONT AND REAR AXLES MAINTENANCE

### 6-6. FRONT AND REAR AXLES MAINTENANCE TASK SUMMARY

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6-7. HALFSHAFT MAINTENANCE

This task covers:

a. Removal
d. Wear Sleeve Installation
b. Disassembly
e. Assembly
c. Cleaning and Inspection f. Installation

tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Boot service kit (Appendix G, Item 4)
Clip (Appendix G, Item 11)
Cotter pin (Appendix G, Item 19)
Six two-piece lockwashers (Appendix G, Item 191)
Lockwasher (Appendix G, Item 156)
Drycleaning solvent (Appendix C, Item 26)
Lithium grease (Appendix C, Item 36)
Sealing compound (Appendix C, Item 63)
Wear sleeve (Appendix G, Item 311.1)

Manual References
TM 9-2320-387-24P

Equipment Condition
- Wheel removed [para. 8-3].
- Brake protection guard removed [para. 7-11] or [para. 7-11.1].

General Safety Instructions
Drycleaning solvent is flammable and will not be used near an open flame.

Maintenance Level
Unit

a. Removal

1. Remove access plug (8) and washer (7) from geared hub (4).
2. Remove halfshaft retaining capscrew (6) and lockwasher (5) from halfshaft (9) and geared hub (4). Discard lockwasher (5).
3. Remove six capscrews (3), two-piece lockwashers (2), and halfshaft (9) from rotor (1) and output flange (10). Discard two-piece lockwashers (2).

NOTE
Perform steps 4 and 5 for rear halfshafts only.

4. Remove cotter pin (15), washer (16), clevis pin (18), and parking brake clevis (17) from lever (14). Discard cotter pin (15).
5. Remove clip (13) and disconnect cable (11) from caliper cable bracket (12). Discard clip (13).
6-7. HALFSHAFT MAINTENANCE (Cont’d)

b. Disassembly

1. Loosen clamps (6) and (7) securing inner boot (5) to inner joint (1), insert (2), and shaft (4).
2. Clamp shaft (4) in soft-jawed vise.
3. Remove inner boot (5) from insert (2) and slide up on shaft (4).
4. Remove inner joint (1) and insert (2) from spider assembly (3) and shaft (4).
5. Remove insert (2) from inner joint (1). Discard insert (2).
   5.1. Remove dirt deflector (9) from outer joint (8), if present.
6. Remove retainer ring (8) from shaft (4). Discard retainer ring (8).
7. Remove spider assembly (3) from shaft (4).
6-7. HALFSHAFT MAINTENANCE (Cont’d)

8. Remove inner boot (1) and clamps (2) and (3) from shaft (7). Discard boot (1) and clamps (2) and (3).
9. Remove shaft (7) from soft-jawed vise.
10. Remove boot clamps (4) and (5) and outer boot (6) from outer joint (8) and shaft (7). Discard boot (6) and clamps (5) and (4).

**c. Cleaning and Inspection**

**WARNING**

Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

1. Clean all metallic parts with drycleaning solvent.
2. Inspect shaft (7) for cracks and distortion. Replace shaft (7) if cracked or distorted.
3. Inspect splined end of shaft (7) for damage. Replace shaft (7) if damaged.
4. Inspect inner joint (10) for pitting or rough joint operation. Replace inner joint (10) if pitted or unserviceable.
5. Clean output flange threaded holes (11) with a 10-mm tap to remove old sealing compound.
6. Inspect halfshaft end (9) for burrs or grooves. If burrs or grooves are present, carefully sand or grind down burrs on halfshaft end (9).
d. Wear Sleeve Installation

NOTE

When installing wear sleeve over halfshaft spline, ensure wear sleeve does not come into contact with splines.

Using a pipe or like item (11.4), slide wear sleeve (11.3) over halfshaft spline (11.2) until flange (11.5) of wear sleeve (11.3) contacts shoulder adjacent to halfshaft seal surface (11.1).

e. Assembly

1. Pack outer joint (8) with lithium grease.
2. Install outer boot (6) on shaft (7). Ensure boot (6) seats in groove of shaft (7).
3. Secure outer boot (6) on shaft (7) with clamp (4).
4. Install outer boot (6) on joint (8). Ensure boot (6) seats in groove of joint (8).
5. Secure outer boot (6) on joint (8) with clamp (5).
6. Clamp shaft (7) in soft-jawed vise.
7. Position clamps (3) and (2) on shaft (7).
8. Install inner boot (1) on shaft (7). Push boot (1) past groove on shaft (7).
6-7. HALFSHAFT MAINTENANCE (Cont’d)

NOTE
Adhere spider assembly with lithium grease before installing on shaft.

9. Align splines of spider assembly (4) with spline on shaft (5). Use press to install spider assembly (4) on shaft (5) until spider assembly (4) seats into place.
10. Install retainer ring (3) in upper groove of shaft (5).
11. Pack inner joint (1) with lithium grease.
12. Install insert (2) on inner joint (1).
13. Install inner joint (1) and insert (2) on spider assembly (4) and shaft (5).
14. Move inner boot (6) on shaft (5) until inner boot (6) seats in groove of shaft (5).
15. Secure inner boot (6) on shaft (5) with clamp (8).
16. Install inner boot (6) on inner joint (1). Ensure boot (6) seats in groove of inner joint (1).
17. Secure inner boot (6) on inner joint (1) with clamp (7).

NOTE
Perform step 18 for vehicles with serial numbers 299999 and below.

18. Install dirt deflector (8.2) on outer joint (8.1).

CAUTION
Ensure dirt deflector is removed prior to installing halfshaft on vehicles with serial number 300000 and above. Failure to do so will damage geared hub seal.

NOTE
Perform step 1 when installing halfshaft on vehicles with serial numbers 300000 and above.

1. Remove dirt deflector (8.2) from outer joint (8.1), if present.
   1.1. Install halfshaft (18) into geared hub (13).
2. Apply sealing compound to halfshaft retaining capscrew (15) and install halfshaft (18) on geared hub (13) with lockwasher (14) and halfshaft retaining capscrew (15). Tighten halfshaft retaining capscrew (15) to 37 lb-ft (50 N-m).
3. Install washer (16) and access plug (17) into geared hub (13). Tighten access plug (17) to 8-13 lb-ft (11-18 N-m).
6-7. HALFSHAFT MAINTENANCE (Cont’d)

NOTE

- Ensure all six capscrew holes in the rotor align with holes in output flange.
- New capscrews come with preapplied thread-locking compound, however, still apply sealing compound to threads of new capscrews. If old capscrews are to be used, mating threads must be cleaned and sealing compound applied to threads of capscrews.
- Two-piece lockwashers must be installed in sets of two with serrated sawtooth threads facing each other.

4. Apply sealing compound to six capscrews (12). Install halfshaft (18) on rotor (10) and output flange (19) with six two-piece lockwashers (11) and capscrews (12). Tighten capscrews (12) to 58 lb-ft (79 N·m).

NOTE

Perform steps 5 through 7 for rear halfshafts only.

5. Install parking brake cable (27) on caliper cable bracket (20) with clip (21).

CAUTION

- Ensure lever is in contact with caliper cable bracket stop. Damage to equipment and poor performance may result if not aligned properly.
- Ensure that clevis and clevis pin are aligned in lever. Do not move lever to accommodate misadjusted clevis. Damage to equipment and poor performance may result.

6. Install parking brake clevis (25) on lever (22) with clevis pin (26), washer (24), and cotter pin (23). Check position of lever (22) and ensure it is in contact with caliper cable bracket stop (28).

7. If lever (22) is not in contact with caliper cable bracket stop (28), adjust rear dual service parking brake (para. 7-19).

FOLLOW-ON TASKS:  

- Install brake protection guards (para. 7-1 or para. 7-11.1).
- Install wheel (para. 8-3).
6-8. GEARED HUB SIDE COVER MAINTENANCE

This task covers:

a. Removal
b. Cleaning and Inspection
c. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Sealing compound (Appendix C, Item 63)
- RTV silicone compound (Appendix C, Item 74)
- Drycleaning solvent (Appendix C, Item 26)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Wheel removed (para. 8-3).

General Safety Instructions
- Drycleaning solvent is flammable and will not be used near an open flame.

Maintenance Level
- Unit

NOTE
- Have drainage container ready to catch oil.
- The replacement procedure for front and rear geared hub side covers is basically the same. This procedure covers the front side cover.

a. Removal

1. Remove drainplug (5) from geared hub (1) and drain geared hub (1).
2. Install drainplug (5) on geared hub (1). Tighten drainplug (5) to 8-13 lb-ft (11-18 N·m).
3. Remove eight capscrews (4), washers (3), and side cover (2) from geared hub (1).

b. Cleaning and Inspection

WARNING
Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

1. Using drycleaning solvent, clean side cover (2).
2. Inspect side cover (2) for damage. If damaged, replace.

NOTE
Sealing compound is fast drying. Assemble parts as quickly as possible.

1. Apply RTV sealant to side cover (2) and install side cover (2) on geared hub (1).
2. Apply sealing compound to capscrews (4) and install eight washers (3) and capscrews (4) on side cover (2). Tighten capscrews (4) to 15 lb-ft (20 N·m).
FOLLOW-ON TASKS: • Fill geared hub to proper level [para. 2-12].
• Install wheel [para. 8-3].
6-9. GEARED HUB REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
      automotive (Appendix B, Item 2)
   Puller, mechanical (Appendix B, Item 157)

Materials/Parts
   Three cotter pins (Appendix G, Item 22)
   Lockwasher (Appendix G, Item 169)
   Four locknuts (Appendix G, Item 113)
   Four locknuts (Appendix G, Item 128)
   Sealing compound (Appendix C, Item 62)
   Sealing compound, anaerobic (Appendix C, Item 58)

Personnel Required
   One mechanic
   One assistant

Manual References
   TM 9-2320-387-24P

Equipment Condition
   • Wheel removed [para. 8-3].
   • Steering stop removed [para. 6-17].

General Safety Instructions
   Geared hub must be supported during removal and installation.

Maintenance Level
   Unit

CAUTION
   Use of a pickle fork instead of the puller kit may damage serviceable components (boots).

NOTE
   • Have drainage container ready to catch fluid.
   • The replacement procedure for front and rear geared hubs is basically the same. This procedure covers the front geared hub.

a. Removal

1. Remove drainplug (29) from geared hub (12) and drain geared hub (12).
2. Install drainplug (29) in geared hub (12).
3. Remove capscrew (21), washer (20), and vent line bracket and clamp (19) from geared hub (12).
4. Loosen clamp (6) and disconnect vent line (22) from geared hub fitting (7).
5. Remove cotter pin (25), slotted nut (26), and washer (27) from tie rod end (28) and geared hub (12). Discard cotter pin (25).
6. Using puller, disconnect tie rod end (28) from geared hub (12).
7. Remove access plug (11), washer (10), axle halfshaft retaining capscrew (9), lockwasher (8), and disconnect halfshaft (13) from geared hub (12). Discard lockwasher (8).
6-9. GEARED HUB REPLACEMENT (Cont'd)

**WARNING**

Geared hub must be supported during removal. Failure to support geared hub may cause injury to personnel or damage to equipment.

**NOTE**

Note direction of inner and outer capscrews for installation.

8. Remove four locknuts (18), washers (14), capscrews (15), and washers (14) from lower ball joint (16) and lower control arm (17). Discard locknuts (18).

9. Remove four locknuts (3), washers (2), capscrews (1), and washers (2) from upper ball joint (4) and upper control arm (5). Discard locknuts (3).

10. Remove cotter pin (23), slotted nut (24), and upper ball joint (4) from upper control arm (5) and geared hub (12). Discard cotter pin (23).

11. Lower support and remove geared hub (12).
12. Place geared hub (3) in vise.
13. Remove cotter pin (1), slotted nut (2), and lower ball joint (4) from geared hub (3). Discard cotter pin (1).

b. Installation

**WARNING**
Geared hub must be supported during installation. Failure to support geared hub may cause injury to personnel or damage to equipment.

**NOTE**
- If geared hub is received with P/N 6005120 and left front or right rear installation is required, replace steering arm cover P/N 6005120 with P/N 6005121.
- If geared hub is received with P/N 6005121 and right front or left rear installation is required, replace steering arm cover P/N 6005121 with P/N 6005120.
- Use existing steering arm cover if serviceable.
- Perform steps 1 through 1.2 for replacement of steering arm cover. Proceed to step 1.3 for geared hub installation.

1. Remove four capscrews (4.1), washers (4.2), and steering arm cover (4.3) from geared hub (3).

**CAUTION**
When installing steering arm cover, ensure seal in cover is aligned on spindle extension or damage to seal will result.

**NOTE**
Immediately install steering arm cover after application of sealant.

1.1. Clean sealing surfaces on geared hub (3) and steering arm cover (4.3), then apply anaerobic sealing compound to steering arm cover (4.3).
1.2. Apply sealing compound to threads on capscrews (4.1) and install steering arm cover (4.3) on geared hub (3) with four washers (4.2) and capscrews (4.1). Tighten capscrews (4.1) to 65 lb-ft (88 N·m).

**NOTE**
Upper and lower ball joints have grease fittings.

1.3. Install lower ball joint (4) on geared hub (3) with slotted nut (2), but do not tighten.
2. Install upper ball joint (7) on upper control arm (8) and geared hub (3) with slotted nut (19).
3. Tighten slotted nut (19) on upper ball joint (7) to 65 lb-ft (88 N·m). Install cotter pin (18).
4. Install four washers (21), capscrews (20), washers (6), and locknuts (5) on upper ball joint (7) and upper control arm (8). Tighten locknuts (5) to 37 lb-ft (50 N·m).
5. Apply sealing compound to halfshaft retaining capscrew (10) and install halfshaft (15) on geared hub (3) with lockwasher (9) and halfshaft retaining capscrew (10). Tighten halfshaft retaining capscrew (10) to 37 lb-ft (50 N·m).
6. Install washer (11) and access plug (12) on geared hub (3). Tighten access plug (12) to 8-13 lb-ft (11-18 N·m).
7. Install lower ball joint (4) and geared hub (3) on lower control arm (16). Ensure lower ball joint (4) is below lower control arm (16).
6-9. GEARED HUB REPLACEMENT (Cont'd)

NOTE

Ensure outer capscrews are installed from top down and inner capscrews are installed from bottom up.

8. Secure lower ball joint (4) to lower control arm (16) with four washers (13), capscrews (14), washers (13), and locknuts (17). Tighten locknuts (17) to 60 lb-ft (81 N•m).

CAUTION

Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

9. Tighten slotted nut (2) on lower ball joint (4) to 73 lb-ft (99 N•m) and install cotter pin (1).
6-9. GEARED HUB REPLACEMENT (Cont'd)

10. Install tie rod end (4) on geared hub (5) with washer (3) and slotted nut (2). Tighten slotted nut (2) to 70 lb-ft (95 N-m) and install cotter pin (1).

11. Connect vent line (6) to geared hub fitting (7) and tighten clamp (8).

12. Install vent line (6) and vent line bracket and clamp (11) on geared hub (5) with washer (10) and capscrew (9). Tighten capscrew (9) to 38 lb-ft (52 N-m).

13. Tighten drainplug (14) to 8-13 lb-ft (11-18 N-m).

14. Remove fill plug (13) and washer (12) from geared hub (5).

15. Fill geared hub (5) to proper level \( \text{para 2-12} \).

16. Install washer (12) and fill plug (13) on geared hub (5). Tighten fill plug (13) to 8-13 lb-ft (11-18 N-m).
FOLLOW-ON TASKS:
- Install steering stop (para. 6-17).
- Install wheel (para. 8-3).
- Check alignment (paras. 8-9 and 8-10).
6-10. GEARED HUB INPUT SEAL REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
  automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
  automotive (Appendix B, Item 2)
  Vise insert (Appendix B, Item 160)

Special Tools
  Input seal installer (Appendix B, Item 107)
  Driver handle (Appendix B, Item 60)

Materials/Parts
  Input seal (Appendix G, Item 297)
  Lubricating oil (Appendix C, Item 41)

Manual References
  TM 9-2320-387-24P

Equipment Condition
  Halfshaft removed (para. 6-7)

Maintenance Level
  Unit

a. Removal

Shim gaskets must be reused to maintain proper drive gear bearing adjustment.

1. Remove capscrew (1), washer (2), and vent line bracket (3) from drive gear retainer (4).
2. Remove three capscrews (1), washers (2), drive gear retainer (4), and shim gasket(s) (5) from geared hub (6).
3. Install drive gear retainer (4) in vise with inserts and remove input seal (7). Discard input seal (7).

b. Installation

1. Using driver handle and input seal installer, install input seal (7) in drive gear retainer (4). Ensure radius on outer diameter of input seal (7) faces toward inside of geared hub (6).
2. Install shim gasket(s) (5) and drive gear retainer (4) on geared hub (6) with three washers (2) and capscrews (1). Tighten capscrews (1) to 38 lb-ft (52 N·m).
3. Install vent line bracket (3) on drive gear retainer (4) with washer (2) and capscrew (1). Tighten capscrew (1) to 38 lb-ft (52 N·m).
4. Coat lip of input seal (7) with lubricating oil.
FOLLOW-ON TASK: Install halfshaft [para. 6-7].
6-11. GEARED HUB SPINDLE SEAL REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Special Tools
- Spindle seal installer (Appendix B, Item 109)
- Driver handle (Appendix B, Item 60)
- Wrench (Appendix B, Item 108)

Materials/Parts
- Lockwasher (Appendix G, Item 170)
- Seal (Appendix G, Item 290)
- Grease (Appendix C, Item 34)
- Sealing compound, anaerobic (Appendix C, Item 58)
- Lubricating oil (Appendix C, Item 42)
- Sealing compound (Appendix C, Item 62)
- Sealing compound (Appendix C, Item 64)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Wheel removed (para. 8-3).

General Safety Instructions
- Ensure locktab on lockwasher is bent completely into slot on retaining nut.

Maintenance Level
- Unit

a. Removal

NOTE
Have drainage container ready to catch oil.

1. Remove drainplug (2) from geared hub (1) and drain geared hub (1). Install drainplug (2) in geared hub (1) and tighten to 8–13 lb-ft (11–18 N•m).

CAUTION
Do not use sharp objects to aid in removing steering arm cover.

NOTE
It may be necessary to lightly tap steering arm cover with mallet to loosen from geared hub.

2. Remove four capscrews (5), washers (4), and steering arm cover (3) from geared hub (1).
6-11. GEARED HUB SPINDLE SEAL REPLACEMENT (Cont’d)

NOTE
For configuration 2, two locktabs on lockwasher must be bent away from retaining nut for removal.

3. Bend locktab on lockwasher (13) away from retaining nut (14).

NOTE
If four-slotted retaining nut TN-07 is present, it is recommended to replace it with eight-slotted retaining nut 12342680.

4. Using retaining nut wrench, remove retaining nut (14), lockwasher (13), and keyed washer (12) from spindle (7). Discard lockwasher (13)

NOTE
For configuration 3 perform step 4.1.

4.1. Remove three screws (15) from retaining nut (14).

5. Remove spindle (7), outer spacer (6), bearing (11), and inner spacer (10) from geared hub (1).

6. Remove spindle seal (15) from geared hub (1). Discard spindle seal (15).

7. Inspect spindle (7) for rough or corroded sealing surface (8). Replace geared hub (1) if spindle (7) is damaged.

8. Inspect bearings (9) and (11) for damage. Replace geared hub (1) if bearing (9) or (11) is damaged.
6-11. GEARED HUB SPINDLE SEAL REPLACEMENT (Cont’d)

b. Installation

1. Using driver handle and spindle seal installer, install spindle seal (1) in geared hub (2).
2. Coat spindle seal (1) with lubricating oil.

**NOTE**
Ensure that large, flat surface of outer spacer faces drive gear.

3. Install outer spacer (3) and spindle (4) in geared hub (2).
4. Apply grease to face of retaining nut (9).

**NOTE**
- If four-slotted retaining nut is present, it is recommended to replace it with eight-slotted retaining nut 12342680.
- Ensure that large, flat surface of inner spacer faces drive gear.

5. Install inner spacer (5), bearing (6), keyed washer (7), lockwasher (8), and retaining nut (9) on spindle (4).

**NOTE**
For configuration 1 and 2 use a retaining wrench to perform step 6.

6. Tighten retaining nut (9) to 35–45 lb ft (47–61 N•m).
7. Rotate spindle (4) five full rotations clockwise and five full rotations counterclockwise to properly seat bearings.
8. Loosen retaining nut (9) until it is finger-tight, then retighten nut to 23–27 lb-ft (31–37 N•m).

**NOTE**
- For configuration 1 and 2 use a retaining wrench to perform step 6.
- Perform steps 8.1, 8.2 and 8.3 for configuration 3.

8.1. Apply sealing compound to three screws (12).
8.2. Install three screws (12) on retaining nut (9).

**NOTE**
When performing step 8.3 tighten center capscrew first.
8.3. Tighten three screws (12) to 65 lb-in. (7.3 N•m).
8.4. Repeat step 8.3 once.

**WARNING**
Ensure locktab on lockwasher is bent completely into slot on retaining nut. Eight-slotted retaining nut provides additional security by enabling two locktabs on lockwasher to be bent into slots on retaining nut. Failure to do this may cause injury to personnel or damage to equipment.

**NOTE**
- For configuration 2, two locktabs on lockwasher must be bent into slots on retaining nut.
- It may be necessary to slightly loosen or tighten retaining nut to gain proper alignment with locktabs.
- Perform step 9 for configurations 1 and 2.

9. Determine which locktab(s) (10) on lockwasher (8) aligns with slot(s) (11) in retaining nut (9). Bend locktab(s) (10) into slot(s) (11) on retaining nut (9).
6-11. GEARED HUB SPINDLE SEAL REPLACEMENT (Cont’d)
6-12. GEARED HUB SPINDLE BEARING ADJUSTMENT

This task covers:
Adjustment

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

Special Tools
- Wrench (Appendix B, Item 108)

Materials/Parts
- Lockwasher (Appendix G, Item 170)
- Sealing compound, anaerobic
  - (Appendix C, Item 58)
- Sealing compound (Appendix C, Item 62)
- Grease (Appendix C, Item 34)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Wheel removed (para. 8-3).

Maintenance Level
- Unit

General Safety Instructions
Ensure locktab on lockwasher is bent completely into slot on retaining nut.

NOTE

- Have drainage container ready to catch oil.
- Geared hub spindle bearing adjustment is not needed for vehicles S/N 300000 and above.

1. Remove drainplug (2) from geared hub (1) and drain geared hub (1). Install drainplug (2) in geared hub (1) and tighten to 8–13 lb-ft (11–18 N·m).
2. Remove four capscrews (5), washers (4), and steering arm cover (3) from geared hub (1).
6-12. GEARED HUB SPINDLE BEARING ADJUSTMENT

This task covers:

Adjustment

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  automotive (Appendix B, Item 2)

Special Tools
- Wrench (Appendix B, Item 108)

Materials/Parts
- Lockwasher (Appendix G, Item 170)
- Sealing compound, anaerobic
  (Appendix C, Item 58)
- Sealing compound (Appendix C, Item 62)
- Grease (Appendix C, Item 34)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Wheel removed (para. 8-3).

Maintenance Level
- Unit

General Safety Instructions
- Ensure locktab on lockwasher is bent completely into slot on retaining nut.

NOTE

- Have drainage container ready to catch oil.
- Geared hub spindle bearing adjustment is not needed for configuration 3 retaining nut.

1. Remove drainplug (2) from geared hub (1) and drain geared hub (1). Install drainplug (2) in geared hub (1) and tighten to 8–13 lb-ft (11–18 N·m).
2. Remove four capscrews (5), washers (4), and steering arm cover (3) from geared hub (1).

Diagram of geared hub showing drainplug and capscrews.
6-12. GEARED HUB SPINDLE BEARING ADJUSTMENT (Cont’d)

**NOTE**

For configuration 2, two locktabs on lockwasher must be bent away from retaining nut for removal.

3. Bend locktab(s) (5) on lockwasher (2) away from retaining nut (3).

4. Using retaining nut wrench, remove retaining nut (3) and lockwasher (2) from spindle (1). Discard lockwasher (2).

**NOTE**

If four-slotted retaining nut TN-07 is present, it is recommended to replace it with eight-slotted retaining nut 12342680.

5. Apply grease to face of retaining nut (3) and install lockwasher (2) and retaining nut (3) on spindle (1).

6. Using retaining nut wrench, tighten retaining nut (3) to 35-45 lb-ft (47-61 N•m).

7. Rotate spindle (1) five full rotations clockwise and five full rotations counterclockwise to properly seat bearings.

8. Loosen retaining nut (3) until it is finger-tight, then retighten nut to 23-27 lb-ft (31-37 N•m).

**WARNING**

Ensure locktab on lockwasher is bent completely into slot on retaining nut. Eight-slotted retaining nut provides additional security by enabling two locktabs on lockwasher to be bent into slots on retaining nut. Failure to do this may cause injury to personnel or damage to equipment.

**NOTE**

- For configuration 2, two locktabs on lockwasher must be bent into slots on retaining nut.
- It may be necessary to slightly loosen or tighten retaining nut to gain proper alignment with locktabs.

9. Determine which locktab(s) (5) on lockwasher (2) aligns with slot(s) (4) in retaining nut (3). Bend locktab(s) (5) into slot(s) (4) on retaining nut (3).
6-12. GEARED HUB SPINDLE BEARING ADJUSTMENT (Cont'd)

**CAUTION**

When installing steering arm cover, ensure seal in cover is aligned on spindle extension. Damage to seal will result if not aligned.

**NOTE**

Immediately install steering arm cover after application of sealant.

10. Clean sealing surfaces on geared hub (6) and steering arm cover (9). Apply anaerobic sealant to steering arm cover (9) and install steering arm cover (9) on geared hub (6).

11. Apply sealing compound to threads of four capscrews (11) and install steering arm cover (9) on geared hub (6) with four washers (10) and capscrews (11). Tighten capscrews (11) to 65 lb-ft (88 N·m).

12. Remove fill plug (7) and washer (8) from geared hub (6).

13. Fill geared hub (6) to proper oil level [para. 2-12].

14. Install washer (8) and fill plug (7) on geared hub (6). Tighten fill plug (7) to 8-13 lb-ft (11-18 N·m).

**FOLLOW-ON TASK:** Install wheel [para. 8-3].
6-13. WHEEL STUD REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic’s tool kit: automotive (Appendix B, Item 1)</td>
<td>Wheel removed [para. 8-3].</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials/Parts</th>
<th>General Safety Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hex-nut (Appendix G, Item 69)</td>
<td>Always wear eye protection when replacing wheel studs.</td>
</tr>
<tr>
<td>Three flat washers (Appendix G, Item 33.1)</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Manual References</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-387-24P</td>
<td>Unit</td>
</tr>
</tbody>
</table>

**WARNING**

Always wear eye protection when replacing wheel studs. Severe eye injury may result if metal chips contact eyes.

**a. Removal**

1. Rotate spindle (3) to allow clearance for removal of stud (4) from spindle (3).
2. Drive stud (4) from spindle (3). Discard stud (4).

**b. Installation**

1. Align splines on stud (4) with splines in spindle (3) and install stud (4) in spindle (3).
2. Install three washers (2) and hex-nut (1) on stud (4).
3. Tighten hex-nut (1) until head of stud (4) seats against spindle (3).
4. Remove hex-nut (1) and washers (2). Discard hex-nut (1) and washers (2).

FOLLOW-ON TASK: Install wheel [para. 8-3].
6-14. DIFFERENTIAL VENT LINE REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

NOTE
The replacement procedure for differential vent lines is basically the same. This procedure covers the rear differential vent line.

a. Removal

1. Remove vent line (7) from differential fitting (6) and union fitting (1).
2. Remove two line clips (2) from vent line (3) and brake line (5).
3. Remove vent line (3) from union fittings (1) and (4).

b. Installation

1. Install vent line (3) on union fittings (1) and (4).
2. Install two line clips (2) on vent line (3) and brake line (5).
3. Install vent line (7) on differential fitting (6) and union fitting (1).
6-14.1. FRONT DIFFERENTIAL VENT LINE REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal  

b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
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<table>
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<tr>
<th>Materials/Parts</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockwasher (Appendix G, Item 144)</td>
<td>Unit</td>
</tr>
</tbody>
</table>

### a. Removal

1. Disconnect vent line (2) from tee fittings (1) and (5).
2. Pull vent line (2) through clamps (3) and (4).
3. Disconnect vent line (7) from tee fitting (5) and vent line adapter (8).
4. Remove vent line adapter (8) from differential (9).
5. Disconnect vent line (6) from tube adapter (14) and tee fitting (5).
6. Remove nut (10), lockwasher (11), clamp (12), and vent line (6) from crossmember (13).
   Discard lockwasher (11).

### b. Installation

1. Install clamp (12) and vent line (6) on crossmember (13) with lockwasher (11) and nut (10).
2. Connect vent line (6) to tube adapter (14) and tee fitting (5).
3. Install vent line adapter (8) on differential (9).
4. Connect vent line (7) to vent line adapter (8) and tee fitting (5).
5. Pull vent line (2) through clamps (4) and (3).
6. Connect vent line (2) to tee fittings (5) and (1).
6-14.1. FRONT DIFFERENTIAL VENT LINE REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
6-14.2. REAR DIFFERENTIAL VENT LINE REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal  

b. Installation  

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)

Manual References
- TM 9-2320-387-24P

Equipment Condition:
- Parking brake pads removed (para. 7-22)

Maintenance Level:
- Unit

---

**a. Removal**

1. Disconnect vent line (5) from tee fittings (4) and (6).
2. Disconnect vent line (2) from vent line adapter (1) and tee fitting (4).
3. Remove vent line adapter (1) from differential (3).

**b. Installation**

1. Install vent line adapter (1) on differential (3).
2. Connect vent line (2) to vent line adapter (1) and tee fitting (4).
3. Connect vent line (5) to tee fittings (6) and (4).

---

FOLLOW-ON TASK: Install parking brake pads (para. 7-22).
6-15. REAR GEARED HUB VENT LINE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
<thead>
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<th>Tools</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>Unit</td>
</tr>
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</table>

Manual References

TM 9-2320-387-24P

NOTE

The replacement procedure for each rear geared hub vent line is basically the same. This procedure covers the right rear geared hub vent line.

a. Removal

1. Disconnect vent line (4) from geared hub fitting (3).
2. Remove capscrew (7), clamp (6), and vent line (4) from bracket (5).
3. Remove capscrew (8), clamp (1), and vent line (4) from control arm (2).
4. Remove capscrew (10), clamp (9), and vent line (4) from bracket (11).
5. Remove capscrew (15), clamp (14), and vent line (4) from frame (13).
6. Remove vent line (4) from tee fitting (12).

b. Installation

1. Install vent line (4) on tee fitting (12) and geared hub fitting (3).
2. Install vent line (4) on frame (13) with clamp (14) and capscrew (15).
3. Install vent line (4) on bracket (11) with clamp (9) and capscrew (10).
4. Install vent line (4) on control arm (2) with clamp (1) and capscrew (8).

NOTE

Position clamp at a 45° angle toward the wheel before securing with capscrew.

5. Install vent line (4) on bracket (5) with clamp (6) and capscrew (7).
6-15. REAR GEARED HUB VENT LINE REPLACEMENT (Cont'd)
6-16. FRONT GEARED HUB VENT LINE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-24P

Equipment Condition
Wheel removed (para. 8-3).

Maintenance Level
Unit

NOTE

- The replacement procedure for each front geared hub vent line is basically the same. This procedure covers the right front geared hub vent line.
- Mark clamp position before loosening to ensure clamps are properly positioned during installation.

1. Remove four screws (7) and clamps (3) from frame (13), front control arm (2), and geared hub (8).
2. Loosen two clamps (6) and disconnect front vent line (4) from elbow (5) and tee fitting (1).
3. Remove nut (12), washer (11), screw (10), clamp (9), and front vent line (4) from control arm (2).

b. Installation

1. Install clamp (9) and front vent line (4) on control arm (2) with screw (10), washer (11), and nut (12).
2. Connect vent line (4) to elbow (5) and tee fitting (1) with two clamps (6).
3. Install vent line (4) and four clamps (3) on geared hub (8), control arm (2), and frame (13) with four screws (7).
FOLLOW-ON TASK: Install wheel (para. 8-3).
6-17. STEERING STOP MAINTENANCE

This task covers:

a. Removal
b. Installation
c. Adjustment

INITIAL SETUP:

Tools

General mechanic's tool kit:
- automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
- automotive (Appendix B, Item 2)

Personnel Required

One mechanic
One assistant

Manual References

TM 9-2320-387-24P

Materials/Parts

Sealing compound (Appendix C, Item 62)
Chalk (Appendix C, Item 20)

Maintenance Level

Unit

a. Removal

1. Loosen jamnut (2) and remove steering stop capscrew (3) and jamnut (2) from geared hub (1).
2. Remove jamnut (2) from capscrew (3).

b. Installation

1. Apply sealing compound to capscrew (3).
2. Install jamnut (2) on capscrew (3).
3. Install capscrew (3) and jamnut (2) on geared hub (1). Tighten capscrew (3) finger-tight.

c. Adjustment

Prior to adjustment, ensure length of each tie rod is the same. If tie rod lengths are not the same ± 1/8 in. (3 mm), check toe-in alignment (para. 8-9).

1. Draw a reference chalk line (6) 30 ft. long (9 m). Mark this line A.
2. Position vehicle so that center of left rear and left front tires are positioned directly on reference line A (6).
3. Using a protractor, draw a second reference line B (5) at 34°. Mark this line B.
4. Again, using a protractor, draw a third reference line C (4) at 36°. Mark this line C.
5. Roll vehicle forward until center of left front tire is over intersection of lines A, B, and C.
6. Turn steering wheel full left.
7. If the centerline of front and rear of left front tire (7) is over area between lines B and C, no adjustment is necessary.
8. If centerline of front and rear of left front is not over area between lines B and C, loosen jamnut (2) and turn capscrew (3) all the way in.
9. Turn steering wheel until centerline of front and rear of tire (7) is over area between lines B and C.
10. Loosen capscrew (3) until head makes contact with wheel stop (9) on lower control arm (8).
11. Secure capscrew (3) with jamnut (2).
12. Repeat adjustment procedure for opposite side.
6-17. STEERING STOP MAINTENANCE (Cont’d)
6-18. DIFFERENTIAL COVER MAINTENANCE  
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:
  a. Removal  
  b. Cleaning and Inspection  
  c. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- RTV silicone compound (Appendix C, Item 74)
- Drycleaning solvent (Appendix C, Item 26)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Rear cooler hoses removed (if applicable)
  (para. 3-84 or para. 3-85).

**General Safety Instructions**
- Drycleaning solvent is flammable and will not be used near an open flame.

**Maintenance Level**
- Unit

---

**NOTE**

- Have drainage container ready to catch fluid.
- All original differential covers without cooler assemblies will be replaced with new differential covers with cooler assemblies.
- This procedure covers differential covers with cooler assemblies.
- Differential covers with cooler assemblies are serviced as an assembly only.
- Removal of old differential covers without cooler assemblies is basically the same.

---

**a. Removal**

1. Remove drainplug (4) from differential assembly (5) and drain differential assembly (5).
   1.1 Remove fill plug (2) if necessary.
2. Remove twelve capscrews (3) and cooler cover assembly (1) from differential assembly (5).

---

**b. Cleaning and Inspection**

**WARNING**

Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel or damage to equipment.

1. Using drycleaning solvent, clean cooler cover assembly (1), twelve capscrews (3), and differential assembly (5).
2. Inspect differential cooler cover assembly (1) and internal cooler for cracks, wear, or breaks. Replace cooler cover as an assembly (1) if cracked, worn, or broken.
6-18. DIFFERENTIAL COVER MAINTENANCE
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

c. Installation

1. Apply RTV silicone compound to face of rear differential (6).

2. Install cooler cover assembly (1) on rear differential by rotating cooler cover assembly (1) upward from below and secure with twelve capscrews (3).

3. Install drainplug (4) on rear differential (5) and tighten to 13-18 lb-ft (18-24 N•m).

FOLLOW-ON TASKS:  • Install cooler hoses (para. 3-84 or para. 3-85).
• Fill differential to proper level (para. 2-12).
6-18.1. AIR LIFTING BRACKET REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
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<tbody>
<tr>
<td>General mechanic's tool kit:</td>
<td>TM 9-2320-387-24P</td>
</tr>
<tr>
<td>automotive (Appendix B, Item 1)</td>
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<table>
<thead>
<tr>
<th>Materials/Parts</th>
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</thead>
<tbody>
<tr>
<td>Four lockwashers (Appendix G, Item 101.10)</td>
</tr>
</tbody>
</table>

a. Removal

Remove four capscrews (4), lockwashers (3), and lifting bracket (2) from geared hub (1). Discard lockwashers (3).

b. Installation

Install lifting bracket (2) to geared hub (1) with four lockwashers (3) and capscrews (4). Tighten capscrews (4) to 43 lb-ft (58 N-m).
6-18.1. AIR LIFTING BRACKET REPLACEMENT (Cont’d)
### 6-19. SUSPENSION MAINTENANCE TASK SUMMARY

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</table>
6-20. STABILIZER BAR REPLACEMENT (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
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<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
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<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
</tr>
<tr>
<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>Maintenance Level Unit</td>
</tr>
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<table>
<thead>
<tr>
<th>Materials/Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two locknuts (Appendix G, Item 83)</td>
</tr>
</tbody>
</table>

a. Removal

1. Remove two locknuts (1), nuts (5), and six washers (2) from two bar links (3) and stabilizer bar (11).

2. Remove two bar links (3) and pins (4) from stabilizer bar (11).

3. Remove four nuts (9), washers (10), two clamps (8), and stabilizer bar (11) from two frame brackets (6).

b. Installation

1. Install two stabilizer bar bushings (7) on stabilizer bar (11).

2. Install stabilizer bar (11) on two frame brackets (6) with two clamps (8), four washers (10), and nuts (9).

3. Install two pins (4) in bar links (3).

4. Install stabilizer bar (11) on two bar links (3) with six washers (2), two nuts (5), and locknuts (1).

   Tighten locknuts (1) to 75 lb-ft (102 N•m).
6-20.1. STABILIZER BAR REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Manual References
TM 9-2320-387-24P

Equipment Condition
Stabilizer bar link removed (para. 6-21)

Maintenance Level
Unit

FOLLOW-ON TASK: Install stabilizer bar link (para. 6-21).

a. Removal

1. Remove four capscrews (5), washers (4), two clamps (3), and stabilizer bar (6) from two frame brackets (1).

2. Remove two stabilizer bar bushings (2) from stabilizer bar (6).

b. Installation

1. Install two stabilizer bar bushings (2) on stabilizer bar (6).

2. Install stabilizer bar (6) on two frame brackets (1) with two clamps (3), four washers (4), and capscrews (5). Tighten capscrews (5) to 39–47 lb-ft (53–63 N•m).
6-21. STABILIZER BAR LINK REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Locknut (Appendix G, Item 83)
- Sealing compound (Appendix C, Item 63)

**Manual References**
- TM 9-2320-387-24P

**Maintenance Level**
- Unit

---

**a. Removal**

1. Remove locknut (1) and two washers (2) from bar link (3) and stabilizer bar (4). Discard locknut (1).
2. Remove capscrew (5), two washers (6), and bar link (3) from lower control arm (7).

**b. Installation**

1. Apply sealing compound to threads of capscrew (5). Install bar link (3) on lower control arm (7) with two washers (6) and capscrew (5). Tighten capscrew (5) to 70 lb-ft (95 N·m).
2. Install bar link (3) on stabilizer bar (4) with two washers (2) and locknut (1). Tighten locknut (1) to 75 lb-ft (102 N·m).
6-22. RADIUS ROD REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

Materials/Parts
- Cotter pin (Appendix G, Item 22)
- Locknut (Appendix G, Item 88)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Wheel removed (para. 8-3)

Maintenance Level
- Unit

a. Removal

1. Remove cotter pin (7), slotted nut (6), and washer (5) from radius rod (4) and geared hub (8). Discard cotter pin (7).
2. Remove locknut (9), washer (2), capscrew (1), washer (2), and radius rod (4) from bracket (3) and geared hub (8). Discard locknut (9).

b. Installation

1. Install radius rod (4) on bracket (3) with washer (2), capscrew (1), washer (2), and locknut (9).

   **CAUTION**
   
   Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

2. Install radius rod (4) on geared hub (8) with washer (5) and slotted nut (6). Tighten slotted nut (6) to 70 lb-ft (95 N•m). Install cotter pin (7).
3. Tighten locknut (9) to 260 lb-ft (353 N•m).

FOLLOW-ON TASKS:
- Lubricate radius rod (TM 9-2320-387-10).
- Install wheel (para. 8-3).
- Adjust rear wheel toe-out alignment (para. 8-10).
6-23. UPPER BALL JOINT MAINTENANCE

This task covers:

a. Inspection  
b. Removal  
c. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Special Tools
- Socket adapter (Appendix B, Item 135)
- Crowfoot, 15/16 in. (Appendix B, Item 140)

Materials/Parts
- Cotter pin (Appendix G, Item 22)
- Four locknuts (Appendix G, Item 113)

Personnel Required

One mechanic
One assistant

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Maintenance Level
- Unit

Manual References
- TM 9-2320-387-24-1

a. Inspection

1. Chock rear wheels.
2. Raise and support front wheels 2 in. (5.1 cm) off ground.

NOTE

If boot is ripped or torn, upper ball joint is unserviceable.

3. Visually inspect ball joint boot (7), and replace upper ball joint (2) if boot is ripped or torn.
4. Grasp top of tire and attempt to move tire in and out. Observe upper control arm (1) and gear hub (3) where upper ball joint (2) is mounted. If lateral movement is observed, upper ball joint (2) may be worn.
5. Replace upper ball joint (2) if movement is 1/8 in. (3 mm) or more (refer to para. 6-23).
6. Deleted.
7. Deleted.
8. Deleted.
10. Deleted.
6-23. UPPER BALL JOINT MAINTENANCE (Cont’d)

b. Removal

1. Remove wheel (para. 8-3).
2. Remove cotter pin (7) and slotted nut (6) from upper ball joint (4) and geared hub (5). Discard cotter pin (7).
3. Remove four locknuts (3), washers (2), capscrews (8), washers (2), upper ball joint (4), and upper control arm (1) from geared hub (5). Discard locknuts (3).

c. Installation

1. Install upper ball joint (4) and upper control arm (1) on geared hub (5) with four washers (2), capscrews (8), washers (2), and locknuts (3). Tighten locknuts (3) to 37 lb-ft (41 N·m).

   **CAUTION**

   Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

2. Install slotted nut (6) on upper ball joint (4). Using crowfoot and adapter, tighten slotted nut (6) to 73 lb-ft (99 N·m). Install cotter pin (7).
FOLLOW-ON TASKS:  
- Lubricate upper ball joint (TM 9-2320-387-10).  
- Install wheel [para. 8-3].
6-24. LOWER BALL JOINT MAINTENANCE

This task covers:

a. Inspection
b. Removal
c. Installation

INITIAL SETUP:

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<tr>
<td>Four locknuts (Appendix G, Item 128)</td>
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a. Inspection

1. Chock rear wheels.
2. Raise and support front wheels 2 in. (5.1 cm) off ground.
3. Mark a line across top screw (11) of steering arm cover (10). Mark should be parallel with lower control arm (9).
4. Set a 6-in. (15-cm) ruler upright between lower control arm (9) and marked screw (11).
5. Install prybar between lower control arm (9) and geared hub (5). Push down on prybar and try to move geared hub (5).
6. Measure any movement in geared hub (5). Replace lower ball joint (3) if any movement is more than 1/8 in. (3 mm) or more.

b. Removal

1. Remove wheel (para 8-3).
1.1. Raise and support lower control arm (9).
2. Remove cotter pin (7) and slotted nut (6) from ball joint (3) and geared hub (5). Discard cotter pin (7).

   **NOTE**

   Note direction of inner and outer capscrews for installation.
3. Remove four locknuts (2), washers (1), capscrews (8), and washers (1) from ball joint (3) and control arm (9). Discard locknuts (2).
4. Using puller, remove ball joint (3) with boot retainer (4) from geared hub (5).

   **NOTE**

   Ensure outer capscrews are installed from top down and inner capscrews are installed from bottom up.

   1. Install ball joint (3) with boot retainer (4) on control arm (9), ensuring ball joint (3) is placed below control arm (9), with four washers (1), capscrews (8), washers (1), and locknuts (2). Tighten locknuts (2) to 60 lb-ft (81 N·m).
CAUTION

Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

2. Install ball joint (3) on geared hub (5) with slotted nut (6). Tighten slotted nut (6) to 73 lb-ft (99 N•m). Install cotter pin (7) in slotted nut (6).

FOLLOW-ON TASKS:  • Lubricate lower ball joint (TM 9-2320-387-10).
• Install wheel [para. 8-3].
6-25. UPPER CONTROL ARM REPLACEMENT

This task covers:

| a. Removal | b. Installation |

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)
- Puller, mechanical (Appendix B, Item 157)

**Materials/Parts**
- Four locknuts (Appendix G, Item 128)
- Two cotter pins (Appendix G, Item 22)
- Lockwasher (Appendix G, Item 169)
- Two locknuts (Appendix G, Item 88)
- Sealing compound (Appendix C, Item 63)
- Locknut (Appendix G, Item 82)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Wheel removed (para. 8-3).
- Hood raised and secured (TM 9-2320-387-10) (front upper control arm only).

**Maintenance Level**
- Unit

**NOTE**
Replacement procedures for front and rear upper control arms are basically the same. This procedure covers the left front upper control arm.

### a. Removal

1. Remove capscrew (1), washer (2), and vent line bracket (3) from geared hub (4).
2. Loosen clamp (6) and disconnect vent line (5) from fitting (7).
3. Remove capscrew (21), clamp (20), and vent line (5) from upper control arm (15).
4. Remove locknut (25), clamp (24), capscrew (23), washer (22), and vent line (5) from upper control arm (15). Discard locknut (25).
5. Remove cotter pin (31), slotted nut (32), and washer (33) from tie rod end (30). Discard cotter pin (31).
6. Using puller, disconnect tie rod end (30) from geared hub (4).
7. Remove access plug (8), washer (9), halfshaft retaining capscrew (10), and lockwasher (11) from halfshaft (29) and geared hub (4). Discard lockwasher (11).
8. Remove cotter pin (27), slotted nut (28), and disconnect upper ball joint (13) from geared hub (4). Discard cotter pin (27).
9. Remove four locknuts (14), washers (12), capscrews (26), and washers (12) from upper ball joint (13) and upper control arm (15). Discard locknuts (14).
10. Remove two locknuts (16), washers (17), capscrews (19), washers (17), and upper control arm (15) from two brackets (18). Discard locknuts (16).

### b. Installation

**NOTE**
On front control arms, capscrew head is toward rear of vehicle. On rear control arms, capscrew head is toward front of vehicle.

1. Install upper control arm (15) on two brackets (18) with two washers (17), capscrews (19), washers (17), and locknuts (16). Do not tighten locknuts (16) at this time.
2. Install upper ball joint (13) on upper control arm (15) with four washers (12), capscrews (26), washers (12), and locknuts (14). Tighten locknuts (14) to 37 lb-ft (50 N·m). Retorque 15 minutes after initial torque.
3. Install upper ball joint (13) and upper control arm (15) on geared hub (4) with slotted nut (28).

   **CAUTION**
   Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

4. Tighten slotted nut (28) on upper ball joint (13) to 73 lb-ft (99 N·m). Install cotter pin (27).

5. Tighten locknuts (16) to 260 lb-ft (353 N·m).

6. Apply sealing compound to halfshaft retaining capscrew (10) and install halfshaft (29) on geared hub (4) with lockwasher (11) and halfshaft retaining capscrew (10). Tighten capscrew (10) to 37 lb-ft (50 N·m).

7. Install washer (9) and access plug (8) on geared hub (4). Tighten access plug (8) to 8–13 lb-ft (11–18 N·m).

8. Install tie rod end (30) on geared hub (4) with washer (33) and slotted nut (32). Tighten slotted nut (32) to 63–77 lb-ft (85–104 N·m) and install cotter pin (31).

9. Connect vent line (5) to fitting (7) and tighten clamp (6).

   **NOTE**
   If installing new vent line bracket on left front geared hub, bend bracket 30° (from standard 90° angle to 120°) before installation.

10. Install vent line bracket (3) on geared hub (4) with washer (2) and capscrew (1). Tighten capscrew (1) to 30–40 lb-ft (41–54 N·m).

11. Install clamp (20) and vent line (5) on upper control arm (15) with capscrew (21).

12. Install clamp (24) and vent line (5) on upper control arm (15) with washer (22), capscrew (23), and locknut (25).

FOLLOW-ON TASKS: • Lower and secure hood (TM 9-2320-387-10) (front upper control arm only).
• Install wheel [para. 8-3].
6-26. LOWER CONTROL ARM REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Four locknuts (Appendix G, Item 128)
- Two locknuts (Appendix G, Item 88)
- Sealing compound (Appendix C, Item 63)

Personnel Required
- One mechanic
- One assistant

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Wheel removed [para. 8-3].
- Shock absorber removed [para. 6-28].

General Safety Instructions
- Lower control arm is under extreme pressure and must be supported during removal and installation.

Maintenance Level
- Unit

WARNING
Lower control arm is under extreme pressure and must be supported during removal and installation. Failure to support lower control arm may cause injury to personnel or damage to equipment.

NOTE
- Replacement procedures for front and rear lower control arms are basically the same. This procedure covers the left front lower control arm.

a. Removal

- Note direction of inner and outer capscrews for installation.

1. Remove four locknuts (10), washers (9), capscrews (8), and washers (7) from lower ball joint (6), geared hub (5), and lower control arm (11). Discard locknuts (10).

2. Remove capscrew (15), two washers (13), and bar link (14) from lower control arm (11).

3. Raise and support lower control arm (11) and pull geared hub (5) away.

4. Lower the lower control arm (11) and remove coil spring (4).

5. Remove two locknuts (3), washers (2), capscrews (1), washers (2), and lower control arm (11) from two crossmembers (12). Discard locknuts (3).

b. Installation

- On lower control arms, capscrew heads are toward front of vehicle.

1. Install lower control arm (11) on two crossmembers (12) with two washers (2), capscrews (1), washers (2), and locknuts (3).

2. Install coil spring (4) on lower control arm (11), ensuring end of coil spring (4) fits in spring pocket of lower control arm (11).
6-26. LOWER CONTROL ARM REPLACEMENT (Cont’d)

**WARNING**

Lower control arm is under extreme pressure and must be supported during removal and installation. Failure to support lower control arm may cause injury to personnel or damage to equipment.

3. Raise lower control arm (11) to align with geared hub (5) and lower ball joint (6), ensuring lower ball joint (6) is placed below lower control arm (11).

**NOTE**

Ensure outer capscrews are installed from top down and inner capscrews are installed from bottom up.

4. Install geared hub (5) and ball joint (6) on lower control arm (11) with four washers (7), capscrews (8), washers (9), and locknuts (10). Tighten locknuts (10) to 60-65 lb-ft (81-88 N•m) and remove support. Retorque 15 minutes after initial torque.

5. Tighten two locknuts (3) to 260 lb-ft (353 N•m). Retorque 15 minutes after initial torque.

6. Install wheel (para. 8-3).

7. Apply sealing compound to threads of capscrew (15). Install bar link (14) on lower control arm (11) with two washers (13) and capscrew (15). Tighten capscrew (15) to 70 lb-ft (95 N•m).

FOLLOW-ON TASKS:  
- Install shock absorber (para. 6-28).
- Check wheel alignment (para. 21-8).
6-27. COIL SPRING REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

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<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>• Hood raised and secured (front springs only) (TM 9-2320-387-10).</td>
</tr>
<tr>
<td></td>
<td>• Shelter removed (if applicable) (M1113, M1152, and M1152A1 only) (rear springs only) (para. 11-78).</td>
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</tbody>
</table>

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<th>Materials/Parts</th>
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<td>Locknut (Appendix G, Item 78)</td>
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<td>Sealing compound (Appendix C, Item 63)</td>
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<td>Unit</td>
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<tr>
<td>TM 9-2320-387-24P</td>
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</tbody>
</table>

NOTE
Replacement procedures for all four coil springs are basically the same. This procedure covers the left front coil spring.

a. Removal

1. Remove capscrew (13), two washers (14), and stabilizer bar link (15) from lower control arm (12).
2. Remove wheel (para. 8-3).

NOTE
Note direction of inner and outer capscrews for installation.

3. Remove four locknuts (10), washers (8), capscrews (9), and washers (8) from lower ball joint (7), geared hub (6), and lower control arm (12). Discard locknuts (10).

WARNING
Lower control arm is under extreme pressure and must be supported during removal and installation. Failure to support lower control arm may cause injury to personnel or damage to equipment.

4. Place jack under lower control arm (12) and raise lower control arm (12) slightly to relieve tension on shock retaining pin (2).

NOTE
For rear coil spring replacement, it may be necessary to spread frame from body by positioning prybar between hinge mount bracket and rear bumper to gain access to shock absorber retaining pin nut.

5. Remove locknut (5), retaining pin (2), washer (3), and shock absorber (11) from spring seat (4) and collapse shock absorber (11). Discard locknut (5).

NOTE
It may be necessary to loosen lower control arm capscrews to allow lower control arm to be lowered.

6. Pull geared hub (6) and ball joint (7) away from lower control arm (12), lower the control arm (12), and remove coil spring (1) from lower control arm (12) and shock absorber (11).
b. Installation

1. Install coil spring (1) over shock absorber (11) and onto lower control arm (12), ensuring end of coil spring (1) fits in spring pocket of lower control arm (12).
2. Ensure coil spring (1) is aligned with flange of spring seat (4) and raise lower control arm (12).
3. Extend shock absorber (11) into spring seat (4) and install washer (3), retaining pin (2), and locknut (5). Tighten locknut (5) to 300 lb-ft (407 N·m).

   **NOTE**

   Ensure outer capscrews are installed from top down and inner capscrews are installed from bottom up.

4. Install lower ball joint (7) and geared hub (6) on lower control arm (12), ensuring lower ball joint (7) is placed below lower control arm (12). Secure with four washers (8), capscrews (9), washers (8), and locknuts (10). Tighten locknuts (10) to 60 lb-ft (81 N·m).
5. Install wheel (para. 8-3).
6. Apply sealing compound to threads of capscrew (13). Install stabilizer bar link (15) to lower control arm (12) with two washers (14) and capscrew (13). Tighten capscrew (13) to 70 lb-ft (95 N·m).

FOLLOW-ON TASKS: • Lower and secure hood (front springs only) (TM 9-2320-387-10).
• Install shelter (if applicable) (M1113, M1152, and M1152A1 only) (rear springs only) (para. 11-78).
6-28. SHOCK ABSORBER REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)
Drive socket, 3/4 in. (Appendix B, Item 158)

Materials/Parts
Two locknuts (Appendix G, Item 85)
Two lockwashers (Appendix G, Item 171)
Two locknuts (Appendix G, Item 73)
Cotter pin (Appendix G, Item 24)

Personnel Required
One mechanic
One assistant

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
• Hood raised and secured (front shock absorbers only) (TM 9-2320-387-10).
• Shelter removed (if applicable) (M1113, M1152, and M1152A1 only) (rear shock absorbers only) (para. 11-78).

Maintenance Level
Unit

NOTE

• Replacement procedures for all shock absorbers are the same except rear lower shock pins must be installed with head of pin facing rearward. This procedure covers the left rear shock absorber.

• If shock absorber P/Ns 12480613-1 (Front) or 12480613-2 (Rear) are used, they must be replaced in pairs.

a. Removal

For rear shock absorber replacement on M1113, M1152, and M1152A1 models, it may be necessary to spread frame from body by positioning prybar between hinge mount bracket and rear bumper to gain access to shock absorber retaining pin nut. Perform steps 1 and 2 only if required.

1. Remove cotter pin (9), slotted nut (8), washer (7), and shackle (4) from body mount bracket (3) and rear bumper (6). Discard cotter pin (9).

2. Remove two locknuts (1), washers (2), capscrews (5), washers (2), and body mount bracket (3) from rear bumper (6). Discard locknuts (1).
6-28. SHOCK ABSORBER REPLACEMENT (Cont'd)
3. Remove two capscrews (10), lockwashers (9), and washers (8) from bracket (11) and lower control arm (6). Discard lockwashers (9).

**NOTE**

Note position of pin for installation.

4. Remove locknut (5), pin (2), and washer (3) from shock absorber (1) and spring seat (4). Discard locknut (5).

5. Compress shock absorber (1) and remove shock absorber (1) and bracket (11).

**NOTE**

Note alignment of shock absorber and bracket for installation.

6. Position shock absorber (1) in vise, and remove locknut (7), pin (13), washer (12), and bracket (11) from shock absorber (1). Discard locknut (7).

### b. Installation

**NOTE**

- If shock absorber P/Ns 12480613-1 (Front) or 12480613-2 (Rear) are used, they must be replaced in pairs.
- It may be necessary to spread spring seat to allow installation of shock absorber.
- Shock absorbers are marked FRONT or REAR to aid identification.

1. Position shock absorber (1) in vise, and install bracket (11) on shock absorber (1) with washer (12), pin (13), and locknut (7). Tighten locknut (7) to 300 lb-ft (407 N·m).

**CAUTION**

Do not pry or use sharp tools on shock absorber position rod. A damaged rod will cause shock failure.

2. Install shock absorber (1) and bracket (11) through lower control arm (6).

3. Extend shock absorber (1) and install piston rod end of shock absorber (1) on spring seat (4) with washer (3), pin (2), and locknut (5). Tighten locknut (5) to 300 lb-ft (407 N·m).

4. Install bracket (11) on lower control arm (6) with two washers (8), lockwashers (9), and capscrews (10). Tighten capscrews (10) to 178 lb-ft (241 N·m).
6-28. SHOCK ABSORBER REPLACEMENT (Cont'd)
Perform steps 5 through 8 if necessary to reassemble body mount bracket to frame and rear bumper.

5. Install shackle (4) and body mount bracket (3) on rear bumper (6) with washer (7) and slotted nut (8).

6. Tighten slotted nut (8) and install cotter pin (9).

7. Secure body mount bracket (3) to rear bumper (6) with two washers (2), capscrews (5), washers (2), and locknuts (1).

8. Tighten locknuts (1) to 90 lb-ft (122 N·m).

FOLLOW-ON TASKS:
- Install shelter (if applicable) (M1113, M1152 and M1152A1 only) (rear shock absorbers only) (para. 11-78).
- Lower and secure hood (front shock absorbers only) (TM 9-2320-387-10).
# CHAPTER 7
## BRAKE SYSTEM (UNIT) MAINTENANCE
### Section I. SERVICE BRAKE SYSTEM MAINTENANCE

### 7-1. SERVICE BRAKE SYSTEM MAINTENANCE TASK SUMMARY

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7-2. SERVICE BRAKE SYSTEM BLEEDING INSTRUCTIONS
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Pressure Bleeding  

b. Manual Bleeding  

c. Master Cylinder Bleeding

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
- Brake fluid (Appendix C, Item 18)

Personnel Required
- One mechanic
- One assistant (task b. only)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Hood raised and secured (TM 9-2320-387-10).
- Master cylinder filled to proper level (para. 2-12, item 11).

General Safety Instructions
- Always wear eye protection when bleeding brakes.

Maintenance Level
- Unit

WARNING
Always wear eye protection when bleeding brakes. Failure to do this may cause injury if brake fluid comes in contact with eyes.

NOTE
- If only the front or rear half of the system has been serviced, it is usually necessary to bleed only that half of the system. However, if a firm brake pedal cannot be obtained after bleeding, it will be necessary to bleed the entire system. The brake hydraulic system can be bled manually or by using a pressure tank and adapters. Each method is outlined in the following procedures.

- Bleed brakes in the following order: right rear, left rear, right front, left front.

a. Pressure Bleeding

CAUTION
- When using a pressure bleeding tank, follow the manufacturer's instructions for its use. Do not exceed the recommended working pressure when pressurizing the tank. A tank pressure of 15-20 psi (103-138 kPa) is sufficient to bleed the brake hydraulic system. Release all air pressure from the tank after using it.

- After refilling pressure bleeding tank with silicone brake fluid, let tank sit undisturbed for 30 minutes minimum to ensure all visible as well as minute air bubbles are gone.

NOTE
This procedure covers bleeding at one wheel. Repeat bleeding task for remaining wheels.

1. Remove cover from master cylinder (1).
2. Install pressure tank bleeder adapter (2) on master cylinder (1).
3. Connect line (3) from pressure tank to adapter (2).
4. Remove protective cap (5) from bleeder screw (6) on caliper assembly (7).
5. Connect short piece of hose (8) to bleeder screw (6) and place other end of hose (8) in container 3/4-full of brake fluid.
6. Open valve (4) on line (3) from pressure tank to master cylinder (1), allowing pressurized brake fluid to enter system.
7. Open bleeder screw (6) 3/4-turn and observe brake fluid in container. Close bleeder screw (6) when brake fluid flows free of air bubbles.
8. Disconnect hose (8) from bleeder screw (6) and install protective cap (5) on bleeder screw (6).
9. Close valve (4) on line (3) from pressure tank to master cylinder (1).
10. Disconnect line (3) from adapter (2).
11. Remove adapter (2) from master cylinder (1).
12. Fill reservoirs with silicone brake fluid and install cover on master cylinder (1).
NOTE

- This procedure covers bleeding at one wheel. Repeat bleeding task for remaining wheels.
- Assistant is required to depress the brake pedal when manually bleeding brakes while mechanic opens and closes bleeder screw.

1. Remove cover (6) from master cylinder (10) and fill reservoir (6) with silicone brake fluid.
1.1 Remove protective cap (1) from bleeder screw (2) on caliper assembly (3).
2. Connect short piece of hose (4) to bleeder screw (2) and place other end of hose (4) in container 3/4-full of brake fluid.

CAUTION

- Check the master cylinder fluid level frequently during the bleeding operation and refill the reservoir as necessary. Do not allow the master cylinder to run out of fluid at any time or additional air will be drawn into the system.
- After adding silicone brake fluid to master cylinder, let cylinder sit undisturbed for 30 minutes minimum to ensure all visible as well as minute air bubbles are gone.

3. Have assistant pump brake pedal toward floor and hold it there. Open bleeder screw (2) 3/4-turn.
4. When pedal reaches floor, tighten bleeder screw (2) and have assistant slowly release brake pedal.
5. Repeat steps 3 and 4 until fluid flows clear and free of air bubbles.
6. Disconnect hose (4) from bleeder screw (2) and install protective cap (1) on bleeder screw (2).
7. Refill reservoir (6) with silicone brake fluid and install cover (5) on master cylinder (10).

NOTE

Perform this procedure prior to installing master cylinder on vehicle.

1. Secure master cylinder flange (9) in vise.
2. Remove cover (5) and fill reservoir (6) with silicone brake fluid.
3. Install threaded end of bleeder hose (7) into brake line port on master cylinder (10) and insert opposite end into reservoir (6). Repeat step for other bleeder hose (7).
4. Slowly push piston (8) into master cylinder (10). Do not release piston (8). While holding piston (8), pinch bleeder hose (7) off and release piston (8). Piston (8) will return automatically.

CAUTION

Whenever the master cylinder is filled with silicone brake fluid, let cylinder sit undisturbed for 30 minutes minimum to ensure all visible as well as minute air bubbles are gone.

5. Refill reservoirs (6) with silicone brake fluid and repeat steps 3 and 4 until no air bubbles remain in brake fluid.
6. Remove two bleeder hose (7) from brake line ports on master cylinder (10).
7. Install cover (5) on master cylinder (10) and remove from vise.
8. Install master cylinder (10).
FOLLOW-ON TASKS:  
- Lower and secure hood (TM 9-2320-387-10).
- Operate vehicle (TM 9-2320-387-10) and check for proper operation.
7-2.1. SERVICE BRAKE SYSTEM BLEEDING INSTRUCTIONS (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:
   a. Pressure Bleeding
   b. Manual Bleeding
   c. Master Cylinder Bleeding

INITIAL SETUP:

Tools
General mechanic’s tool kit:
   automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
   automotive (Appendix B, Item 2)
Materials/Parts
   Brake fluid (Appendix C, Item 18)
Personnel Required
   One mechanic
   One assistant (task b. only)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
- Hood raised and secured (TM 9-2320-387-10).
- Master cylinder filled to proper level (Table 2-1, Item 2).

General Safety Instructions
Always wear eye protection when bleeding brakes.

Maintenance Level
Unit

WARNING
Always wear eye protection when bleeding brakes. Failure to do so may cause injury if brake fluid comes in contact with eyes.

CAUTION
Both sides of each caliper will need to be bled. Do not bleed only one side of brake caliper or brakes may not operate properly.

NOTE
- If only the front or rear half of the system has been serviced, it is usually necessary to bleed only that half of the system. However, if a firm brake pedal cannot be obtained after bleeding, it will be necessary to bleed the entire system.
- Bleed brakes in the following order: right rear, left rear, right front, left front.
- Bleeding procedures for all four brake calipers are basically the same. These procedures cover bleeding of right rear caliper. Repeat procedure for each caliper, as necessary.
- Bleed calipers (pressure and manual) from top bleeder screws only, bottom bleeder screws are for universal caliper replacement.

a. Pressure Bleeding

CAUTION
- When using a pressure tank, follow the manufacturer’s instructions for its use. Do not exceed the recommended working pressure when pressurizing the tank. A tank pressure of 12-15 psi (103-138 kPa) is sufficient to bleed the brake hydraulic system. Release all air pressure from the tank after using it.

- Check the master cylinder fluid level frequently during the pressure bleeding procedure and refill the reservoir as necessary. Do not allow the master cylinder to run out of fluid at any time or additional air will be drawn into the system.
7-2.1. SERVICE BRAKE SYSTEM BLEEDING INSTRUCTIONS
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

1. Install pressure tank hose (2) on master cylinder reservoir cap (3).
2. Connect short piece of hose (8) to bleeder screw (7) on brake caliper (10) and place other end of hose (8) in container ¾ full of brake fluid (9).
3. Open valve (4) on line (2) from pressure tank (5) to master cylinder reservoir (1) allowing pressurized brake fluid to enter system.
4. Open bleeder screw (7) ¾ turn and observe brake fluid in container (9). Close bleeder screw (7) when brake fluid flows free of bubbles. Tighten bleeder screw to 60 lb-ft (81 N•m).
5. Disconnect hose (8) from bleeder screw (7).
6. Close valve (4) on line (2) from pressure tank (5) to master cylinder reservoir (1).
7. Disconnect pressure tank hose (2) from master cylinder reservoir cap (3).
8. Repeat pressure bleeding for opposite side (6) of same brake caliper (10).
9. Fill master cylinder reservoir (1) with silicone brake fluid to MAX line.
7-2.1. SERVICE BRAKE SYSTEM BLEEDING INSTRUCTIONS (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

b. Manual Bleeding

**CAUTION**

- Check the master cylinder fluid level frequently during the bleeding operation and refill the reservoir as necessary. Do not allow the master cylinder to run out of fluid at any time or additional air will be drawn into the system.
- After adding silicone brake fluid to master cylinder, let cylinder sit undisturbed for 30 minutes minimum to ensure all visible as well as minute air bubbles are gone.

**NOTE**

- This procedure covers bleeding at one caliper. Repeat bleeding task for remaining calipers.
- Assistant is required to depress the brake pedal when manually bleeding brakes while mechanic opens and closes bleeder screw.

1. Connect short piece of hose (3) to bleeder screw (2) on brake caliper (5) and place other end of hose in container ¾ full of brake fluid (4).
2. Have assistant pump brake pedal toward floor and hold it there. Open bleeder screw (2) ¾ turn.
3. When pedal reaches floor, tighten bleeder screw (2) and have assistant slowly release brake pedal.
4. Repeat steps 2 and 3 until fluid flows clear and free of air bubbles.
5. Disconnect hose (3) from bleeder screw (2). Tighten bleeder screw to 60 lb-ft (81 N•m).
6. Repeat manual bleeding for opposite side (1) of same caliper (5).
7. Fill master cylinder reservoir with silicone brake fluid to MAX line.
7-2.1. SERVICE BRAKE SYSTEM BLEEDING INSTRUCTIONS
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

**c. Master Cylinder Bleeding**

**NOTE**
Perform this procedure prior to installing master cylinder on vehicle.

1. Secure master cylinder flange (7) in vise (5).
2. Install threaded plug (4) in brake line opening in master cylinder flange (7).
3. Attach threaded plug (3) to end of bleeder hose (2) and install in brake line opening in master cylinder flange (7).
4. Install opposite end of bleeder hose (2) in master cylinder reservoir (1).
5. Fill master cylinder reservoir (1) with silicone brake fluid to MAX line.

**NOTE**
Whenever the master cylinder is filled with silicone brake fluid, let cylinder sit undisturbed for 30 minutes minimum to ensure all visible as well as minute air bubbles are gone.

6. Slowly push piston (6) into master cylinder flange (7). While holding piston (6) in master cylinder flange (7) pinch bleeder hose (2) off and release piston (6). Piston will return automatically.
7. Repeat step 6 until no air bubbles remain in brake fluid.
8. Remove bleeder hose (2) from master cylinder reservoir (1).
9. Install cover on master cylinder reservoir (1) and remove from vise (5).
10. Remove two threaded plugs (3) and (4) from brake line openings in master cylinder flange (7).

**NOTE**
All calipers will need to be bled after installing master cylinder on vehicle to remove remaining air from brake system.

11. Install master cylinder on vehicle [para. 7-5.1].

FOLLOW-ON TASKS:
- Lower and secure hood (TM 9-2320-387-10).
- Operate vehicle (TM 9-2320-387-10) and check for proper operation.
7-3. SERVICE BRAKE PAD MAINTENANCE  
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal  
b. Cleaning and Inspection  
c. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)  
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)  
- Clamp (Appendix B, Item 153)

Special Tools
- Crowfoot, 14-mm (Appendix B, Item 141)

Materials/Parts
- Grease (Appendix C, Item 34)  
- Sealing compound (Appendix C, Item 63)  
- Six two-piece lockwashers (Appendix G, Item 191)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Brake protection guards removed [para. 7-11].

General Safety Instructions
- Ensure brake pads are installed with linings facing rotor.

Maintenance Level
- Unit

a. Removal

CAUTION
Caliper must be supported during removal to prevent damage to brake hose.

NOTE
Perform steps 1 and 2 for right side. Perform steps 3, 4, and 5 for left side.

1. Using crowfoot, remove two capscrews (6), washers (5), clamp (6.1), caliper (3), and yoke (4) from adapter (2).

NOTE
Note positioning of brake pad surfaces for installation.

2. Remove two brake pads (1) from adapter (2).

3. Remove six capscrews (10), two-piece lockwashers (9), and halfshaft (8) from rotor (7). Discard two-piece lockwashers (9).

4. Install two capscrews (10) to hold rotor (7).

NOTE
Note positioning of brake pad surfaces for installation.

5. Remove two brake pads (1) from adapter (2).
7-3. SERVICE BRAKE PAD MAINTENANCE  
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)
b. Cleaning and Inspection

1. Clean mating surfaces of caliper (1) and adapter (6) and lubricate with grease.
2. Inspect caliper (1) and caliper piston (2) for cracks, pitting, or damage. Replace caliper (1) if cracked, pitted, or damaged [para. 7-4].
3. Inspect dust boot (3) for tears or deterioration. Replace caliper (1) if dust boot (3) is torn or deteriorated [para. 7-4].
4. Inspect rotor (5) for heat cracks, discoloration, pitting, scoring, or wear. Replace rotor (5) if thickness of rotor (5) is less than 13/16 in. (20.7 mm), cracked, pitted, or scored [para. 7-12].

**NOTE**

- To ensure proper brake function, replace brake pads in pairs on both sides of differential.
- Replace brake pads if thickness is less than 3/16 in. (4.8 mm) and operation in wet and muddy conditions is expected.

5. Inspect brake pads (4) for glazing, oil saturation, or wear. If glazed, oil saturated, or if brake pad thickness is less than 1/8 in. (3.2 mm), replace both pads (4) and pads on opposite caliper.
6. Clean output flange threaded holes (5.1) behind rotor (5) with a 10-mm tap to remove old sealing compound.

**WARNING**

Ensure brake pads are installed with linings facing rotor. Failure to do this may cause injury to personnel or damage to equipment.

**NOTE**

- Perform steps 1 and 2 for right side. Perform steps 3, 4, and 5 for left side.

7. Position two brake pads (4) on adapter (6).

**NOTE**

- When installing yoke and caliper, use a C-clamp and a block of wood to bottom out piston in caliper. If piston will not bottom out, replace caliper [para. 7-4].

8. Apply sealing compound to tapped holes of adapter (6). Using crowfoot, install yoke (7) and caliper (1) on adapter (6) with clamp (8.1), two washers (8), and capscrews (9). Tighten capscrews (9) to 30-40 lb-ft (41-54 N•m).
9. Install two brake pads (4) on adapter (6).
10. Remove two capscrews (12) from rotor (5).

**NOTE**

- Ensure all six capscrews holes in the rotor align with holes in output flange.
- New capscrews come with preapplied thread-locking compound, however, still apply sealing compound to threads of new capscrews. If old capscrews are to be used, mating threads must be cleaned and sealing compound applied to threads of capscrews.
- Two-piece lockwashers must be installed in sets of two with serrated sawtooth threads facing each other.

11. Apply sealing compound to six capscrews (12), and install halfshaft (10) on rotor (5) with six two-piece lockwashers (11) and capscrews (12). Tighten capscrews (12) to 58 lb-ft (79 N•m).
FOLLOW-ON TASK: Install brake protection guards (para. 7-11).
7-3.1. SERVICE BRAKE PAD MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal
b. Cleaning and Inspection
c. Installation

INITIAL SETUP:

- **Tools**
  - General mechanic's tool kit: automotive (Appendix B, Item 1)
  - Clamp (Appendix B, Item 153)
- **General Safety Instructions**
  - Ensure brake pads are installed with linings facing rotor.
- **Manual References**
  - TM 9-2320-387-24P

**CAUTION**

Ensure master cylinder brake fluid is no higher than half full when seating caliper pistons or over-flow of master cylinder brake fluid may occur.

**NOTE**

- Replacement procedures for service brake pads are basically the same. This procedure covers the right front service brake pads.
- To ensure proper brake function, replace brake pads in pairs on both sides of differential.

**a. Removal**

1. Remove spring clip (3) and guide pin (1) from brake pads (4) and brake caliper (2).
2. Remove inner and outer brake pads (4) from brake caliper (2).

**b. Cleaning and Inspection**

Inspect brake pads for glazing, oil saturation, and excessive wear. If brake pad thickness is less than 3/16-in. (4.8 mm), replace brake pads and brake pads on opposite brake caliper.

**c. Installation**

**WARNING**

Ensure brake pads are installed with linings facing rotor. Failure to do this may cause injury to personnel or damage to equipment.

**NOTE**

When installing brake pads, use a C-clamp and a block of wood to seat caliper pistons.

1. Install inner and outer brake pads (4) in brake caliper (2).
2. Install guide pin (1) through brake caliper (2) and brake pads (4). Secure guide pin (1) with spring clip (3).
7-3.1. SERVICE BRAKE PAD MAINTENANCE
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
7-4. SERVICE BRAKE CALIPER MAINTENANCE  
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:
   a. Removal
   b. Cleaning and Inspection
   c. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
      automotive (Appendix B, Item 2)
      Clamp (Appendix B, Item 153)

Special Tools
   Hex-head driver, 7-mm
      (Appendix B, Item 151)
   Crowfoot, 14-mm (Appendix B, Item 141)

Materials/Parts
   Copper washer (Appendix G, Item 14)
   Grease (Appendix C, Item 34)
   Sealing compound (Appendix C, Item 63)

Manual References
   TM 9-2320-387-24P

Equipment Condition
   • Brake pads removed[para. 7-3].
   • Brake protection guards removed[para. 7-11].

General Safety Instructions
   Ensure brake pads are installed with linings facing rotor.

Maintenance Level
   Unit

NOTE
   For replacement of rear dual service/parking brake caliper, refer to para. 7-15

a. Removal

CAUTION
   Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

NOTE
   Perform steps 1 and 2 for right side. Perform steps 3 through 6 for left side.

1. Disconnect hose (1) from coupling (5).
2. Slide yoke (2) and locating pins (3) out from caliper (4).
3. Disconnect hose (1) from coupling (5).
4. Remove two capscrews (8) from rotor (7).
5. Remove rotor (7) from caliper (4) and adapter (6).
6. Using crowfoot, remove two capscrews (10), washers (11), yoke (2), and caliper (4) from adapter (6).
7-4. SERVICE BRAKE CALIPER MAINTENANCE
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)
7. Remove coupling (1) and copper washer (2) from caliper (3). Discard copper washer (2).

b. Cleaning and Inspection

1. Clean mating surfaces of caliper (3) and adapter (8) and lubricate with grease.
2. Clean cooling fins of rotor (12).
3. Inspect caliper (3) and caliper piston (4) for cracks, pitting, or damage. Replace caliper (3) if cracked, pitted, or damaged.
4. Inspect locating pin bearings and bushings (6) for tears or deterioration. Replace bearings and bushings (6) if torn or deteriorated.
5. Inspect dust boot (5) for tears or deterioration. Replace caliper (3) if dust boot (5) is torn or deteriorated.
6. Inspect yoke locating pins (10) for cracks or corrosion. Perform step 7 if cracked or corroded.
7. Using 7-mm hex-head driver, remove locating pins (10) from yoke (9). Discard locating pins (10).
8. Inspect rotor (12) for heat cracks, discoloration, pitting, or scoring. Replace rotor (12) if cracked, pitted, or scored [para. 7-12].
9. Clean output flange threaded holes (17) with a 10 mm tap to remove old sealing compound.

c. Installation

1. Install copper washer (2) and coupling (1) on caliper (3).
   
   **NOTE**
   - Perform step 2 only if yoke locating pins were replaced.
   - Perform steps 3 and 4 for right side. Perform steps 6 through 9 for left side.

2. Apply sealing compound to threads of locating pins (10) and install locating pins (10) in yoke (9). Tighten locating pins (10) to 25-35 lb-ft (34-47 N·m).
3. Install caliper (3) on yoke (9).
4. Connect hose (7) to coupling (11).
5. Deleted.
6. Install caliper (3) on yoke (9).
7. Position rotor (12) and caliper (3) on adapter (8) and hold rotor (12) with two capscrews (13).
   
   **NOTE**
   When installing yoke and caliper, use a C-clamp and a block of wood to bottom out piston in caliper.

8. Apply sealing compound to tapped holes of adapter (8). Using crowfoot, install yoke (9) and caliper (3) on adapter (8) with two washers (15) and capscrews (16). Tighten two capscrews (16) to 30-40 lb-ft (41-54 N·m).
9. Connect hose (7) to coupling (11).
FOLLOW-ON TASKS:
- Install brake pads (para. 7-3).
- Bleed brake system (para. 7-2).
- Install brake protection guards (para. 7-11).
7-4.1. SERVICE BRAKE CALIPER MAINTENANCE  
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:
   a. Removal  c. Installation
   b. Cleaning and Inspection

INITIAL SETUP:

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<th>Manual References</th>
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Equipment Condition

- Brake pads removed (para. 7-3.1).
- Brake protection guards removed (front only) (para. 7-11.1).
- Horn removed (front only) (para. 4-26.1).

Maintenance Level

Unit

CAUTION

Cover or plug all open brake lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connecting brake lines.

NOTE

- Replacement procedures for brake calipers are basically the same. This procedure covers the right front brake caliper.
- Have drainage container ready to catch brake fluid.
- Front calipers will need to be removed through front crossmember.

a. Removal

1. Remove brake line (5) from fitting (4) on brake caliper (6).
2. Remove two capscrews (1) and washers (2) from brake caliper (6) on anchor plate (3).
3. Remove brake caliper (6) from rotor (7).

b. Cleaning and Inspection

1. Inspect caliper (6) for cracks, pitting, or damage. Replace caliper (6) if necessary.
2. Inspect rotor (para. 7-12.1).
3. Inspect inside of brake caliper for rust. Remove all rust.
7-4.1. SERVICE BRAKE CALIPER MAINTENANCE  
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

c. Installation

1. Install brake caliper (6) on rotor (7).
2. Apply sealing compound to capscrews (1) and secure brake caliper (6) to anchor plate (3) with two washers (2) and capscrews (1). Tighten capscrews (1) to 40 lb-ft (54 N·m).
3. Install brake line (5) on fitting (4) on brake caliper (6).

FOLLOW-ON TASKS:  
- Install horn (front only) [para. 4-26.1].
- Install brake protection guards (front only) [para. 7-11.1].
- Install brake pads [para. 7-3.1].
- Bleed brake system [para. 7-2.1].
7-5. MASTER CYLINDER MAINTENANCE
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:
   a. Removal
   b. Installation
   c. Bleeding

INITIAL SETUP:

Tools
   General mechanic's tool kit:
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
      automotive (Appendix B, Item 2)

Materials/Parts
   Four locknuts (Appendix G, Item 106)

Personnel Required
   One mechanic
   One assistant

Manual References
   TM 9-2320-387-24P

Equipment Condition
   Left splash shield removed (para. 10-23).

Maintenance Level
   Unit

CAUTION
Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE
Perform step 1 for M1114 models only.

1. Remove locknut (10), washer (11), and bracket (12) from hydro-boost (1). Discard locknut (10).

NOTE
Have drainage container ready to catch brake fluid.

2. Disconnect brake lines (5) and (6) from master cylinder (2).
3. Remove locknut (3), washer (4), and differential valve bracket (7) from right master cylinder mounting stud (9). Discard locknut (3).

CAUTION
Do not lean on master cylinder. Damage to master cylinder may result.

4. Remove two locknuts (8) and master cylinder (2) from hydro-boost (1). Discard locknuts (8).

b. Installation

CAUTION
Ensure O-ring is properly seated on master cylinder prior to installation. Damage to master cylinder may result if O-ring is not properly seated.
1. Install master cylinder (2) on hydro-boost (1) with two locknuts (8). Tighten locknuts (8) to 22 lb-ft (30 N·m).
2. Install differential valve bracket (7) on stud (9) with washer (4) and locknut (3). Tighten locknut (3) to 22 lb-ft (30 N·m).
3. Connect brake lines (5) and (6) to master cylinder (2).

**NOTE**

Perform step 4 for M1114 models only.

4. Install bracket (12) on hydro-boost (1) with washer (11) and locknut (10). Tighten locknut (10) to 22 lb-ft (30 N·m).

**c. Bleeding**

**NOTE**

Master cylinder must be filled [(para. 2-12 item 11)] and kept at least half full during bleeding operation.

1. Depress brake pedal slowly and hold. Loosen brake line (5) to purge air from the front reservoir.
2. Tighten brake line (5) and release brake pedal.
3. Repeat steps 1 and 2 until front reservoir is purged of air.
4. Repeat steps 1 through 3 for rear reservoir with brake line (6).

FOLLOW-ON TASKS:
- Install left splash shield (para. 10-23).
- Bleed brake system (para. 7-2).
7-5.1. MASTER CYLINDER REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
O-ring (Appendix G, Item 228.6)
Lockwasher (Appendix G, Item 144)
Two locknuts (Appendix G, Item 106)
Two locknuts (Appendix G, Item 132.1)

Personnel Required
One mechanic
One assistant

Manual References
TM 9-2320-387-24-1
TM 9-2320-387-24P

Equipment Condition
Left splash shield removed (para. 10-23.1).

Maintenance Level
Unit

CAUTION
Cover or plug all open brake lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connecting brake lines.

a. Removal

NOTE
Have drainage container ready to catch brake fluid.

1. Remove vent hose (2) from reservoir cap (3).
2. Loosen and remove left and right front brake lines (5) from proportioning valve (9) and master cylinder (4).
3. Remove capscrew (8), lockwasher (7), washer (6), and bracket (10) from bracket (13). Discard lockwasher (7).

CAUTION
Do not lean on master cylinder or damage to master cylinder may occur.

NOTE
O-ring may fall when master cylinder is removed from hydro-booster.

4. Remove two locknuts (11), washers (12), two locknuts (14), bracket (13), O-ring (16), splash shield bracket (1), and master cylinder (4) from hydro-booster (15). Discard locknuts (11) and (14), and O-ring (16).
7-5.1. MASTER CYLINDER REPLACEMENT  
(SERIAL NUMBERS 300000 AND ABOVE)  (Cont’d)

b. Installation

CAUTION

- Perform master cylinder bleeding procedure before installing master cylinder on vehicle. Damage to master cylinder may result if bleeding is not done properly (para. 7-2.1).  
- Ensure O-ring is properly seated in master cylinder prior to installation or damage to master cylinder may occur.

1. Install master cylinder (4) on hydro-booster (15) with O-ring (16), splash shield bracket (1), two locknuts (14), bracket (13), two washers (12), and locknuts (11). Tighten locknuts (11) and (14) to 22 lb-ft (30 N•m).
2. Install bracket (10) on bracket (13) with capscrew (8), lockwasher (7), and washer (6).
3. Install left and right front brake lines (5) on proportioning valve (9) and master cylinder (4).
4. Install vent hose (2) on reservoir cap (3).

FOLLOW-ON TASKS:  
- Install left splash shield (para. 10-23.1).  
- Bleed brake system master cylinder (para. 7-2.1).
7-6. HYDRO-BOOSTER REPLACEMENT

This task covers:

- a. Removal
- b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Cotter pin (Appendix G, Item 23)
- Spring washer (Appendix G, Item 319)
- Four lockwashers (Appendix G, Item 144)
- Four locknuts (Appendix G, Item 106)

**Personnel Required**
- One mechanic
- One assistant

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Master cylinder removed (para. 7-5 or para. 7-5.1)

**Maintenance Level**
- Unit

---

**a. Removal**

CAUTION

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

**NOTE**

Have drainage container ready to catch brake fluid.

1. Mark and disconnect two high-pressure lines (4) and return line (5) from hydro-booster (6).
2. Remove cotter pin (3) and washer (2), and disconnect pushrod (7) from brake pedal bellcrank (13). Remove spring washer (1) from brake pedal bellcrank (13). Discard cotter pin (3) and spring washer (1).
3. Remove four locknuts (12), lockwashers (11), washers (10), hydro-booster (6), and gasket (8) from cowl (9). Discard lockwashers (11) and locknuts (12).

**b. Installation**

1. Install gasket (8) and hydro-booster (6) on cowl (9) with four washers (10), lockwashers (11), and locknuts (12). Do not tighten locknuts (12).
2. Install spring washer (1) on brake pedal bellcrank (13). Connect hydro-booster pushrod (7) to brake pedal bellcrank (13) with washer (2) and cotter pin (3).
3. Tighten locknuts (12) to 21 lb-ft (29 N·m).
4. Connect two high-pressure lines (4) and return line (5) to hydro-booster (6).
7-6. HYDRO-BOOSTER REPLACEMENT (Cont’d)

FOLLOW-ON TASK:  
- Install master cylinder (para. 7-5 or para. 7-5.1).  
- Bleed power steering system (para. 8-27 or para. 8-27.1).
7-7. BRAKE LINES REPLACEMENT  
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Front Caliper-to-Intermediate Brake Line Removal  
b. Front Caliper-to-Intermediate Brake Line Installation  
c. Rear Caliper-to-Intermediate Brake Line Removal  
d. Rear Caliper-to-Intermediate Brake Line Installation  
e. Caliper-to-Intermediate Support Brackets Removal  
f. Caliper-to-Intermediate Support Brackets Installation  
g. Rear Brake Line Removal  
h. Rear Brake Line Installation  
i. Intermediate Brake Line Removal  
j. Intermediate Brake Line Installation  
k. Proportioning Valve-to-Union Brake Line Removal  
l. Proportioning Valve-to-Union Brake Line Installation  
m. Pressure Limiter Valve-to-Differential Valve Removal  
n. Pressure Limiter Valve-to-Differential Valve Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: 
automotive (Appendix B, Item 1)

Materials/Parts
Two tiedown straps (Appendix G, Item 324) 
Tube coupling (Appendix G, Item 27)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

CAUTION

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE

- Have drainage container ready to catch brake fluid.
- Brake line replacement procedures for service brake system and rear dual service/parking brake system are basically the same.
- Left side is shown, right side is similar.

a. Front Caliper-to-Intermediate Brake Line Removal

1. Disconnect left front brake line (1) from tube coupling (13.2).
1.1. Remove tube coupling (13.2) and washer (13.1) from caliper (13). Discard tube coupling (13.2).
2. Remove capscrew (15), washer (14), and clamp (11) from yoke (12).
3. Remove capscrew (7), washer (6), and clamp (5) from bracket (8).
4. Remove two tiedown straps (10) from brake lines (9) and (1). Discard tiedown straps (10).
5. Remove clip (4) and left front brake line (1) from bracket (2) and intermediate brake line (3).

b. Front Caliper-to-Intermediate Brake Line Installation

1. Install left front brake line (1) on intermediate brake line (3) and bracket (2) with clip (4).
2. Install clamp (5) and left front brake line (1) on bracket (8) with washer (6) and capscrew (7). Secure brake lines (9) and (1) with two tiedown straps (10).
3. Install clamp (11) and brake line (1) on yoke (12) with washer (14) and capscrew (15).
4. Install washer (13.1) and tube coupling (13.2) on caliper (13).
5. Connect left front brake line (1) to tube coupling (13.2).
7-7. BRAKE LINES REPLACEMENT  
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

NOTE
Left side shown, right side similar.

c. Rear Caliper-to-Intermediate Brake Line Removal

1. Disconnect left rear brake line (1) from caliper adapter fitting (7.2).
1.1. Remove tube coupling (7.2) and washer (7.1) from caliper (7). Discard tube coupling (7.2).
2. Remove capscrew (9), washer (8), and clamp (5) from yoke (6).
3. Remove capscrew (10), clamp (11), and brake line (1) from bracket (12).
4. Remove clip (4) and left rear brake line (1) from bracket (2) and intermediate brake line (3).

d. Rear Caliper-to-Intermediate Brake Line Installation

1. Install left rear brake line (1) on intermediate brake line (3) and bracket (2) with clip (4).
2. Install clamp (11) and brake line (1) on bracket (12) with capscrew (10).
3. Install clamp (5) on yoke (6) with washer (8) and capscrew (9).
4. Install washer (7.1) and tube coupling (7.2) on caliper (7).
5. Connect left rear brake line (1) to tube coupling (7.2).
7-7. BRAKE LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)
7-7. BRAKE LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

**e. Caliper-to-Intermediate Support Brackets Removal**

**NOTE**
Perform steps 1 through 3 for front support bracket. Perform steps 4 through 6 for rear support bracket.

1. Remove two tiedown straps (8) from front brake lines (4) and intermediate brake line (11).
2. Remove two capscrews (7), washers (6), and clamps (5) from support bracket (2).
3. Remove nut (10), washer (9), capscrew (3), and support bracket (2) from crossmember (1).
4. Remove capscrew (13), clamp (14), and brake line (12) from left support bracket (15).
5. Remove capscrew (16), washer (17), and left support bracket (15) from frame bracket (18).
6. Repeat steps 4 and 5 for right support bracket.

**f. Caliper-to-Intermediate Support Brackets Installation**

**NOTE**
Perform steps 1 through 3 for front support bracket. Perform steps 4 through 6 for rear support bracket.

1. Install support bracket (2) on crossmember (1) with capscrew (3), washer (9), and nut (10).
2. Install two clamps (5) on support bracket (2) with two washers (6) and capscrews (7).
3. Secure front brake lines (4) and intermediate brake line (11) with two tiedown straps (8).
4. Install left support bracket (15) on frame bracket (18) with washer (17) and capscrew (16).
5. Install brake line (12) and clamp (14) on support bracket (15) with capscrew (13).
6. Repeat steps 4 and 5 for right support bracket.
7-7. BRAKE LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)
7-7. BRAKE LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

g. Rear Brake Line Removal

1. Disconnect rear brake line (2) from rear union (1).
2. Remove capscrew (5) and clamp (4) from rear brake line (2) and forward rear crossmember (3).
3. Disconnect rear brake line (2) from intermediate brake line (6).

h. Rear Brake Line Installation

1. Connect rear brake line (2) to intermediate brake line (6).
2. Install rear brake line (2) on forward rear crossmember (3) with clamp (4) and capscrew (5).
3. Connect rear brake line (2) to rear union (1).

i. Intermediate Brake Line Removal

1. Disconnect intermediate brake line (6) from rear brake line (2).
2. Remove five capscrews (8) and clamps (7) from intermediate brake line (6) and frame (9).
3. Disconnect coupling (11) from proportioning valve-to-union brake line (10).
j. Intermediate Brake Line Installation

1. Connect coupling (11) to proportioning valve-to-union brake line (10).
2. Connect intermediate brake line (6) to rear brake line (2).
3. Install intermediate brake line (6) on frame (9) with five clamps (7) and capscrews (8).
7-7. BRAKE LINES REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

k. Proportioning Valve-to-Union Brake Line Removal
1. Disconnect brake line (2) from proportioning valve (3).
2. Remove nut (7), washer (6), capscrew (1), clamp (10), and brake line (2) from bracket (8).
3. Remove brake line (2) from coupling (9).
4. Disconnect brake line (4) from proportioning valve (3).
5. Remove brake line (4) from union (5).

l. Proportioning Valve-to-Union Brake Line Installation
1. Install brake line (4) on union (5).
2. Connect brake line (4) to proportioning valve (3).
3. Install brake line (2) on coupling (9).
4. Install brake line (2) and clamp (10) on bracket (8) with capscrew (1), washer (6), and nut (7).
5. Connect brake line (2) to proportioning valve (3).

m. Pressure Limiter Valve-to-Differential Valve Removal
1. Disconnect brake lines (13) and (14) from pressure limiter valves (11) and (15).
2. Remove brake lines (13) and (14) from differential valve (12).

n. Pressure Limiter Valve-to-Differential Valve Installation
1. Install brake lines (13) and (14) on differential valve (12).
2. Connect brake lines (13) and (14) to pressure limiter valves (11) and (15).
FOLLOW-ON TASK: Bleed brake system (para. 7-2).
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Front Caliper Brake Line Removal  
b. Front Caliper Brake Line Installation  
c. Rear Caliper Brake Line Removal  
d. Rear Caliper Brake Line Installation  
e. Front Brake Line Removal  
f. Front Brake Line Installation  
g. Rear Brake Line Removal  
h. Rear Brake Line Installation  
i. Proportioning Valve Brake Line Removal  
j. Proportioning Valve Brake Line Installation  
k. Differential Valve Brake Line Removal  
l. Differential Valve Brake Line Installation

INITIAL SETUP:

Tools  
- General mechanic's tool kit: 
  automotive (Appendix B, Item 1)  
- Maintenance and repair shop equipment: 
  automotive (Appendix B, Item 2)  

Equipment Condition  
- Radiator removed (para. 3-62.1).  
- Parking brake access cover removed (para. 10-58.4).

Manual References  
- TM 9-2320-387-24P

Maintenance Level  
- Unit

CAUTION

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE

Have drainage container ready to catch brake fluid.

a. Front Caliper Brake Line Removal

1. Disconnect brake line (1) from caliper fitting (10) on right caliper (11).
2. Disconnect brake line (1) from tee fitting (4).
3. Remove capscrew (6), washer (5), clamp (2), and brake line (1) from front crossmember bracket (3).
4. Disconnect brake line (7) from tee fitting (4).
5. Disconnect brake line (7) from caliper fitting (9) on left caliper (8).

b. Front Caliper Brake Line Installation

1. Connect brake line (7) to caliper fitting (9) of left caliper (8). Tighten to 8 lb-ft (11 N•m).
2. Connect brake line (7) to tee fitting (4).
3. Install brake line (1) on front crossmember bracket (3) with clamp (2), washer (5), and capscrew (6).
4. Connect brake line (1) to tee fitting (4).
5. Connect brake line (1) to caliper fitting (10) of right caliper (11). Tighten to 8 lb-ft (11 N•m).
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FRONT OF VEHICLE
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

c. Rear Caliper Brake Line Removal

1. Disconnect brake line (4) from caliper fitting (8) on right caliper (7).
2. Disconnect brake line (4) from tee fitting (12) on brake line (1).
3. Remove cap screw (6), washer (5), clamp (3), and brake line (4) from rear crossmember bracket (2).
4. Disconnect brake line (11) from caliper fitting (10) on left caliper (9).
5. Disconnect brake line (11) from tee fitting (12).

d. Rear Caliper Brake Line Installation

1. Connect brake line (11) to tee fitting (12).
2. Connect brake line (11) to caliper fitting (10) of left caliper (9). Tighten to 8 lb-ft (11 N•m).
3. Install brake line (4) on rear crossmember bracket (2) with clamp (3), cap screw (6), and washer (5).
4. Connect brake line (4) to tee fitting (12) on brake line (1).
5. Connect brake line (4) to caliper fitting (8) of right caliper (7). Tighten to 8 lb-ft (11 N•m).
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

e. Front Brake Line Removal

1. Disconnect front and rear brake lines (2) and (3) from proportioning valve (1).
2. Remove two capscrews (4) and (9), washers (5) and (10), clamps (6) and (11), and brake lines (2) and (8) from two left-hand frame rail support brackets (13) on left-hand frame rail (12).
3. Disconnect brake line (8) from front tee union (14).
4. Disconnect brake lines (2) and (8) from front union (7).
5. Disconnect brake line (3) from front union (19).
6. Remove capscrew (15), washer (16), clamp (18), and brake line (3) from frame rail (17).

f. Front Brake Line Installation

1. Install brake line (3) on frame rail (17) with clamp (18), washer (16) and capscrew (15).
2. Connect brake line (3) to front union (19).
3. Connect brake lines (2) and (8) to front union (7).
4. Connect brake line (8) to front tee union (14).
5. Install brake lines (2) and (8) on two left-hand frame rail support brackets (13) on left hand frame rail (12) with two clamps (6) and (11), washers (5) and (10), and capscrews (4) and (9).
6. Connect front and rear brake lines (2) and (3) to proportioning valve (1).
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)(Cont’d)

**g. Rear Brake Line Removal**

1. Disconnect brake line (5) from rear tee union (1).
2. Disconnect brake line (5) from rear union (9).
3. Remove two capscrews (2) and (6), washers (3) and (7), clamps (4) and (8), and brake line (5) from left frame rail support bracket (15).
4. Disconnect brake line (13) from rear union (9).
5. Disconnect brake line (13) from rear union (29).
6. Remove capscrew (10), washer (11), clamp (12), and brake line (13) from left frame rail support bracket (14).
7. Remove three capscrews (25), (22), and (19), washers (24), (21), and (18), clamps (23), (20), and (17), and brake line (13) from left frame rail (16).
8. Remove capscrew (27), washer (26), clamp (28), and brake line (13) from engine mount bracket (30).

**h. Rear Brake Line Installation**

1. Install brake line (13) on engine mount bracket (30) with clamp (28), washer (26), and capscrew (27).
2. Install brake line (13) on left frame rail (16) with three clamps (23), (20), and (17), washers (24), (21), and (18), and capscrews (25), (22), and (19).
3. Install brake line (13) on left frame rail support bracket (14) with clamp (12), washer (11), and capscrew (10).
4. Connect brake line (13) to rear union (9).
5. Connect brake line (13) to rear union (29).
6. Install brake line (5) on left frame rail support bracket (15) with two clamps (4) and (8), washers (3) and (7), and capscrews (2) and (6).
7. Connect brake line (5) to rear union (9).
8. Connect brake line (5) to rear tee union (1).
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)(Cont’d)

i. Proportioning Valve Brake Line Removal

1. Disconnect brake line (1) from proportioning valve (4) and pressure limiter valve (2).
2. Disconnect brake line (5) from proportioning valve (4) and pressure limiter valve (3).

j. Proportioning Valve Brake Line Installation

1. Connect brake line (5) to proportioning valve (4) and pressure limiter valve (3).
2. Connect brake line (1) to proportioning valve (4) and pressure limiter valve (2).
7-7.1. BRAKE LINES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

k. Differential Valve Brake Line Removal

1. Disconnect brake line (18) from differential valve (24) and pressure limiter valve (19).
2. Disconnect brake line (25) from differential valve (24) and pressure limiter valve (21).
3. Disconnect brake line (20) from differential valve (24) and master cylinder (23).
4. Disconnect brake line (22) from differential valve (24) and master cylinder (23).

l. Differential Valve Brake Line Installation

1. Connect brake line (22) to differential valve (24) and master cylinder (23).
2. Connect brake line (20) to differential valve (24) and master cylinder (23).
3. Connect brake line (25) to differential valve (24) and pressure limiter valve (21).
4. Connect brake line (18) to differential valve (24) and pressure limiter valve (19).

FOLLOW-ON TASKS:
- Install parking brake access cover (para. 10-58.4).
- Install radiator [para. 3-62.1].
- Bleed brake system [para. 7-2.1].
7-8. BRAKE PRESSURE LIMITER VALVE REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
- General mechanic’s tool kit: automotive (Appendix B, Item 1)

Materials/Parts
- Two lockwashers (Appendix G, Item 185)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Hood raised and secured (TM 9-2320-387-10).
- Battery ground cables disconnected [para. 4-68].

Maintenance Level
- Unit

a. Removal

**CAUTION**

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

**NOTE**

Have drainage container ready to catch brake fluid.

1. Disconnect brake lines (6) and (7) from adapter fittings (8) on brake pressure limiter valves (1).
2. Remove four adapter fittings (8) from two pressure limiter valves (1).
3. Remove two capscrews (3), lockwashers (4), washers (5), and pressure limiter valves (1) from bracket (2). Discard lockwashers (4).

b. Installation

1. Install two pressure limiter valves (1) on bracket (2) with two washers (5), lockwashers (4), and capscrews (3).
2. Install four adapter fittings (8) on two pressure limiter valves (1).
3. Connect brake lines (6) and (7) to adapter fittings (8) on brake pressure limiter valves (1).
FOLLOW-ON TASKS:  • Bleed brake system (para. 7-2 or para. 7-2.1).
• Lower and secure hood (TM 9-2320-387-10).
• Connect battery ground cables (para. 4-68).
This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Special Tools
Crowfoot, 7/8-in. (Appendix B, Item 142)
Socket adapter (Appendix B, Item 135)

Materials/Parts
Cotter pin (Appendix G, Item 23)
Spring washer (Appendix G, Item 319)
Two bearing sleeves (Appendix G, Item 3)
Grease (Appendix C, Item 34)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
• Protective Control Box (PCB) removed (para. 4-4).
• Stoplight switch removed (para. 4-60).

Maintenance Level
Unit

a. Removal

1. Disconnect return spring (4) from brake pedal bracket (12).
2. Remove cotter pin (7), washer (8), hydro-booster pushrod (5), and spring washer (9) from brake pedal bellcrank (10). Discard cotter pin (7) and spring washer (9).
3. Remove nut (6), washer (2), pivot pin (1), washer (2), and brake pedal assembly (11) from bracket (3).
4. Remove two bearing sleeves (13) from brake pedal assembly (11). Discard bearing sleeves (13).

b. Installation

1. Apply grease to inside of two bearing sleeves (13) and install bearing sleeves (13) in brake pedal assembly (11).
2. Install brake pedal assembly (11) on bracket (3) with washer (2), pivot pin (1), washer (2), and nut (6). Using adapter and crowfoot, tighten nut (6) to 60 lb-ft (81 N•m).
3. Install spring washer (9) and hydro-booster pushrod (5) on brake pedal bellcrank (10) with washer (8) and cotter pin (7).
4. Connect return spring (4) to brake pedal bracket (12).
FOLLOW-ON TASKS:
- Install stoplight switch [para. 4-60].
- Install protective control box [para. 4-4].
- Operate vehicle (TM 9-2320-387-10) and check brakes for proper operation.
7-10. PROPORTIONING VALVE AND DIFFERENTIAL VALVE REPLACEMENT

This task covers:

a. Differential Valve Removal
b. Differential Valve Installation
c. Proportioning Valve Removal
d. Proportioning Valve Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Locknut (Appendix G, Item 78)
- Locknut (Appendix G, Item 106)
- Lubricating oil (Appendix C, Item 46)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
- Unit

CAUTION

• Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.
• Do not attempt to disassemble proportioning valve. Damage to equipment will result.

NOTE

Have drainage container ready to catch brake fluid.

a. Differential Valve Removal

1. Disconnect electrical connector (2) from differential valve (4).
2. Disconnect two brake lines (3) from differential valve (4).
3. Disconnect two brake lines (5) from differential valve (4).
4. Remove locknut (6), washer (7), and differential valve (4) with differential valve bracket (8) from hydro-boost (1). Discard locknut (6).

b. Differential Valve Installation

1. Install differential valve (4) and differential valve bracket (8) on hydro-boost (1) with washer (7) and locknut (6). Tighten locknut (6) to 22 lb-ft (30 N•m).
2. Connect two brake lines (5) to bottom of differential valve (4).
3. Connect two brake lines (3) to top of differential valve (4).
4. Apply lubricating oil to pins (9) of differential valve (4).
5. Connect electrical connector (2) to differential valve (4).

c. Proportioning Valve Removal

1. Disconnect two brake lines (17) from proportioning valve (16).
2. Disconnect two brake lines (15) from proportioning valve (16).
3. Remove locknut (14), washer (13), screw (11), and proportioning valve (16) with proportioning valve bracket (12) from bracket (10). Discard locknut (14).
7-10. PROPORTIONING VALVE AND DIFFERENTIAL VALVE REPLACEMENT (Cont’d)

d. Proportioning Valve Installation

1. Install proportioning valve (16) and proportioning valve bracket (12) on bracket (10) with screw (11), washer (13), and locknut (14). Tighten locknut (14) to 22 lb-ft (30 N·m).
2. Connect two brake lines (15) to bottom of proportioning valve (16).
3. Connect two brake lines (17) to top of proportioning valve (16).

FOLLOW-ON TASKS: • Connect battery ground cables [para. 4-68].
• Bleed brake system [para. 7-3 or para. 7-2.1].
This task covers:

- a. Removal
- b. Installation

**INITIAL SETUP:**

**Tools**
- General mechanic’s tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Six locknuts (without 10,500 lb hydraulic winch) (Appendix G, Item 106)
- Three locknuts (with 10,500 lb hydraulic winch) (Appendix G, Item 106)
- Six locknuts (Appendix G, Item 82)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Vehicle raised and supported (para. 8-2).

**Maintenance Level**
- Unit

---

**a. Removal**

**NOTE**

Perform steps 1 and 2 for vehicles equipped with 10,500 lb hydraulic winch only.

1. Remove two locknuts (3), washers (4), capscrews (8), washers (4), spacer (5), and left front brake protection guard (7) from bracket (9) and bumper (6). Discard locknuts (3).

2. Remove four locknuts (2), washers (1), capscrews (12), washers (1), two spacers (5), and right front brake protection guards (10) from bracket (11) and bumper (6). Discard locknuts (2).

---

*Equipped 10,500 LB Winch.*
Perform steps 3 through 6 for vehicles equipped with 9,000 lb electric winch only.

3. Remove two locknuts (15), washers (16), capscrews (30), washers (16), and left front brake protection guard (31) from brackets (32) and (29). Discard locknuts (15).

4. Remove four locknuts (20), washers (21), capscrews (28), washers (21), and right front brake protection guards (22) from brackets (19) and (25). Discard locknuts (20).

5. Remove two locknuts (13), washers (14), capscrews (18), washers (14), and brackets (32) and (29) from front rear crossmember (17) and front crossmember (27). Discard locknuts (13).

6. Remove four locknuts (23), washers (24), capscrews (26), washers (24), and brackets (19) and (25) from front rear crossmember (17) and front crossmember (27). Discard locknuts (23).
7-11. BRAKE PROTECTION GUARDS REPLACEMENT  
(SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

b. Installation

NOTE
Perform steps 1 and 2 for vehicles with 10,500 lb hydraulic winch only.

1. Install two spacers (5) and right front brake protection guards (10) on bumper (6) and bracket (11) with four washers (1), capscrews (12), washers (1), and locknuts (2).

2. Install spacer (5) and left front brake protection guard (7) on bumper (6) and bracket (9) with two washers (4), capscrews (8), washers (4), and locknuts (3).

Equipped 10,500 LB Winch.
Perform steps 3 through 6 for vehicles with 9,000 lb electric winch only.

3. Install brackets (25) and (19) on front rear crossmember (17) and front crossmember (27) with four washers (24), capscrew (26), washers (24), and locknuts (23).

4. Install brackets (31) and (29) on front rear crossmember (17) and front crossmember (27) with two washers (14), capscrew (18), washers (14), and locknuts (13).

5. Install right front brake protection guards (22) on brackets (25) and (19) with four washers (21), capscrews (18), and locknuts (20).

6. Install left front brake protection guard (31) on brackets (32) and (29) with two washers (14), capscrews (30), washers (14), and locknuts (15).

Equipped 9,000 LB Winch.

FOLLOW-ON TASK: Lower vehicle (para. 8-2).
7-11.1. BRAKE PROTECTION GUARDS REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit: automotive (Appendix B, Item 1)

Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
Ten locknuts (Appendix G, Item 82)
Fourteen locknuts (Appendix G, Item 106)
Locknut (Appendix G, Item 128)
Three lockwashers (Appendix G, Item 145)

Manual References
TM 9-2320-387-24P

Maintenance Level
Unit

a. Removal

NOTE
Perform steps 1 and 2 for rear brake protection guards removal.

1. Remove eight locknuts (1), washers (2), capscrews (6), washers (5), and four brake guards (7) from brackets (10). Discard locknuts (1).

2. Remove eight locknuts (12), washers (11), capscrews (8), washers (9), and four brackets (10) from crossmembers (3) and (4). Discard locknuts (12).

NOTE
Perform steps 3 through 8 for front brake protection guards removal.

3. Remove two locknuts (31), washers (32), capscrews (35), washers (34), and left front brake guard (36) from brackets (33) and (40). Discard locknuts (31).

4. Remove four locknuts (23), washers (24), capscrews (27), washers (26), and two right front brake guards (25) from brackets (16) and (19). Discard locknuts (23).

5. Remove two locknuts (14), washers (15), capscrews (18), washers (17), and bracket (16) from rear crossmember (13). Discard locknuts (14).

6. Remove two capscrews (22), lockwashers (21), washers (20), and bracket (19) from front crossmember (37). Discard lockwashers (21).

7. Remove locknut (42), washer (41), capscrew (38), washer (39), and bracket (40) from rear crossmember (13). Discard locknut (42).

8. Remove capscrew (30), lockwasher (29), washer (28), and bracket (33) from front crossmember (37). Discard lockwasher (29).
7-11.1. BRAKE PROTECTION GUARDS REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
7-11.1. BRAKE PROTECTION GUARDS REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

b. Installation

NOTE
Perform steps 1 through 6 for front brake protection guards installation only.

1. Install bracket (21) on front crossmember (25) with washer (16), lockwasher (17), and capscrew (18).
2. Install bracket (28) on rear crossmember (1) with washer (27), capscrew (26), washer (29), and locknut (30).
3. Install bracket (7) on front crossmember (25) with two washers (8), lockwashers (9), and capscrews (10).
4. Install bracket (4) on rear crossmember (1) with two washers (5), capscrews (6), washers (3), and locknuts (2).
5. Install two right front brake guards (13) on brackets (7) and (4) with four washers (14), capscrews (15), washers (12), and locknuts (11).
6. Install left front brake guard (24) on brackets (28) and (21) with two washers (22), capscrews (23), washers (20), and locknuts (19).

NOTE
Perform steps 7 and 8 for rear brake protection guards installation only.

7. Install four brackets (40) on crossmembers (34) and (33) with washers (39), capscrews (38), washers (41), and locknuts (42).
8. Install four brake protection guards (37) on brackets (40) with eight washers (35), capscrews (36), washers (32), and locknuts (31).
7-11.1. BRAKE PROTECTION GUARDS REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
7-12. SERVICE BRAKE ROTOR REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal          b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
avtomotive (Appendix B, Item 2)

Materials/Parts
Sealing compound (Appendix C, Item 63)
Six two-piece lockwashers
(Appendix G, Item 191)

Manual References
TM 9-2320-387-24P

Equipment Condition
Service brake caliper removed
(para. 7-4).

Maintenance Level
Unit

a. Removal

1. Remove six capscrews (1) and two-piece lockwashers (2) from halfshaft (3), rotor (4), and output flange (5). Discard two-piece lockwashers (2).

NOTE
Clean excess sealant from output flange threaded holes with a 10 mm tap.

2. Disconnect halfshaft (3) and remove rotor (4) from output flange (5).

b. Installation

NOTE

- New capscrews come with preapplied thread-locking compound, however, still apply sealing compound to threads of new capscrews. If old capscrews are to be used, mating threads must be cleaned and sealing compound applied to threads of capscrews.
- Two-piece lockwashers must be installed in sets of two with serrated sawtooth threads facing each other.

1. Apply sealing compound to threads of six capscrews (1).
2. Install rotor (4) on output flange (5).
3. Install halfshaft (3) on rotor (4) with six two-piece lockwashers (2) and capscrews (1). Tighten capscrews (1) to 58 lb-ft (79 N·m).

FOLLOW-ON TASK: Install service brake caliper
(para. 7-4).
7-12.1. SERVICE BRAKE ROTOR REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal
b. Installation

**INITIAL SETUP:**

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Sealing compound (Appendix C, Item 62)
- Six two-piece lockwashers (Appendix G, Item 191)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Service brake caliper removed (para. 7-4.1).
- Parking brake pad removed (para. 7-22).

**Maintenance Level**
- Unit

**NOTE**
Replacement procedures for all rotors are basically the same. This procedure covers the front rotor.

**a. Removal**

1. Remove six capscrews (5) and two-piece lockwashers (4) from halfshaft (3), rotor (2), and output flange (1). Discard two-piece lockwashers (4).

**NOTE**
Clean excess sealant from output flange threaded holes with a 10 mm tap.

2. Disconnect halfshaft (3) and remove rotor (2) from output flange (1).

**b. Installation**

**NOTE**
- Use capscrew to align rotor to mounting holes until halfshaft is installed.
- New capscrews come with pre-applied thread-locking compound, however, still apply sealing compound to threads of new capscrews. If old capscrews are to be used, mating threads must be cleaned and sealing compound applied to threads of capscrews.
- Two-piece lockwashers must be installed in sets of two with serrated sawtooth threads facing each other.

1. Install rotor (2) on output flange (1).
2. Install halfshaft (3) on rotor (2) with six two-piece lockwashers (4) and capscrews (5). Tighten capscrews (5) to 58 lb-ft (79 N•m).
FOLLOW-ON TASKS:  
- Install parking brake pad [para. 7-22].
- Install service brake caliper [para. 7-4.1].
Section II. REAR DUAL SERVICE/PARKING BRAKE SYSTEM MAINTENANCE

### 7-13. REAR DUAL SERVICE/PARKING BRAKE SYSTEM MAINTENANCE TASK SUMMARY

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7-14. REAR DUAL SERVICE/PARKING BRAKE PAD MAINTENANCE

This task covers:

a. Removal c. Installation
b. Cleaning and Inspection

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Special Tools
Crowfoot, 14-mm (Appendix B, Item 141)

Materials/Parts
Clip (Appendix G, Item 11)
Cotter pin (Appendix G, Item 19)
Sealing compound (Appendix C, Item 63)
Grease (Appendix C, Item 34)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Wheels chocked and parking brake released (TM 9-2320-387-10).

General Safety Instructions
Ensure brake pads are installed with linings facing rotor.

Maintenance Level
Unit

a. Removal

1. Remove cotter pin (4), washer (5), and clevis pin (7) from parking brake clevis (6) and lever (3). Discard cotter pin (4).

2. Remove clip (2) and disconnect parking brake cable (8) from caliper cable bracket (1). Discard clip (2).

   **CAUTION**

   Caliper must be supported during removal to prevent damage to brake line.

3. Using crowfoot, remove two capscrews (12), washers (13), clamp (13.1), and pull yoke (14) and caliper (15) away from rotor (10).

   **NOTE**

   Note positioning of brake pad surfaces for installation.

4. Remove two brake pads (9) from adapter (11) and rotor (10).
b. Cleaning and Inspection

NOTE
Apply a light coat of grease on adapter slides.

1. Clean mating surfaces of caliper (1) and adapter (7) and lubricate adapter slides with grease.
2. Inspect caliper (1) and caliper piston (3) for cracks, pitting, or damage. Replace caliper assembly if cracked, pitted, or damaged [para. 7-15].
3. Inspect dust boot (4) for tears or deterioration. Replace caliper (1) if dust boot (4) is torn or deteriorated [para. 7-15].
4. Inspect caliper cable bracket (2) for looseness, damage, and rotation. If loose, damaged, or repositioned, replace caliper (1) [para. 7-15].
5. Thoroughly clean and inspect rotor (6) for heat cracks, discoloration, pitting, or scoring. Replace rotor (6) if cracked, pitted, or scored [para. 7-12].

CAUTION
Ensure grease and oil are not in contact with rotor and/or shoe and lining friction surface. Failure to do so will result in damage to equipment and poor performance.

NOTE
• Replace brake pads in sets on both sides of differential.
• Replace brake pads if thickness is less than 1/8 in. (3.2 mm) and operation in wet and muddy conditions is expected.

6. Inspect brake pads (5) for glazing, oil saturation, or wear. If glazed, oil saturated, or if brake pad thickness is less than 1/8 in. (3.2 mm), replace both pads (5) and pads on opposite caliper.

CAUTION
Applying force to piston cap will result in piston cap damage.

3. Rotate caliper piston (3) in a clockwise direction and at the same time apply force on outer piston hex until caliper piston (3) is seated in piston bore.

4. Install caliper (1) and yoke (10) on adapter (7) and rotor (6) with clamp (9.1), two washers (9), and capscrews (8). Using crowfoot, tighten capscrews (8) to 30-40 lb-ft (41-54 N-m).

5. Install parking brake cable (18) on caliper cable bracket (11) with clip (12).

CAUTION
• Ensure lever is in contact with caliper cable bracket stop. Damage to equipment and poor performance will result if not aligned properly.
• Ensure clevis and clevis pin are aligned to lever. Do not move lever to accommodate a misadjusted clevis. Damage to equipment and poor performance will result.

6. Check position of lever (13) and ensure it is in contact with caliper cable stop bracket (19). Install parking brake clevis (16) on lever (13) with clevis pin (17), washer (15), and cotter pin (14).
FOLLOW-ON TASK: Adjust rear dual service/parking brake (para. 7-19).
7-15. REAR DUAL SERVICE/PARKING BRAKE CALIPER MAINTENANCE

This task covers:

a. Removal
b. Cleaning and Inspection
c. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Special Tools
Crowfoot, 14-mm (Appendix B, Item 141)
Hex-head driver, 7-mm (Appendix B, Item 151)

Materials/Parts
Cotter pin (Appendix G, Item 19)
Copper washer (Appendix G, Item 14)
Clip (Appendix G, Item 11)
Sealing compound (Appendix C, Item 63)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Wheels chocked and parking brake released (TM 9-2320-387-10).

Maintenance Level
Unit

a. Removal

CAUTION
Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

1. Remove cotter pin (4), washer (5), and clevis pin (7) from parking brake clevis (6) and lever (3). Discard cotter pin (4).
2. Remove clip (2) and disconnect parking brake cable (8) from caliper cable bracket (1). Discard clip (2).

NOTE
Have drainage container ready to catch brake fluid.

3. Disconnect brake line (17) from coupling (16).
4. Remove coupling (16) and copper washer (15) from caliper (14). Discard copper washer (15).
5. Using crawfoot, remove two capscrews (10), washers (11), clamp (11.1), and pull yoke (12) and caliper (14) away from adapter (9).
6. Slide yoke (12) and locating pins (13) out from caliper (14).
7-15. REAR DUAL SERVICE/PARKING BRAKE CALIPER MAINTENANCE (Cont’d)

b. Cleaning and Inspection

NOTE
Apply a light coat of grease on adapter slides.
1. Clean mating surfaces of caliper (1) and adapter (7) and lubricate adapter slides with grease.
2. Clean cooling fins of rotor (6).
3. Inspect caliper (1) and caliper piston (4) for cracks, pitting, or damage. Replace caliper (1) if cracked, pitted, or damaged.
4. Inspect caliper cable bracket (2) for looseness, damage, and rotation. If loose, damaged, or repositioned, replace caliper (1).
5. Inspect dust boot (5) for tears or deterioration. Replace caliper (1) if dust boot (5) is torn or deteriorated.
6. Inspect rotor (6) for heat cracks, discoloration, pitting, or damage. Replace rotor (6) if cracked, pitted, or scored [para. 7-12].
7. Inspect yoke locating pins (12) for cracks or corrosion. Perform step 8 if cracked or corroded. If not, perform step 9.
8. Using 7-mm hex-head driver, remove locating pins (12) from yoke (11). Discard locating pins (12).

NOTE
• Replace brake pads in sets on both sides of differential.
• Replace brake pads if thickness is less than 1/8 in. (3.2 mm) and operation in wet and muddy conditions is expected.
9. Inspect brake pads (8) for glazing, oil saturation, or wear. If glazed, oil saturated, or if brake pad thickness is less than 1/8 in. (3.2 mm), replace both pads (8) and pads on opposite caliper [para. 7-14].

CAUTION
Ensure grease and oil are not in contact with rotor and/or brake pad friction surface. Failure to do so will result in damage to equipment and poor performance.
1. Open bleeder valve (3) and depress piston (4) into caliper (1) while rotating piston (4) in a clockwise direction and, at the same time, apply pressure until piston (4) is seated in piston bore.

NOTE
Perform step 2 only if yoke locating pins were removed.
2. Apply sealing compound to threads of locating pins (12) and install locating pins (12) in yoke (11) using 7-mm hex-head driver. Tighten locating pins (12) to 25-35 lb-ft (34-47 N·m).
3. Slide yoke (11) and two locating pins (12) into caliper (1).
4. Apply sealing compound to tapped holes of adapter (7).
5. Install caliper (1) and yoke (11) on adapter (7) with clamp (10.1), two washers (10), and capscrews (9). Using crowfoot, tighten capscrews (9) to 30-40 lb-ft (41-54 N·m).
6. Install copper washer (13) and coupling (14) on caliper (1) and connect brake line (15) to coupling (14).
7. Install parking brake cable (23) on caliper cable bracket (16) with clip (17).

CAUTION
• Ensure lever is in contact with caliper cable bracket stop. Damage to equipment and poor performance will result if not aligned properly.
• Ensure clevis and clevis pin are aligned to lever. Do not move lever to accommodate a misadjusted clevis, or damage to equipment and poor performance will result.
8. Check position of lever (18) and ensure it is in contact with caliper cable bracket stop (24).
9. Install parking brake clevis (21) on lever (18) with clevis pin (22), washer (20), and cotter pin (19).
FOLLOW-ON TASKS:  
- Bleed brake system [para. 7-2].
- Adjust rear dual service/parking brake [para. 7-19].
7-16. RIGHT PARKING BRAKE CABLE REPLACEMENT

This task covers:
  a. Removal
  b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Cotter pin (Appendix G, Item 19)
- Two lockwashers (Appendix G, Item 146)
- Two clips (Appendix G, Item 11)
- Two locknuts (Appendix G, Item 133)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Muffler and catalytic converter removed (para. 3-49).
- Wheels chocked and parking brake released (TM 9-2320-387-10).

**Maintenance Level**
- Unit

---

**a. Removal**

1. Remove cotter pin (29), washer (28), clevis pin (26), and brake clevis (27) from rear caliper lever (30). Discard cotter pin (29).
2. Remove brake cable clip (1) and parking brake cable sleeve (25) from rear caliper cable bracket (2) and remove cable assembly (4) from caliper cable bracket (2). Discard cable clip (1).
3. Remove parking brake cable clip (7) from parking brake cable sleeve (6) and C-beam (9). Disconnect parking brake cable (4) from parking brake equalizer bar (8). Discard cable clip (7).
4. Remove two capscrews (12), parking brake cable clamps (5), and parking brake cable assembly (4) from body (11).
5. Remove locknut (15), capscrew (17), lockwasher (16), and parking brake cable clamp (18) from clamp bracket (22). Discard lockwasher (16) and locknut (15).
6. Remove capscrew (19), lockwasher (20), and parking brake cable clamp (21) from bracket (22). Discard lockwasher (20).

**NOTE**
Perform step 7 if replacing clamp bracket.

7. Remove locknut (24), washer (23), capscrew (13), washer (14), and clamp bracket (22) from support bracket (3). Discard locknut (24).

**b. Installation**

**NOTE**
Perform step 1 if clamp bracket was removed.

1. Install clamp bracket (22) on support bracket (3) with washer (14), capscrew (13), washer (23), and locknut (24).
2. Slide parking brake cable clamp (21) onto parking brake cable assembly (4) and install on clamp bracket (22) with lockwasher (20) and capscrew (19).
3. Slide parking brake cable clamp (18) on parking brake cable assembly (4) and install on clamp bracket (22) with capscrew (17), lockwasher (16), and locknut (15).
4. Install two parking brake cable clamps (5) on parking brake cable assembly (4) and body (11) with capscrews (12).
5. Install parking brake cable sleeve (6) on C-beam (9) and parking brake cable (10) to parking brake equalizer bar (8) with parking brake cable clip (7).
7-16. RIGHT PARKING BRAKE CABLE REPLACEMENT (Cont’d)

**CAUTION**

Ensure caliper cable bracket is secure with no signs of looseness and lever is in contact with caliper cable bracket stop. Damage to equipment and poor performance will result if not aligned properly.

6. Install parking brake cable sleeve (25) on rear caliper cable bracket (2) with brake cable clip (1).

7. Install brake clevis (27) on rear caliper lever (30) with clevis pin (26), washer (28), and cotter pin (29).

FOLLOW-ON TASKS:  
- Adjust parking brake lever (TM 9-2320-387-10).
- Install muffler and catalytic converter (para. 3-49).
7-17. LEFT PARKING BRAKE CABLE/MOUNTING BRACKET REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
</thead>
</table>
| General mechanic's tool kit:  
  automotive (Appendix B, Item 1) | TM 9-2320-387-10  
  TM 9-2320-387-24P |

<table>
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<th>Materials/Parts</th>
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</table>
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  Two lockwashers (Appendix G, Item 146)  
  Cotter pin (Appendix G, Item 19)  
  Two clips (Appendix G, Item 11)  
  Two locknuts (Appendix G, Item 133)  
  Two locknuts (Appendix G, Item 106) |  
  - Wheels chocked and parking brake released (TM 9-2320-387-10).  
  - Muffler and catalytic converter removed (para. 3-49). |

<table>
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<th>Maintenance Level</th>
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</table>

a. Removal

1. Remove cotter pin (11), washer (12), clevis pin (14), and brake clevis (13) from rear caliper lever (10). Discard cotter pin (11).
2. Remove brake cable clip (9) and parking brake cable sleeve (2) from rear caliper cable bracket (8). Discard cable clip (9).
3. Remove parking brake cable clip (23) and parking brake cable sleeve (2) from C-beam (24). Disconnect parking brake cable (1) from parking brake equalizer bar (22). Discard cable clip (23).
4. Remove assembled locknut (3), cap screw (6), washer (4), and brake cable clamp (5) from mounting bracket (25) and parking brake cable assembly (15). Discard assembled locknut (3).
5. Remove locknut (21), cap screw (28), lock washer (29), and parking brake cable clamp (19) from bracket (30). Discard lockwasher (29) and locknut (21).
6. Remove cap screw (18), lock washer (17), and parking brake cable clamp (16) from bracket (30). Discard lock washer (17).

**NOTE**

Perform step 7 if replacing clamp bracket.

7. Remove locknut (32), washer (31), cap screw (27), washer (26), and clamp bracket (30) from support bracket (7). Discard locknut (32).

**NOTE**

Perform step 8 if replacing parking cable mounting bracket.

8. Remove two locknuts (33), washers (35), cap screws (36), washers (35), mounting bracket (25), and tailpipe hanger (37) from rear body mount (38). Discard locknuts (33).
7-17. LEFT PARKING BRAKE CABLE/MOUNTING BRACKET REPLACEMENT (Cont’d)
b. Installation

**NOTE**
Perform step 1 if parking brake cable mounting bracket was removed.

1. Install parking brake cable mounting bracket (4) and tailpipe hanger (6) on rear body mount (7) with two washers (3), capscrews (5), washers (3), and locknuts (1).

**NOTE**
Perform step 2 if clamp bracket was removed.

2. Install clamp bracket (35) on support bracket (14) with washer (32), capscrew (37), washer (34), and locknut (33).

3. Slide parking brake cable clamp (23) onto parking bracket cable assembly (22) and install on clamp bracket (35) with lockwasher (24) and capscrew (25).

4. Slide parking brake cable clamp (26) onto parking brake cable assembly (22) and install on clamp bracket (35) with lockwasher (36), capscrew (38), and locknut (28).

5. Install parking brake cable clamp (12) on parking brake cable assembly (22) and parking brake cable mounting bracket (4) with capscrew (13), washer (11), and assembled locknut (10).

6. Install parking brake cable sleeve (9) on C-beam (29) and parking brake cable (8) on equalizer bar (30) with parking brake cable clip (31).

**CAUTION**
Ensure caliper cable bracket is secure with no signs of looseness and lever is in contact with the caliper cable bracket stop. Damage to equipment and poor performance will result if not aligned properly.

7. Install parking brake cable sleeve (9) on rear caliper cable bracket (15) with brake cable clip (16).

8. Install brake clevis (20) on rear caliper lever (17) with clevis pin (21), washer (19), and cotter pin (18).
7-17. LEFT PARKING BRAKE CABLE/MOUNTING BRACKET REPLACEMENT (Cont’d)

FOLLOW-ON TASKS:  
- Adjust parking brake lever (TM 9-2320-387-10).  
- Install muffler and catalytic converter (para. 3-49).
This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
Three cotter pins (Appendix G, Item 19)
Locknut (Appendix G, Item 82)
Locknut (Appendix G, Item 87)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
- Muffler and catalytic converter removed (para. 3-49).
- Wheels chocked and parking brake released (TM 9-2320-387-10).

Maintenance Level
Unit

a. Removal

1. Remove two cotter pins (left and right) (23), washers (22), clevis pins (20), and brake clevises (21) from caliper levers (24). Discard cotter pins (23).
2. Remove clip (5) and spread boot (6) to allow access to cotter pin (12).
3. Remove cotter pin (12), washer (11), clevis pin (8), and clevis (9) from brake rod (14) and bellcrank (7). Discard cotter pin (12).
4. Remove locknut (17), washer (16), spacer (15), washer (3), capscrew (4), and spring (2) from body (13). Discard locknut (17).
5. Remove locknut (19) and convex washer (18) from brake rod (14) and brake cable equalizer bar (1). Discard locknut (19).
6. Remove brake rod (14) from brake cable equalizer bar (1) by sliding brake rod (14) forward.
7. Remove clevis (9) and nut (10) from brake rod (14).
8. Remove brake rod insulator (17.1) from brake rod (14).

b. Installation

1. Install brake rod insulator (17.1) on brake rod (14).
1.1 Install spring (2) and spacer (15) on body (13) with washer (3), capscrew (4), washer (16), and locknut (17).
2. Install nut (10) and clevis (9) on brake rod (14).
3. Slide brake rod (14) rearward through spring (2).
4. Install brake rod (14) on brake cable equalizer bar (1) with convex washer (18) and locknut (19). Tighten locknut (19) far enough to expose 3 to 5 threads on end of brake rod (14).
5. Spread boot (6) and install clevis (9) on bellcrank (7) with clevis pin (8), washer (11), and cotter pin (12).
6. Install clip (5) on boot (6).

CAUTION
Ensure caliper cable bracket is secure with no signs of looseness and lever is in contact with caliper cable bracket stop. Damage to equipment and poor performance will result if not aligned properly.

7. Install two brake clevises (21) on rear caliper levers (24) with clevis pins (20), washers (22), and cotter pins (23).
FOLLOW-ON TASKS:

- Adjust rear dual service/parking brake [para. 7-19].
- Install muffler and catalytic converter [para. 3-49].
This task covers:

Adjustment

### INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

**Materials/Parts**
- Cotter pin (Appendix G, Item 19)

**Personnel Required**
- One mechanic
- One assistant

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Wheels chocked and parking brake released (TM 9-2320-387-10).

**Maintenance Level**
- Unit

---

**NOTE**

The Kelsey-Hayes parking brake mechanism has an automatic adjusting feature and does not require periodic manual adjustment. When parking brake components or rear brake pads are replaced, the parking brake linkage must be initially positioned to ensure proper parking brake system operation. The only additional adjustment necessary is accomplished with parking brake hand lever. Refer to TM 9-2320-387-10.

### Adjustment

1. Remove clip (1) and spread boot (2) to allow access to cotter pin (9).
2. Remove cotter pin (9), washer (8), and clevis pin (4) from clevis (5) and bellcrank (3). Discard cotter pin (9).
3. Repeatedly apply and adjust parking brake hand lever until bellcrank (3) linear travel is 0.75 in. (19 mm).

**CAUTION**

Holes in parking brake clevis must align to holes in adjusting bellcrank without force for proper parking brake adjustment. Failure to do this may result in damage to equipment and poor performance.

4. Release parking brake. Loosen nut (6) and adjust clevis (5) so holes in clevis (5) align to holes in bellcrank (3). Install clevis (5) on bellcrank (3) with clevis pin (4), washer (8), and cotter pin (9).

**CAUTION**

Do not overtighten brake rod. Overtightening brake rod may result in dragging brakes.

5. If necessary, remove excess slack in parking brake cables by turning parking brake rod (7) clockwise or counterclockwise into clevis (5).
7-19. REAR DUAL SERVICE/PARKING BRAKE ADJUSTMENT (Cont’d)

CAUTION

Ensure caliper cable bracket is secure with no signs of looseness and lever is in contact with caliper cable bracket stop. Damage to equipment and poor performance will result if not aligned properly.

NOTE

Perform step 6 on both sides.

6. Parking brake rod (7) is properly adjusted if lever (11) is in contact with caliper cable bracket stop (10).
7. Tighten nut (6) against clevis (5).
8. Install clip (1) in boot (2).

FOLLOW-ON TASK: Adjust parking brake lever (TM 9-2320-387-10).
7-20. PARKING BRAKE LEVER REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
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</thead>
<tbody>
<tr>
<td>General mechanic's tool kit:</td>
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</tr>
<tr>
<td>automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
</tr>
<tr>
<td>Maintenance repair shop equipment:</td>
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<tr>
<td>automotive (Appendix B, Item 2)</td>
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<table>
<thead>
<tr>
<th>Materials/Parts</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two nut and lockwasher assemblies</td>
<td>• Wheels chocked and parking brake released</td>
</tr>
<tr>
<td>(Appendix G, Item 194)</td>
<td>(TM 9-2320-387-10)</td>
</tr>
<tr>
<td>Five locknuts (Appendix G, Item 77)</td>
<td>• Parking brake switch removed</td>
</tr>
<tr>
<td>Cotter pin (Appendix G, Item 19)</td>
<td>[para. 4-23]</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Personnel Required</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>One mechanic</td>
<td>Unit</td>
</tr>
<tr>
<td>One assistant</td>
<td></td>
</tr>
</tbody>
</table>

a. Removal

1. Remove clip (1) and open boot (2) to allow access to clevis pin (4).
2. Remove cotter pin (7), washer (6), and clevis pin (4) from clevis (5) and bellcrank (3). Discard cotter pin (7).
3. Remove nut and lockwasher assembly (9), wiring harness clamp (10), nut and lockwasher assembly (9), and capscrew (19) from parking brake lever (8). Discard nut and lockwasher assemblies (9).
4. Remove three locknuts (11), washers (12), and capscrews (17) from parking brake lever (8) and body (20). Discard locknuts (11).
5. Remove two locknuts (16), washers (15), capscrews (13), washers (14), and parking brake lever (8) from body (20). Discard locknuts (16).
6. Remove upper boot (18) from parking brake lever (8).
7. Remove lower boot (2) from body (20).

b. Installation

1. Install lower boot (2) on body (20).
2. Install upper boot (18) on parking brake lever (8).
3. Install parking brake lever (8) on body (20) with two washers (14), capscrews (13), washers (15), and locknuts (16).
4. Install capscrew (19), nut and lockwasher assembly (9), wiring harness clamp (10), and nut and lockwasher assembly (9) on parking brake lever (8).
5. Secure parking brake lever (8) on body (20) with three capscrews (17), washers (12), and locknuts (11).
6. Install clevis (5) on bellcrank (3) with clevis pin (4), washer (6), and cotter pin (7).
7. Apply parking brake lever (8) and tighten capscrews (13), (17), and (19) to 8 lb-ft (11 N•m).
8. Close boot (2) and install clip (1).
FOLLOW-ON TASK: Install parking brake switch (para. 4-23).
### Section III. REAR DUAL PARKING BRAKE SYSTEM MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE)

#### 7-21. REAR DUAL PARKING BRAKE SYSTEM MAINTENANCE TASK SUMMARY (SERIAL NUMBERS 300000 AND ABOVE)

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<th>PAGE NO.</th>
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<td>7-60</td>
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<tr>
<td>7-23.</td>
<td>Parking Brake Cable Replacement</td>
<td>7-62</td>
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<tr>
<td>7-24.</td>
<td>Parking Brake Rod Replacement</td>
<td>7-64</td>
</tr>
<tr>
<td>7-25.</td>
<td>Parking Brake Adjustment</td>
<td>7-66</td>
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</tbody>
</table>
7-22. PARKING BRAKE PAD MAINTENANCE

This task covers:

a. Removal  
c. Installation  
b. Cleaning and Inspection  

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
<th>Equipment Condition</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
<td>Access cover removed (para. 10-58.4)</td>
<td>Unit</td>
</tr>
<tr>
<td>Materials and Parts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two cotter pins (Appendix G, item 25.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four cotter pins (Appendix G, item 25.1)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

a. Removal

1. Remove return spring (1) from caliper arm (2).
2. Remove cotter pin (8), clevis bolt (4), washers (5) and (9), and clevis (3) from caliper arm (2). Discard cotter pin (8).

   **NOTE**

   Use 1/2 in. line wrench for removing parking brake cable from caliper bracket.

3. Remove parking brake cable (6) from cable bracket (7).
4. Remove two cotter pins (18), bars (17), and springs (10) from assembly mount (15). Discard cotter pins (18).
5. Lift parking brake subassembly (13) up and away from vehicle (16).
6. Remove parking brake pads (14) from parking brake subassembly (13).

   **NOTE**

   Perform step 4 if replacing parking brake cable bracket.

7. Remove two capscrews (12) and parking brake cable adapter (11) from parking brake subassembly (13).

b. Cleaning and Inspection

   **NOTE**

   - Replace brake pads in sets on both sides of differential.
   - Replace brake pads if thickness is less than 1/8 in. (3.2 mm) and operation in wet and muddy conditions is expected.

   Inspect brake pads (14) for glazing, oil saturation, or wear. If glazed, oil saturated, or if brake pad thickness is less than 1/8 in. (3.2 mm), replace both pads (14) and pads on opposite caliper.

c. Installation

   **NOTE**

   Perform step 1 if parking brake cable bracket (11) was replaced.

1. Install parking brake cable bracket (11) on parking brake subassembly (13) with two capscrews (12).
2. Install parking brake pads (14) on parking brake subassembly (13).
3. Install parking brake subassembly (13) on assembly mount (15) with two springs (10), bars (17), and cotter pins (18).
4. Install parking brake cable (6) on cable bracket (7).
5. Install clevis (3) on caliper arm (2) with washer (5), clevis bolt (4), washer (9), and cotter pin (8).
6. Install return spring (1) on caliper arm (2).
7-22. PARKING BRAKE PAD MAINTENANCE (Cont’d)

FOLLOW-ON TASKS:
- Adjust parking brake (para. 7-25).
- Install access cover (para. 10-58.4).
7-23. PARKING BRAKE CABLE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
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<tr>
<th>Tools</th>
<th>General mechanic's tool kit: automotive (Appendix B, Item 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual References</td>
<td>TM 9-2320-387-10</td>
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<table>
<thead>
<tr>
<th>Equipment Condition</th>
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</thead>
<tbody>
<tr>
<td>• Wheels chocked and parking brake released (TM 9-2320-387-10).</td>
</tr>
<tr>
<td>• Access cover removed (para. 10-58.4).</td>
</tr>
<tr>
<td>• Muffler and catalytic converter removed [para. 3-49].</td>
</tr>
<tr>
<td>• Rear propeller shaft removed [para. 6-4].</td>
</tr>
</tbody>
</table>

Maintenance Level

Unit

NOTE

Replacement procedures for left and right side parking brake cables are basically the same. This procedure covers the left side.

a. Removal

1. Remove clevis pin (6), clevis bolt (2), washers (3) and (7), and clevis (1) from caliper lever (8).
2. Remove parking brake cable (4) from cable bracket (5).

   NOTE

   Use 1/2 in. line wrench for removing parking brake cable from caliper bracket.

3. Remove retaining ring (11) from parking brake cable (4).
4. Remove parking brake cable (4) from equalizer cable bar (9) and C-beam (10).
5. Pull parking brake cable (4) forward and remove from vehicle.

b. Installation

1. Install parking brake cable (4) over rear front crossmember (13) and muffler bracket (12).
2. Slide parking brake cable (4) through C-beam (10) and install on equalizer cable bar (9).
3. Secure parking brake cable (4) to C-beam (10) with retaining ring (11).
4. Install parking brake cable (4) on cable bracket (5).
5. Install clevis (1) on caliper lever (8) with washer (3), clevis bolt (2), washer (7), and clevis pin (6).
7-23. PARKING BRAKE CABLE REPLACEMENT (Cont’d)

FOLLOW-ON TASKS

- Install rear propeller shaft \(^{(\text{para. 6-4})}\).
- Install muffler and catalytic converter \(^{(\text{para. 3-49})}\).
- Adjust parking brake lever (TM 9-2320-387-10).
- Install access cover (para. 10-58.4).
- Unchock wheels (TM 9-2320-387-10).
7-24. PARKING BRAKE ROD REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

<table>
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<th>Tools</th>
<th>General mechanic's tool kit: automotive (Appendix B, Item 1)</th>
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<tbody>
<tr>
<td>Materials/Parts</td>
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<td>Locknut (Appendix G, Item 82)</td>
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<td>Locknut (Appendix G, Item 87)</td>
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<td>TM 9-2320-387-24P</td>
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<tr>
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<tbody>
<tr>
<td>Wheels chocked and parking brake released (TM 9-2320-387-10).</td>
</tr>
<tr>
<td>Muffler and catalytic converter removed para. 3-49.</td>
</tr>
<tr>
<td>Rear propeller shaft removed para. 6-4.</td>
</tr>
<tr>
<td>Access cover removed para. 10-58.4.</td>
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<table>
<thead>
<tr>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
</tr>
</tbody>
</table>

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**a. Removal**

1. Remove clevis pin (6), clevis bolt (2), washers (3) and (7), and clevis (1) from caliper lever (8).
2. Remove parking brake cable (4) from cable bracket (5).
3. Remove clip (13) and spread boot (14) to allow access to cotter pin (20).
4. Remove cotter pin (20), washer (19), clevis bolt (16), and clevis (17) from bellcrank (15).
   Discard cotter pin (20).
5. Remove locknut (25), washer (24), capscrew (12), washer (11), spring (10), and spacer (23) from body (21).
   Discard locknut (25).
6. Remove locknut (28) and convex washer (27) from parking brake rod (22) and brake cable equalizer bar (9).
   Discard locknut (27).
7. Remove parking brake rod (22) from brake cable equalizer bar (9) by sliding parking brake rod (22) forward.
8. Remove clevis (17), nut (18), and insulator rod (26) from parking brake rod (22).

**b. Installation**

1. Install spring (10) and spacer (23) on body (21) with washer (11), capscrew (12), washer (24), and locknut (25).
2. Install nut (18), clevis (17), and insulator rod (26) on parking brake rod (22).
3. Slide parking brake rod (22) rearward through spring (10).
4. Install parking brake rod (22) on brake cable equalizer bar (9) with convex washer (27) and locknut (28).
   Tighten locknut (27) far enough to expose 3 to 5 threads on end of parking brake rod (22).
5. Spread boot (14) and install clevis (17) on bellcrank (15) with clevis pin (16), washer (19), and cotter pin (20).
6. Install clip (13) on boot (14).
7. Install parking brake cable (4) on cable bracket (5).
8. Install clevis (1) on caliper lever (8) with washer (3), clevis bolt (2), washer (7), and clevis pin (6).
FOLLOW-ON TASKS:

- Install rear propeller shaft (para. 6-4).
- Install muffler and catalytic converter (para. 3-49).
- Adjust parking brake (para. 7-25).
- Install access cover (para. 10-58.4).
- Unchock wheels (TM 9-2320-387-10).
7-25. PARKING BRAKE ADJUSTMENT

This task covers:
   a. Adjustment

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit:</td>
<td>• Wheels chocked and parking brake released (TM 9-2320-387-10).</td>
</tr>
<tr>
<td>automotive (Appendix B, Item 1)</td>
<td>• Parking brake access cover removed (para. 10-58.4).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manual References</th>
<th>Maintenance Level</th>
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<td>Unit</td>
</tr>
<tr>
<td>TM 9-2320-387-24P</td>
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</tr>
</tbody>
</table>

**NOTE**

- Ensure parking brake lever is backed all the way out.
- Parking brakes are adjusted semi-annually, when pads are replaced, or when running clearance reaches a total of 0.100 in. per side.
- It may require several attempts to properly adjust parking brake.
- Artwork shows right side parking brake caliper. Left side parking brake is similar.

**a. Adjustment**

1. Remove cotter pin (5), washer (4), clevis pin (1), washer (2), and clevis (6) from caliper arm (3).
2. Back off stop bolt (9) counterclockwise from parking brake caliper (10).
   **NOTE**
   Perform step 3 for right side of vehicle.
3. Rotate caliper arm (3) counterclockwise, toward rear of vehicle, until it stops and back off adjusting screw (14) counterclockwise ½ turns (3 flats), resulting in 0.025 in. of running clearance.
   **NOTE**
   Perform step 4 for left side of vehicle.
4. Rotate caliper arm (3) clockwise, toward rear of vehicle, until it stops and back off adjusting screw (14) counterclockwise ½ turns (3 flats), resulting in 0.025 in. of running clearance.
5. Rotate adjusting screw (14) clockwise until outboard pad (11) is lightly clamped on brake rotor (12).
6. Rotate stop bolt (9) clockwise until inboard pad (13) touches brake rotor (12).
7. Back off stop bolt (9) counterclockwise 1/6 turn (1 flat) resulting in 0.010 in. of running clearance.
8. Hole in clevis (6) should line up with hole in caliper arm (3).
   **NOTE**
   Perform step 9 if clevis hole does not line up with caliper arm.
9. Adjust nut (8) on parking brake rod (7) until hole in clevis (6) lines up with hole in caliper arm (3).
10. Install clevis (6) on caliper arm (3) with washer (2), clevis pin (1), washer (4), and cotter pin (5).
7-25. PARKING BRAKE ADJUSTMENT (Cont’d)

FOLLOW-ON TASKS:  
- Adjust parking brake lever (TM 9-2320-387-10). 
- Install parking brake access cover (para. 10-58.4). 
- Unchock wheels (TM 9-2320-387-10).
# CHAPTER 8
WHEELS AND STEERING (UNIT) MAINTENANCE

## Section I. WHEEL AND RUNFLAT SYSTEM MAINTENANCE

### 8-1. WHEEL AND RUNFLAT SYSTEM MAINTENANCE TASK SUMMARY

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<th>PROCEDURES</th>
<th>PAGE NO.</th>
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<td>8-2</td>
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<td>Jacking Instructions (M1151A1, M1152A1, M1165A1, w/Perimeter B Kit)</td>
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<td>8-6</td>
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8-2. JACKING INSTRUCTIONS (VEHICLES WITHOUT ARMOR)

This task covers:

- a. Raising Corner of Vehicle
- b. Lowering Corner of Vehicle
- c. Raising Front of Vehicle
- d. Lowering Front of Vehicle
- e. Raising Rear of Vehicle
- f. Lowering Rear of Vehicle
- g. Raising Entire Vehicle
- h. Lowering Entire Vehicle

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic’s tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Safety Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never work under vehicle unless wheels are blocked and it is properly supported.</td>
</tr>
</tbody>
</table>

**WARNING**

Hydraulic jacks are used for raising and lowering, and are not used to support vehicle. Never work under vehicle unless wheels are blocked and it is properly supported. Injury or damage to equipment may result if vehicle suddenly shifts or moves.

**a. Raising Corner of Vehicle**

1. Block wheels (2) or (4).
2. Place jack under lower control arm (5) on corner to be raised.
3. Raise vehicle (1) high enough to place trestle (3).
4. Place trestle (3) under flat portion of frame rail (7) and lower jack until weight is supported by trestle (3).

**b. Lowering Corner of Vehicle**

1. Raise vehicle (1) and remove trestle (3).
2. Lower vehicle (1).
3. Remove blocks from wheels (2) or (4).

**c. Raising Front of Vehicle**

1. Block rear wheels (2).
2. Center jack under front suspension front crossmember (6). Use a wood block between jack and crossmember (6).
3. Raise vehicle (1) high enough to place trestles (3).
4. Place trestles (3) under flat portion of frame rails (7) and lower jack until weight is supported by trestles (3).

**d. Lowering Front of Vehicle**

1. Raise vehicle (1) and remove trestles (3).
2. Lower vehicle (1).
3. Remove blocks from rear wheels (2).
8-2. JACKING INSTRUCTIONS (VEHICLES WITHOUT ARMOR) (Cont’d)
8-2. JACKING INSTRUCTIONS (VEHICLES WITHOUT ARMOR) (Cont’d)

e. Raising Rear of Vehicle

1. Block front wheels (4).
2. Center jack under rear suspension rear crossmember (6). Use a wood block between jack and crossmember (6).
3. Raise vehicle (1) high enough to place trestles (3).
4. Place trestles (3) under flat portion of frame rails (5) and lower jack until weight is supported by trestles (3).

f. Lowering Rear of Vehicle

1. Raise vehicle (1) and remove trestles (3).
2. Lower vehicle (1).
3. Remove blocks from front wheels (4).

g. Raising Entire Vehicle

1. Raise front of vehicle (task c.).
2. Center jack under rear suspension rear crossmember (6). Use a wood block between jack and crossmember (6).
3. Raise vehicle (1) high enough to place trestles (3).
4. Place trestles (3) under flat portion of frame rails (5) and lower jack until weight is supported by trestles (3).
5. Move wheel blocks aside.

h. Lowering Entire Vehicle

1. Raise rear of vehicle (1) and remove trestles (3).
2. Lower rear of vehicle (1) and block rear wheels (2).
3. Lower front of vehicle (task d.).
8-2. JACKING INSTRUCTIONS (VEHICLES WITHOUT ARMOR) (Cont’d)
8-2.1. JACKING INSTRUCTIONS (M1151A1, M1152A1, M1165A1 W/PERIMETER B KIT) (AND ALL VEHICLES EQUIPPED WITH FRAG KIT ARMOR)

This task covers:

- a. Raising Front of Vehicle
- b. Lowering Front of Vehicle
- c. Raising Rear of Vehicle
- d. Lowering Rear of Vehicle
- e. Raising Entire Vehicle
- f. Lowering Entire Vehicle

INITIAL SETUP:

**Tools**

- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Manual References**

- TM 9-2320-387-24P

**General Safety Instructions**

Never work under vehicle unless wheels are blocked and it is properly supported. Injury to personnel or damage to equipment may result if vehicle suddenly shifts or moves.

**Maintenance Level**

Unit

**WARNING**

Hydraulic jacks are used for raising and lowering, and are not used to support vehicle. Never work under vehicle unless wheels are blocked and it is properly supported. Injury to personnel or damage to equipment may result if vehicle suddenly shifts or moves.

**a. Raising Front of Vehicle**

1. Block rear wheels (2).
2. Center hydraulic jack under front suspension front crossmember (4). Use wood block between hydraulic jack and crossmember (4).
3. Raise vehicle (1) high enough to clear trestle stand (3).
4. Place trestle stand (3) under first set of mending plates (1).
5. Lower hydraulic jack until the weight is supported by trestle stand (3).

**b. Lowering Front of Vehicle**

1. Raise vehicle (1) and remove trestle stands (3).
2. Lower vehicle (1).
3. Remove blocks from rear wheels (2).

**c. Raising Rear of Vehicle**

1. Block rear wheels (4).
2. Center hydraulic jack under rear suspension rear crossmember (3). Use wood block between hydraulic jack and crossmember (3).
3. Raise vehicle (1) high enough to clear trestle stand (3).
4. Place trestle stand (3) under rear bumper (2).
5. Lower hydraulic jack until weight is supported by trestle stand (3).
8-2.1. JACKING INSTRUCTIONS (M1151A1, M1152A1, M1165A1 W/PERIMETER B KIT) (AND ALL VEHICLES EQUIPPED WITH FRAG KIT ARMOR) (Cont’d)
8-2.1. JACKING INSTRUCTIONS (M1151A1, M1152A1, M1165A1 W/PERIMETER B KIT) (AND ALL VEHICLES EQUIPPED WITH FRAG KIT ARMOR) (Cont’d)

d. Lowering Rear of Vehicle

1. Raise vehicle (1) and remove trestle stands (3).
2. Lower vehicle (1).
3. Remove blocks from front wheels (4).


e. Raising Entire Vehicle

1. Block rear wheels (2).
2. Center hydraulic jack under front suspension front crossmember (4). Use wood block between hydraulic jack and crossmember (4).
3. Raise vehicle (1) high enough to clear trestle stand (3).
4. Place trestle stand (3) under first set of mending plates (1).
5. Lower hydraulic jack until the weight is supported by trestle (3).
6. Center hydraulic jack under rear suspension rear crossmember (3). Use wood block between hydraulic jack and crossmember (3).
7. Raise vehicle (1) high enough to clear trestle stand (3).
8. Place trestle stand (3) under rear bumper (2).
9. Lower hydraulic jack until weight is supported by trestle stands (3).
10. For additional safety place two trestle stands (3) under front bumper (5).

f. Lowering Entire Vehicle

1. Raise rear of vehicle (1) and remove trestle stands (3).
2. Lower rear of vehicle (1).
3. Block rear wheels (2).
4. Raise front of vehicle (1) and remove trestle stands (3) from first set of mending plates and under front bumper.
5. Lower vehicle (1).
6. Remove blocks from rear wheels (2).
8-2.1. J acking Instructions (M1151A1, M1152A1, M1165A1 W/Perimeter B Kit) (And All Vehicles Equipped with Frag Kit Armor) (Cont’d)
## 8-3. WHEEL REPLACEMENT

This task covers:

- a. Removal
- b. Installation

### INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>General Safety Instructions</th>
<th>Maintenance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic’s tool kit:</td>
<td>• Always apply parking brake and chock opposite wheel before removing wheel.</td>
<td>Unit</td>
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<tr>
<td>automotive (Appendix B, Item 1)</td>
<td>• Remove only inner group of nuts when removing a wheel from vehicle.</td>
<td></td>
</tr>
<tr>
<td>Maintenance and repair shop equipment:</td>
<td>• Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.</td>
<td></td>
</tr>
<tr>
<td>(automotive (Appendix B, Item 2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**WARNING**

- Always apply parking brake and chock opposite wheel before removing wheel. Avoid removing wheel when vehicle is on sloping terrain. Injury to personnel or damage to equipment may result.
- Remove only inner group of nuts when removing a wheel from vehicle. Removing outer nuts which hold the rim together while the assembly is inflated could result in serious injury or death.
- Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

### a. Removal

1. Loosen eight lug nuts (2), but do not remove.
2. Raise and support corner of vehicle.[para. 8-2](para. 8-2).
3. Remove eight lug nuts (2) and wheel (1) from geared hub (3).

### NOTE

- Install lug nuts with fingers to full engagement. If nuts resist finger-tightening, discard nuts. Examine studs for damage and replace if damaged.[para. 6-13](para. 6-13).
- The radial tire is nondirectional and can be used in either position.

1. Install wheel (1) on geared hub (3) with eight lug nuts (2).
2. Remove support and lower corner of vehicle.[para. 8-2](para. 8-2).
3. Tighten eight lug nuts (2) to 90-110 lb-ft (122-149 N·m) in tightening sequence shown.
8-3. WHEEL REPLACEMENT (Cont’d)

Tightening Sequence
8-4. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (12-STUD)

This task covers:

- a. Disassembly
- b. Inspection and cleaning
- c. Repair
- d. Assembly

INITIAL SETUP:

Tools

General mechanic’s tool kit:
- automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
- automotive (Appendix B, Item 2)

Special Tools

- Runflat compressor (Appendix B, Item 115)
- Torque adapter, 9/16-in. (Appendix B, Item 133)
- Socket adapter (Appendix B, Item 135)

Materials/Parts

- Twelve locknuts (Appendix G, Item 84)
- O-ring seal (Appendix G, Item 287)
- Locknut (Appendix G, Item 86)
- O-ring (Appendix G, Item 232)
- Lubricant (Appendix G, Item 192)
- Detergent (Appendix C, Item 25)
- Sealing compound, if required
  (Appendix C, Item 61)

Manual References

- TM 9-2320-387-10
- TM 9-2610-200-14
- TM 9-2320-387-24P

Equipment Condition

Wheel removed [para. 8-3].

General Safety Instructions

- Do not use tire machine.
- Ensure tire is totally deflated before removing wheel locknuts.
- Never use tubes in wheel assemblies.
- Rim surfaces must be kept clean and free of rust and dirt.
- Never use wheel assemblies with damaged studs.
- Never inflate a wheel assembly with the wheel locknuts removed.
- Never inflate a wheel assembly without first checking wheel locknut torques.
- Do not exceed recommended tire inflation pressure.
- Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.
- Ensure runflat compressor strap is centered around runflat.
- Never install radial tire on eight-bolt wheel.

Maintenance Level

- Unit

**WARNING**

- Do not use tire machine. Injury to personnel or damage to equipment may result.
- In all disassembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions could cause serious injury or death.
- Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
- Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

a. Disassembly

1. Remove valve core (7) from insert (8) and deflate tire (6).
2. Use a circular pattern and loosen twelve wheel locknuts (2) securing rim halves (1) and (5) together. If you hear escaping air, do not proceed. Wait until sound stops. When tire (6) is fully deflated, remove wheel locknuts (2). Discard locknuts (2).
3. Remove outer rim half (1) from tire (6).
4. Remove insert (8) and locknut (10) from outer rim (1). Discard locknut (10).
5. Remove O-ring (9) from insert (8). Discard O-ring (9).
6. Remove O-ring seal (3) from inner rim half (5). Cut O-ring seal (3) in two to make sure it cannot be reused. Discard O-ring seal (3).
7. Remove tire (6) from inner rim half (5).
8. Remove balance weights (4) from rim halves (1) and (5), if present. Discard balance weights (4).

**WARNING**

Never inflate a wheel assembly with the wheel locknuts removed in an attempt to separate inner and outer rim halves. The assembly will separate under pressure, resulting in serious injury or death.
9. Lay tire (1) flat.

**WARNING**

Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered around runflat. Failure to do so may cause injury to personnel.

**NOTE**

Perform steps 11 and 12 when using runflat compressor P/N J39250. Perform steps 13 and 14 when using runflat compressor P/N 528236.

10. Position runflat compressor (3) on runflat (2) so that runflat compressor hex-drive (4) is facing up and strap (5) is centered around runflat (2).

**NOTE**

Compress runflat by rotating hex-drive in either direction. Rotate hex-drive the opposite direction to loosen.


12. Position runflat compressor (6) on an outer edge of runflat (2) with handle assembly (7) facing up and strap (8) centered around runflat (2).

**NOTE**

Compress runflat by rotating handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

13. Using runflat compressor (6), compress runflat (2).

**NOTE**

- It may be necessary to use a tire spoon and tire soap to remove runflat from tire.
- When using runflat compressor P/N 528236, handle may need to be removed before removing runflat.

14. Remove runflat (2) from tire (1) and remove runflat compressor (3) or (6) from runflat (2).
8-4. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (12-STUD) (Cont’d)

b. Inspection and Cleaning

**CAUTION**

Do not reuse a tire which has been run flat without thoroughly inspecting for damage. Failure to follow these instructions may result in damage to equipment.

1. Inspect inside of tire (1) for cord or belt separation and inner liner damage. Replace tire (1) if damaged.
2. Inspect tire bead (9) for abrasions caused from runflat (2). Replace tire (1) if damaged.
3. Check for protruding objects inside tire (1) which may not be visible from outside. Repair tire (1) if damaged.
4. Check tread depth on tire (1). Tread should not be worn below level of wear bars (10). Replace tire (1) if tread is worn below wear bars (10) or 1/16 in. (1.59 mm).
5. Clean all grease, dirt, and foreign material from the runflat (2) with soap and water and allow to air-dry. Inspect runflat (2) for splitting, wear, or excessive chafing. Replace runflat (2) if damaged.
8-4. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (12-STUD) (Cont’d)

**WARNING**

O-ring sealing surfaces and pressure relief grooves must be kept clean and free of rust and dirt. Failure to do so may cause the wheel assembly to separate under pressure, causing serious injury or death.

6. Using wire brush, clean studs (4). Clean all dirt and foreign material from rim halves (1) and (2) with soap and water and allow to air-dry. Ensure O-ring sealing surfaces (5) and pressure relief grooves (3) on rim halves (1) and (2) are smooth and clean.

7. Inspect rim halves (1) and (2) for cracks, bent sealing surfaces (5), or oversized mounting holes. Replace rim halves (1) or (2) if cracked, bent, or if mounting holes are oversized.

**WARNING**

Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which may cause individual fasteners to fail. Any of these situations may cause serious injury or death.

8. Inspect inner rim half (2) for cracked, broken, rusted, pitted, bent, or loose studs (4) and studs (4) with damaged, mutilated, or deformed threads. Replace studs (4) (para. 8-7) if damaged, loose, or threads are damaged.

9. Inspect insert (6) for damage. Replace insert (6) if damaged.

c. Repair

Refer to TM 9-2610-200-14 for maintenance and repair of tires.
8-4. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (12-STUD) (Cont’d)

d. Assembly

**WARNING**

- Never use tubes in wheel assemblies. Use of a tube defeats built-in safety features, and may allow the wheel to come apart under pressure, resulting in serious injury or death.
- Use only replacement parts specified in TM 9-2320-387-24P for radial tires. Never install radial tire components on eight-bolt rims. Wheels assembled with components not specified for radial tires could cause the assembly to separate under pressure, resulting in serious injury or death.
- Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered on runflat. Failure to do so could cause injury to personnel.

**NOTE**

Perform steps 1 and 2 when using runflat compressor P/N J39250.
Perform steps 3 and 4 when using runflat compressor P/N 528236.

1. Position runflat compressor (8) on runflat (7) so that runflat compressor hex-drive (9) is facing up and strap (10) is centered around runflat (7).

**NOTE**

Compress runflat by rotating hex-drive in either direction. Rotate hex-drive opposite to loosen.

2. Using runflat compressor (8), compress runflat (7).

3. Position runflat compressor (11) on an outer edge of runflat (7) with handle assembly (12) facing up and strap (13) centered around runflat (7).

**NOTE**

Compress runflat by rotating the handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

4. Using runflat compressor (11), compress runflat (7).
8-4. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (12-STUD) (Cont’d)

**WARNING**

Always wear eye protection and rubber gloves when applying runflat lubricant. Failure to do so may result in injury to personnel.

**NOTE**
The radial tire is a bidirectional tire and the tread may be positioned in either direction.

5. Using a 2- to 6-inch paint brush, apply an entire 11-oz tube of lubricant evenly (a depth of 1/8 to 3/16 in. (.32 to .475 cm)) on inside of tire (1).

**WARNING**

Runflat compressor belt and handle may be greasy, which could slip and cause damage to equipment or injury to personnel.

**NOTE**
It may be necessary to remove handle assembly on runflat compressor P/N 528236 before inserting runflat into tire.

6. Insert runflat (2), compressor side first, as far as possible into tire (1).

7. Lay tire (1) flat on protruding runflat side. Loosen compressor (4). Runflat (2) should insert itself inside tire (1). If not, repeat steps 5 through 7 and/or use a tire spoon to assist in installation.

**NOTE**
If required, clean and lubricate bearing assembly on runflat compressor P/N 528236 after removal.

8. Loosen runflat compressor (4) and remove from tire (1).

9. Lubricate tire bead (3) and rim bead seat areas with tire soap.

**WARNING**

Never install radial tire on eight-bolt wheel. Damage to equipment may result, causing injury to personnel.

**NOTE**
Before installing tire on inner rim half, inspect tire sidewalls for a paint dot. Paint dots are often painted on tires to indicate the tire’s light spot for balancing purposes. If paint dot is present, position tire on rim halves so that paint dot is aligned with insert hole on outer rim half.

10. Center runflat (2) in tire (1). Carefully lower tire (1) over inner rim half (8).

11. Ensure runflat (2) is not binding on flat portion of inner rim half (8). Runflat (2) should clear inner rim half (8).

![Diagram of radial tire, wheel, and rubber runflat maintenance](image-url)
8-4. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (12-STUD) (Cont’d)

**NOTE**
- Ensure longer lip of runflat seats against outer rim half.
- Align air notch in runflat with valve stem in the rim.

12. Lubricate O-ring seal (7) with tire soap. Install O-ring seal (7), in groove (9) on top of inner rim half (8), around studs (10). Ensure O-ring seal (7) is not twisted and that it is uniformly positioned in groove (9). Do not overstretch O-ring seal (7).

13. Install insert (12) and O-ring (13) on outer rim half (6) with locknut (14). Tighten locknut (14) to 40-60 lb-in. (5-7 N•m).


15. Install outer rim half (6) on inner rim half (8).

**CAUTION**
Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components.

16. Secure outer rim half (6) to inner rim half (8) with twelve locknuts (5). Do not tighten locknuts (5).
17. Tighten locknuts (1) to 85 lb-ft (115 N•m) in tightening sequence shown.

18. Tighten locknuts (1) to 125 lb-ft (170 N•m) in tightening sequence shown.

19. Check wheel assembly (4) for gaps at each stud (2). Use a 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly (4) and recheck for gaps. If gaps are still detected, replace outer rim half (3).

**WARNING**

- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation; never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold-inflation pressure. Failure to follow these instructions may result in serious injury or death.

- Never inflate a wheel assembly without having checked wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

20. Place wheel assembly (4) in safety cage and inflate tire to recommended tire pressure (TM 9-2320-387-10).

**TIGHTENING SEQUENCE**

FOLLOW-ON TASKS: • Balance tire (para. 8-8).
8-4.1. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (24-STUD)

This task covers:

a. Disassembly  
b. Inspection and cleaning  
c. Repair  
d. Assembly

INITIAL SETUP:

Equipment Condition
Wheel removed (para. 8-3).

General Safety Instructions
• Do not use tire machine.  
• Ensure tire is totally deflated before removing wheel locknuts.  
• Never use tubes in wheel assemblies.  
• Rim surfaces must be kept clean and free of rust and dirt.  
• Never use wheel assemblies with damaged studs.  
• Never inflate a wheel assembly with the wheel locknuts removed.  
• Never inflate a wheel assembly without first checking wheel locknut torques.  
• Do not exceed recommended tire inflation pressure.  
• Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.  
• Ensure runflat compressor strap is centered around runflat.  
• Never install radial tire on eight-bolt wheel.

Maintenance Level
Unit

WARNING

• Do not use tire machine. Injury to personnel or damage to equipment may result.  
• In all disassembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions could cause serious injury or death to personnel.  
• Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.  
• Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

a. Disassembly

1. Remove valve core (7) from insert (8) and deflate tire (6).
2. Use a circular pattern and loosen twenty-four wheel locknuts (2) securing rim halves (1) and (5) together. If you hear escaping air, do not proceed. Wait until sound stops. When tire (6) is fully deflated, remove wheel locknuts (2). Discard locknuts (2).
3. Remove outer rim half (1) from tire (6).
4. Remove insert (8) and locknut (10) from outer rim (1). Discard locknut (10).
5. Remove O-ring (9) from insert (8). Discard O-ring (9).
6. Remove O-ring seal (3) from inner rim half (5). Cut O-ring seal (3) in two to make sure it cannot be reused. Discard O-ring seal (3).
7. Remove tire (6) from inner rim half (5).
8. Remove balance weights (4) from rim halves (1) and (5), if present. Discard balance weights (4).

**WARNING**

Never inflate a wheel assembly with the wheel locknuts removed in an attempt to separate inner and outer rim halves. The assembly will separate under pressure, resulting in serious injury or death.
9. Lay tire (1) flat.

**WARNING**
Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered around runflat. Failure to do so may cause injury to personnel.

**NOTE**
Perform steps 10 and 11 when using runflat compressor P/N J39250. Perform steps 12 and 13 when using runflat compressor P/N 528236.

10. Position runflat compressor (3) on runflat (2) so that runflat compressor hex-drive (4) is facing up and strap (5) is centered around runflat (2).

**NOTE**
Compress runflat by rotating hex-drive in either direction. Rotate hex-drive the opposite direction to loosen.


12. Position runflat compressor (6) on outer edge of runflat (2) with handle assembly (7) facing up and strap (8) centered around runflat (2).

**NOTE**
Compress runflat by rotating handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

13. Using runflat compressor (6), compress runflat (2).

**NOTE**
- It may be necessary to use a tire spoon and tire soap to remove runflat from tire.
- When using runflat compressor P/N 528236, handle may need to be removed before removing runflat.

14. Remove runflat (2) from tire (1) and remove runflat compressor (3) or (6) from runflat (2).
b. Inspection and Cleaning

**CAUTION**

Do not reuse a tire which has been run flat without thoroughly inspecting for damage. Failure to follow these instructions may result in damage to equipment.

1. Inspect inside of tire (1) for cord or belt separation and inner liner damage. Replace tire (1) if damaged.

2. Inspect tire bead (9) for abrasions caused from runflat (2). Replace tire (1) if damaged.

3. Check for protruding objects inside tire (1) which may not be visible from outside. Repair tire (1) if damaged.

4. Check tread depth on tire (1). Tread should not be worn below level of wear bars (10). Replace tire (1) if tread is worn below wear bars (10) or 1/16 in. (1.59 mm).

5. Clean all grease, dirt, and foreign material from the runflat (2) with soap and water and allow to air-dry. Inspect runflat (2) for splitting, wear, or excessive chafing. Replace runflat (2) if damaged.
8-4.1. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (24-STUD) (Cont’d)

**WARNING**

O-ring sealing surfaces and pressure relief grooves must be kept clean and free of rust and dirt. Failure to do so may cause the wheel assembly to separate under pressure, causing serious injury or death.

6. Using wire brush, clean studs (4). Clean all dirt and foreign material from rim halves (1) and (2) with soap and water and allow to air-dry. Ensure O-ring sealing surfaces (5) and pressure relief grooves (3) on rim halves (1) and (2) are smooth and clean.

7. Inspect rim halves (1) and (2) for cracks, bent sealing surfaces (5), or oversized mounting holes. Replace rim halves (1) or (2) if cracked, bent, or if mounting holes are oversized.

**WARNING**

Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which may cause individual fasteners to fail. Any of these situations may cause serious injury or death.

8. Inspect inner rim half (2) for cracked, broken, rusted, pitted, bent, or loose studs (4) and studs (4) with damaged, mutilated, or deformed threads. Replace studs (4) (para. 8-7) if damaged, loose, or threads are damaged.

9. Inspect insert (6) for damage. Replace insert (6) if damaged.

c. Repair

Refer to TM 9-2610-200-14 for maintenance and repair of tires.
8-4.1. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (24-STUD) (Cont’d)

d. Assembly

**WARNING**

- Never use tubes in wheel assemblies. Use of a tube defeats built-in safety features, and may allow the wheel to come apart under pressure, resulting in serious injury or death.
- Use only replacement parts specified in TM 9-2320-387-24P for radial tires. Never install radial tire components on eight-bolt rims. Wheels assembled with components not specified for radial tires could cause the assembly to separate under pressure, resulting in serious injury or death.
- Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered on runflat. Failure to do so could cause injury to personnel.

**NOTE**

Perform steps 1 and 2 when using runflat compressor P/N J39250. Perform steps 3 and 4 when using runflat compressor P/N 528236.

1. Position runflat compressor (8) on runflat (7) so that runflat compressor hex-drive (9) is facing up and strap (10) is centered around runflat (7).

**NOTE**

Compress runflat by rotating hex-drive in either direction. Rotate hex-drive opposite to loosen.

2. Using runflat compressor (8), compress runflat (7).

3. Position runflat compressor (11) on an outer edge of runflat (7) with handle assembly (12) facing up and strap (13) centered around runflat (7).

**NOTE**

Compress runflat by rotating the handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

4. Using runflat compressor (11), compress runflat (7).
8-4.1. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (24-STUD) (Cont’d)

**WARNING**
Always wear eye protection and rubber gloves when applying runflat lubricant. Failure to do so may result in injury to personnel.

**NOTE**
The radial tire is a bidirectional tire and the tread may be positioned in either direction.

5. Using 2- to 6-inch paint brush, apply entire 11-oz tube of lubricant evenly (depth of 1/8 to 3/16 in. (0.32 to 0.475 cm) on inside of tire (1).

**WARNING**
Runflat compressor belt and handle may be greasy, which could slip and cause damage to equipment or injury to personnel.

**NOTE**
It may be necessary to remove handle assembly on runflat compressor P/N 528236 before inserting runflat into tire.

6. Insert runflat (2), compressor side first, as far as possible into tire (1).

7. Lay tire (1) flat on protruding runflat side. Loosen compressor (4). Runflat (2) should insert itself inside tire (1). If not, repeat steps 5 through 7 and/or use a tire spoon to assist in installation.

**NOTE**
If required, clean and lubricate bearing assembly on runflat compressor P/N 528236 after removal.

8. Loosen runflat compressor (4) and remove from tire (1).

9. Lubricate tire bead (3) and rim bead seat areas with tire soap.

**WARNING**
Never install radial tire on eight-bolt wheel. Damage to equipment may result, causing injury to personnel.

**NOTE**
Before installing tire on inner rim half, inspect tire sidewalls for a paint dot. Paint dots are often painted on tires to indicate the tire’s light spot for balancing purposes. If paint dot is present, position tire on rim halves so that paint dot is aligned with insert hole on outer rim half.

10. Center runflat (2) in tire (1). Carefully lower tire (1) over inner rim half (8).

11. Ensure runflat (2) is not binding on flat portion of inner rim half (8). Runflat (2) should clear inner rim half (8).
8-4.1. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (24-STUD) (Cont’d)

**NOTE**

- Ensure longer lip of runflat seats against outer rim half.
- Align air notch in runflat with valve stem in the rim.

12. Lubricate O-ring seal (7) with tire soap. Install O-ring seal (7), in groove (9) on top of inner rim half (8), around studs (10). Ensure O-ring seal (7) is not twisted and that it is uniformly positioned in groove (9). Do not overstretch O-ring seal (7).

13. Install insert (12) and O-ring (13) on outer rim half (6) with locknut (14). Tighten locknut (14) to 40–60 lb-in. (5-7 N·m).


15. Install outer rim half (6) on inner rim half (8).

**CAUTION**

Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components.

16. Secure outer rim half (6) to inner rim half (8) with twenty-four locknuts (5). Do not tighten locknuts (5).
8-4.1. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (24-STUD) (Cont’d)

17. Tighten locknuts (1) to 85 lb-ft (115 N\(\cdot\)m) in tightening sequence shown.
18. Tighten locknuts (1) to 110 lb-ft (149 N\(\cdot\)m) in tightening sequence shown.
19. Check wheel assembly (4) for gaps at each stud (2). Use 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly (4) and recheck for gaps. If gaps are still detected, replace outer rim half (3).

**WARNING**

- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation; never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold-inflation pressure. Failure to follow these instructions may result in serious injury or death.
- Never inflate a wheel assembly without having checked wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

20. Place wheel assembly (4) in safety cage and inflate tire to recommended tire pressure (TM 9-2320-387-10).

FOLLOW-ON TASKS: Balance tire \(\text{(para. 8-8)}\).
8-4.2. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE
(PAIRED 24-STUD)

This task covers:

a. Disassembly
b. Inspection and cleaning
c. Repair
d. Assembly

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)
Torque wrench 1/2 in. drive 250 lb-ft

Special Tools
Runflat compressor (Appendix B, Item 115)
Torque adapter, 9/16-in. (Appendix B, Item 133)
Socket adapter (Appendix B, Item 135)

Materials/Parts
Twenty-four locknuts (Appendix G, Item 84)
O-ring seal (Appendix G, Item 280.3)
Locknut (Appendix G, Item 86)
O-ring (Appendix G, Item 232)
Lubricant (Appendix G, Item 192)
Detergent (Appendix C, Item 25)
Sealing compound, if required
(Appendix C, Item 61)

Manual References
TM 9-2320-387-10
TM 9-2610-200-14
TM 9-2320-387-24P

Equipment Condition
Wheel removed (para. 8-3).

General Safety Instructions
• Do not use tire machine.
• Ensure tire is totally deflated before removing wheel locknuts.
• Never use tubes in wheel assemblies.
• Rim surfaces must be kept clean and free of rust and dirt.
• Never use wheel assemblies with damaged studs.
• Never inflate a wheel assembly with the wheel locknuts removed.
• Never inflate a wheel assembly without first checking wheel locknut torques.
• Do not exceed recommended tire inflation pressure.
• Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.
• Ensure runflat compressor strap is centered around runflat.
• Never install radial tire on eight-bolt wheel.

Maintenance Level
Unit

WARNING

• Do not use tire machine. Injury to personnel or damage to equipment may result.
• In all disassembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions could cause serious injury or death to personnel.
• Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
• Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

a. Disassembly

1. Remove valve core (7) from insert (8) and deflate tire (6).
2. Use a circular pattern and loosen twenty-four wheel locknuts (2) securing rim halves (1) and (5) together. If you hear escaping air, do not proceed. Wait until sound stops. When tire (6) is fully deflated, remove wheel locknuts (2). Discard locknuts (2).
8-4.2. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE
(PAired 24-STUD) (Cont’d)

WARNING

Never inflate a wheel assembly with the wheel locknuts removed in an attempt to separate inner and outer rim halves. The assembly will separate under pressure, resulting in serious injury or death.

3. Remove outer rim half (1) from tire (6).
4. Remove insert (8) and locknut (10) from outer rim (1). Discard locknut (10).
5. Remove O-ring (9) from insert (8). Discard O-ring (9).
6. Remove O-ring seal (3) from inner rim half (5). Cut O-ring seal (3) in two to make sure it cannot be reused. Discard O-ring seal (3).
7. Remove tire (6) from inner rim half (5).
8. Remove balance weights (4) from rim halves (1) and (5), if present. Discard balance weights (4).
9. Lay tire (1) flat.

**WARNING**
Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered around runflat. Failure to do so may cause injury to personnel.

**NOTE**
Perform steps 10 and 11 when using runflat compressor P/N J39250. Perform steps 12 and 13 when using runflat compressor P/N 528236.

10. Position runflat compressor (3) on runflat (2) so that runflat compressor hex-drive (4) is facing up and strap (5) is centered around runflat (2).

**NOTE**
Compress runflat by rotating hex-drive in either direction. Rotate hex-drive the opposite direction to loosen.


12. Position runflat compressor (6) on outer edge of runflat (2) with handle assembly (7) facing up and strap (8) centered around runflat (2).

**NOTE**
Compress runflat by rotating handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

13. Using runflat compressor (6), compress runflat (2).

**NOTE**
- It may be necessary to use a tire spoon and tire soap to remove runflat from tire.
- When using runflat compressor P/N 528236, handle may need to be removed before removing runflat.

14. Remove runflat (2) from tire (1) and remove runflat compressor (3) or (6) from runflat (2).
b. Inspection and Cleaning

**CAUTION**

Do not reuse a tire which has been run flat without thoroughly inspecting for damage. Failure to follow these instructions may result in damage to equipment.

1. Inspect inside of tire (1) for cord or belt separation and inner liner damage. Replace tire (1) if damaged.
2. Inspect tire bead (9) for abrasions caused from runflat (2). Replace tire (1) if damaged.
3. Check for protruding objects inside tire (1) which may not be visible from outside. Repair tire (1) if damaged.
4. Check tread depth on tire (1). Tread should not be worn below level of wear bars (10). Replace tire (1) if tread is worn below wear bars (10) or 1/16 in. (1.59 mm).
5. Clean all grease, dirt, and foreign material from the runflat (2) with soap and water and allow to air-dry. Inspect runflat (2) for splitting, wear, or excessive chafing. Replace runflat (2) if damaged.
8-4.2. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE
(PAIRED 24-STUD) (Cont’d)

**WARNING**

O-ring sealing surfaces and pressure relief grooves must be kept clean and free of rust and dirt. Failure to do so may cause the wheel assembly to separate under pressure, causing serious injury or death.

6. Using wire brush, clean studs (4). Clean all dirt and foreign material from rim halves (1) and (2) with soap and water and allow to air-dry. Ensure O-ring sealing surfaces (5) and pressure relief grooves (3) on rim halves (1) and (2) are smooth and clean.

7. Inspect rim halves (1) and (2) for cracks, bent sealing surfaces (5), or oversized mounting holes. Replace rim halves (1) or (2) if cracked, bent, or if mounting holes are oversized.

**WARNING**

Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which may cause individual fasteners to fail. Any of these situations may cause serious injury or death.

8. Inspect inner rim half (2) for cracked, broken, rusted, pitted, bent, or loose studs (4) and studs (4) with damaged, mutilated, or deformed threads. Replace studs (4) (para. 8-7) if damaged, loose, or threads are damaged.

9. Inspect insert (6) for damage. Replace insert (6) if damaged.

c. Repair

Refer to TM 9-2610-200-14 for maintenance and repair of tires.
8-4.2. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE
(PAIRED 24-STUD) (Cont’d)

d. Assembly

**WARNING**

- Never use tubes in wheel assemblies. Use of a tube defeats built-in safety features, and may allow the wheel to come apart under pressure, resulting in serious injury or death.
- Use only replacement parts specified in TM 9-2320-387-24P for radial tires. Never install radial tire components on eight-bolt rims. Wheels assembled with components not specified for radial tires could cause the assembly to separate under pressure, resulting in serious injury or death.
- Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered on runflat. Failure to do so could cause injury to personnel.

**NOTE**

Perform steps 1 and 2 when using runflat compressor P/N J39250. Perform steps 3 and 4 when using runflat compressor P/N 528236.

1. Position runflat compressor (8) on runflat (7) so that runflat compressor hex-drive (9) is facing up and strap (10) is centered around runflat (7).

**NOTE**

Compress runflat by rotating hex-drive in either direction. Rotate hex-drive opposite to loosen.

2. Using runflat compressor (8), compress runflat (7).

3. Position runflat compressor (11) on an outer edge of runflat (7) with handle assembly (12) facing up and strap (13) centered around runflat (7).

**NOTE**

Compress runflat by rotating the handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

4. Using runflat compressor (11), compress runflat (7).
8-4.2. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE  
(PAired 24-Stud) (Cont’d)

**WARNING**
Always wear eye protection and rubber gloves when applying runflat lubricant. Failure to do so may result in injury to personnel.

**NOTE**
The radial tire is a bidirectional tire and the tread may be positioned in either direction.

5. Using 2- to 6-inch paint brush, apply entire 11-oz tube of lubricant evenly (depth of 1/8 to 3/16 in. (0.32 to 0.475 cm) on inside of tire (1).

**WARNING**
Runflat compressor belt and handle may be greasy, which could slip and cause damage to equipment or injury to personnel.

**NOTE**
It may be necessary to remove handle assembly on runflat compressor P/N 528236 before inserting runflat into tire.

6. Insert runflat (2), compressor side first, as far as possible into tire (1).

7. Lay tire (1) flat on protruding runflat side. Loosen compressor (4). Runflat (2) should insert itself inside tire (1). If not, repeat steps 5 through 7 and/or use a tire spoon to assist in installation.

**NOTE**
If required, clean and lubricate bearing assembly on runflat compressor P/N 528236 after removal.

8. Loosen runflat compressor (4) and remove from tire (1).

9. Lubricate tire bead (3) and rim bead seat areas with tire soap.

**WARNING**
Never install radial tire on eight-bolt wheel. Damage to equipment may result, causing injury to personnel.

**NOTE**
Before installing tire on inner rim half, inspect tire sidewalls for a paint dot. Paint dots are often painted on tires to indicate the tire’s light spot for balancing purposes. If paint dot is present, position tire on rim halves so that paint dot is aligned with insert hole on outer rim half.

10. Center runflat (2) in tire (1). Carefully lower tire (1) over inner rim half (8).

11. Ensure runflat (2) is not binding on flat portion of inner rim half (8). Runflat (2) should clear inner rim half (8).
NOTE

- Ensure longer lip of runflat seats against outer rim half.
- Align air notch in runflat with valve stem in the rim.

12. Lubricate O-ring seal (7) with tire soap. Install O-ring seal (7), in groove (9) on top of inner rim half (8), around studs (10). Ensure O-ring seal (7) is not twisted and that it is uniformly positioned in groove (9). Do not overstretch O-ring seal (7).

13. Install insert (12) and O-ring (13) on outer rim half (6) with locknut (14). Tighten locknut (14) to 40–60 lb-in. (5-7 N·m).


15. Install outer rim half (6) on inner rim half (8).

CAUTION

Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components.

16. Secure outer rim half (6) to inner rim half (8) with twenty-four locknuts (5). Do not tighten locknuts (5).
17. Tighten locknuts (1) to 85 lb-ft (115 N•m) in tightening sequence shown.
18. Tighten locknuts (1) to 110 lb-ft (149 N•m) in tightening sequence shown.
19. Check wheel assembly (4) for gaps at each stud (2). Use 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly (4) and recheck for gaps. If gaps are still detected, replace outer rim half (3).

**WARNING**

- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation; never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold-inflation pressure. Failure to follow these instructions may result in serious injury or death.
- Never inflate a wheel assembly without having checked wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

20. Place wheel assembly (4) in safety cage and inflate tire to recommended tire pressure (TM 9-2320-387-10).

**FOLLOW-ON TASK:** Balance tire (para. 8-8).

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**VALVE TIGHTENING SEQUENCE**

1 13 7 19 11 23 4 16 10 22 6 18 21 4 20 12 24 3 15 9 21 5 17 1

**TIGHTENING SEQUENCE**

1 2 3 4
### 8-4.3. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (20-STUD)

This task covers:

- a. Disassembly
- b. Inspection and cleaning
- c. Repair
- d. Assembly

#### INITIAL SETUP:

**Tools**
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)
- Torque wrench 1/2 in. drive, 250 lb-ft

**Special Tools**
- Runflat compressor (Appendix B, Item 115)
- Torque adapter, 9/16-in. (Appendix B, Item 133)
- Socket adapter (Appendix B, Item 135)

**Materials/Parts**
- Twenty locknuts (Appendix G, Item 84)
- O-ring seal (Appendix G, Item 280.3)
- Locknut (Appendix G, Item 86)
- O-ring (Appendix G, Item 232)
- Lubricant (Appendix G, Item 192)
- Detergent (Appendix C, Item 25)
- Sealing compound, if required
  - (Appendix C, Item 61)

**Manual References**
- TM 9-2320-387-10
- TM 9-2610-200-14
- TM 9-2320-387-24P

**Equipment Condition**
- Wheel removed [para. 8-3].

**General Safety Instructions**
- Do not use tire machine.
- Ensure tire is totally deflated before removing wheel locknuts.
- Never use tubes in wheel assemblies.
- Rim surfaces must be kept clean and free of rust and dirt.
- Never use wheel assemblies with damaged studs.
- Never inflate a wheel assembly with the wheel locknuts removed.
- Never inflate a wheel assembly without first checking wheel locknut torques.
- Do not exceed recommended tire inflation pressure.
- Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.
- Ensure runflat compressor strap is centered around runflat.
- Never install radial tire on eight-bolt wheel.

**Maintenance Level**
- Unit

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**WARNING**

- Do not use tire machine. Injury to personnel or damage to equipment may result.
- In all disassembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions could cause serious injury or death to personnel.
- Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
- Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

**a. Disassembly**

1. Remove valve core (7) from insert (8) and deflate tire (6).
2. Use a circular pattern and loosen twenty wheel locknuts (2) securing rim halves (1) and (5) together. If you hear escaping air, do not proceed. Wait until sound stops. When tire (6) is fully deflated, remove wheel locknuts (2). Discard locknuts (2).
8-4.3. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (20-STUD) (Cont’d)

**WARNING**

Never inflate a wheel assembly with the wheel locknuts removed in an attempt to separate inner and outer rim halves. The assembly will separate under pressure, resulting in serious injury or death.

3. Remove outer rim half (1) from tire (6).
4. Remove insert (8) and locknut (10) from outer rim (1). Discard locknut (10).
5. Remove O-ring (9) from insert (8). Discard O-ring (9).
6. Remove O-ring seal (3) from inner rim half (5). Cut O-ring seal (3) in two to make sure it cannot be reused. Discard O-ring seal (3).
7. Remove tire (6) from inner rim half (5).
8. Remove balance weights from rim halves (1) and (5), if present. Discard balance weights.
9. Lay tire (1) flat.

**WARNING**
Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered around runflat. Failure to do so may cause injury to personnel.

**NOTE**
Perform steps 10 and 11 when using runflat compressor P/N J39250. Perform steps 12 and 13 when using runflat compressor P/N 528236.

10. Position runflat compressor (3) on runflat (2) so that runflat compressor hex-drive (4) is facing up and strap (5) is centered around runflat (2).

**NOTE**
Compress runflat by rotating hex-drive in either direction. Rotate hex-drive the opposite direction to loosen.


12. Position runflat compressor (6) on outer edge of runflat (2) with handle assembly (7) facing up and strap (8) centered around runflat (2).

**NOTE**
Compress runflat by rotating handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

13. Using runflat compressor (6), compress runflat (2).

**NOTE**
- It may be necessary to use a tire spoon and tire soap to remove runflat from tire.
- When using runflat compressor P/N 528236, handle may need to be removed before removing runflat.

14. Remove runflat (2) from tire (1) and remove runflat compressor (3) or (6) from runflat (2).
b. Inspection and Cleaning

**CAUTION**

Do not reuse a tire which has been run flat without thoroughly inspecting for damage. Failure to follow these instructions may result in damage to equipment.

1. Inspect inside of tire (1) for cord or belt separation and inner liner damage. Replace tire (1) if damaged.
2. Inspect tire bead (9) for abrasions caused from runflat (2). Replace tire (1) if damaged.
3. Check for protruding objects inside tire (1) which may not be visible from outside. Repair tire (1) if damaged.
4. Check tread depth on tire (1). Tread should not be worn below level of wear bars (10). Replace tire (1) if tread is worn below wear bars (10) or 1/16 in. (1.59 mm).
5. Clean all grease, dirt, and foreign material from the runflat (2) with soap and water and allow to air-dry. Inspect runflat (2) for splitting, wear, or excessive chafing. Replace runflat (2) if damaged.
8-4.3. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (20-STUD) (Cont’d)

**WARNING**

O-ring sealing surfaces and pressure relief grooves must be kept clean and free of rust and dirt. Failure to do so may cause the wheel assembly to separate under pressure, causing serious injury or death.

6. Using wire brush, clean studs (4). Clean all dirt and foreign material from rim halves (1) and (2) with soap and water and allow to air-dry. Ensure O-ring sealing surfaces (5) and pressure relief grooves (3) on rim halves (1) and (2) are smooth and clean.

7. Inspect rim halves (1) and (2) for cracks, bent sealing surfaces (5), or oversized mounting holes. Replace rim halves (1) or (2) if cracked, bent, or if mounting holes are oversized.

**WARNING**

Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which may cause individual fasteners to fail. Any of these situations may cause serious injury or death.

8. Inspect inner rim half (2) for cracked, broken, rusted, pitted, bent, or loose studs (4) and studs (4) with damaged, mutilated, or deformed threads. Replace studs (4) [para. 8-7] if damaged, loose, or threads are damaged.

9. Inspect insert (6) for damage. Replace insert (6) if damaged.

c. Repair

Refer to TM 9-2610-200-14 for maintenance and repair of tires.
8-4.3. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (20-STUD) (Cont’d)

d. Assembly

**WARNING**

- Never use tubes in wheel assemblies. Use of a tube defeats built-in safety features, and may allow the wheel to come apart under pressure, resulting in serious injury or death.
- Use only replacement parts specified in TM 9-2320-387-24P for radial tires. Never install radial tire components on eight-bolt rims. Wheels assembled with components not specified for radial tires could cause the assembly to separate under pressure, resulting in serious injury or death.
- Do not use compressor strap if it is frayed or damaged. Ensure runflat is free of grease and runflat compressor strap is centered on runflat. Failure to do so could cause injury to personnel.

**NOTE**

Perform steps 1 and 2 when using runflat compressor P/N J39250. Perform steps 3 and 4 when using runflat compressor P/N 528236.

1. Position runflat compressor (8) on runflat (7) so that runflat compressor hex-drive (9) is facing up and strap (10) is centered around runflat (7).

**NOTE**

Compress runflat by rotating hex-drive in either direction. Rotate hex-drive opposite to loosen.

2. Using runflat compressor (8), compress runflat (7).

3. Position runflat compressor (11) on an outer edge of runflat (7) with handle assembly (12) facing up and strap (13) centered around runflat (7).

**NOTE**

Compress runflat by rotating the handle assembly in a clockwise direction. Rotate handle assembly counterclockwise to loosen.

4. Using runflat compressor (11), compress runflat (7).
8-4.3. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (20-STUD) (Cont’d)

**WARNING**
Always wear eye protection and rubber gloves when applying runflat lubricant. Failure to do so may result in injury to personnel.

**NOTE**
The radial tire is a bidirectional tire and the tread may be positioned in either direction.

5. Using 2- to 6-inch paint brush, apply entire 11-oz tube of lubricant evenly (depth of 1/8 to 3/16 in. (0.32 to 0.475 cm) on inside of tire (1).

**WARNING**
Runflat compressor belt and handle may be greasy, which could slip and cause damage to equipment or injury to personnel.

**NOTE**
It may be necessary to remove handle assembly on runflat compressor P/N 528236 before inserting runflat into tire.

6. Insert runflat (2), compressor side first, as far as possible into tire (1).

7. Lay tire (1) flat on protruding runflat side. Loosen compressor (4). Runflat (2) should insert itself inside tire (1). If not, repeat steps 5 through 7 and/or use a tire spoon to assist in installation.

**NOTE**
If required, clean and lubricate bearing assembly on runflat compressor P/N 528236 after removal.

8. Loosen runflat compressor (4) and remove from tire (1).

9. Lubricate tire bead (3) and rim bead seat areas with tire soap.

**WARNING**
Never install radial tire on eight-bolt wheel. Damage to equipment may result, causing injury to personnel.

**NOTE**
Before installing tire on inner rim half, inspect tire sidewalls for a paint dot. Paint dots are often painted on tires to indicate the tire’s light spot for balancing purposes. If paint dot is present, position tire on rim halves so that paint dot is aligned with insert hole on outer rim half.

10. Center runflat (2) in tire (1). Carefully lower tire (1) over inner rim half (8).

11. Ensure runflat (2) is not binding on flat portion of inner rim half (8). Runflat (2) should clear inner rim half (8).
8-4.3. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (20-STUD) (Cont’d)

NOTE

- Ensure longer lip of runflat seats against outer rim half.
- Align air notch in runflat with valve stem in the rim.

12. Lubricate O-ring seal (7) with tire soap. Install O-ring seal (7), in groove (9) on top of inner rim half (8), around studs (10). Ensure O-ring seal (7) is not twisted and that it is uniformly positioned in groove (9). Do not overstretc O-ring seal (7).

13. Install insert (12) and O-ring (13) on outer rim half (6) with locknut (14). Tighten locknut (14) to 40–60 lb-in. (5-7 N•m).


15. Install outer rim half (6) on inner rim half (8).

CAUTION

Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components.

16. Secure outer rim half (6) to inner rim half (8) with twenty locknuts (5). Do not tighten locknuts (5).
8-4.3. RADIAL TIRE, WHEEL, AND RUBBER RUNFLAT MAINTENANCE (20-STUD) (Cont’d)

17. Tighten locknuts (1) to 85 lb·ft (115 N•m) in tightening sequence shown.
18. Tighten locknuts (1) to 110 lb·ft (149 N•m) in tightening sequence shown.
19. Check wheel assembly (4) for gaps at each stud (2). Use 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly (4) and recheck for gaps. If gaps are still detected, replace outer rim half (3).

**WARNING**

- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation; never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold-inflation pressure. Failure to follow these instructions may result in serious injury or death.
- Never inflate a wheel assembly without having checked wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

20. Place wheel assembly (4) in safety cage and inflate tire to recommended tire pressure (TM 9-2320-387-10).

**FOLLOW-ON TASK:** Balance tire (para. 8-8).
8-5. RUNFLAT COMPRESSOR (P/N J39250) BELT REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
Runflat belt repair kit
(Appendix G, Item 275)

Manual References
TM 9-2320-387-24P

Maintenance Level
Unit

NOTE
Note position of belt for installation.

1. Remove small pin (8) from belt (4) and worm gear shaft assembly (1). Discard small pin (8).
2. Remove shaft pin (7) and worm gear shaft assembly (1) from compressor assembly (6). Discard shaft pin (7).
3. Remove two locknuts (5), socket-head screws (2), spacers (3), and belt (4) from compressor assembly (6). Discard locknuts (5).

b. Installation

NOTE
Belt overlap is to be positioned so there is an equal amount of belt on each side of worm gear shaft assembly.

1. Install belt (4) on compressor assembly (6) with two spacers (3), socket-head screws (2), and locknuts (5).
2. Install worm gear shaft assembly (1) on compressor assembly (6) with shaft pin (7).
3. Install belt (4) to worm gear shaft assembly (1) with small pin (8).
8-6. RUNFLAT COMPRESSOR (P/N 528236) BELT REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

**Tools**  
General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**  
Runflat belt repair kit (Appendix G, Item 276)

**Manual References**  
TM 9-2320-387-24P

**Maintenance Level**  
Unit

### a. Removal

**NOTE**

Note position of belt for installation.

Remove locknut (1), capscrew (2), and belt (3) from compressor (4). Discard locknut (1).

### b. Installation

1. Install belt (3) on compressor (4) with capscrew (2) and locknut (1).
2. Loop free end of belt (3) around retaining bracket (5) as shown.
8-7. INNER RIM STUD MAINTENANCE (12-STUD)

This task covers:

a. Removal
b. Cleaning and Inspection
c. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic’s tool kit: automotive (Appendix B, Item 1)</td>
</tr>
<tr>
<td>Manual References</td>
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<tr>
<td>TM 9-2320-387-10</td>
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<td>TM 9-2320-387-24P</td>
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<tr>
<td>Equipment Condition</td>
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<tr>
<td>Wheel removed [para. 8-3]</td>
</tr>
<tr>
<td>General Safety Instructions</td>
</tr>
<tr>
<td>• Always wear eye protection when replacing wheel studs.</td>
</tr>
</tbody>
</table>

General Safety Instructions (Cont’d)

- Ensure tire is totally deflated before removing wheel locknuts.
- Never use wheel assemblies with damaged studs.
- Never inflate a wheel assembly without first checking wheel locknut torques.
- Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.

Maintenance Level

Unit

WARNING

- Always wear eye protection when replacing wheel studs. Severe eye injury may result if metal chips contact eyes.
- Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
- Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

NOTE

Perform steps 1 through 4 for stud removal without disassembly of wheel. Perform steps 5 and 6 for stud removal with disassembled wheel.

1. Place wheel assembly in tire inflation cage.

WARNING

In all assembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions may result in serious injury or death.

2. Remove valve core (3) from valve bore (4) and deflate tire (1). Run a wire through valve bore (4) to ensure it is not plugged.

3. When tire (1) is fully deflated, loosen wheel locknut (2) from each side of the broken stud(s) (5). If you hear escaping air, do not proceed. Wait until the sound stops and recheck valve bore (4). When you are certain tire is fully deflated, proceed to remove wheel locknut (2). Discard locknut (2).
8-7. INNER RIM STUD MAINTENANCE (12-STUD) (Cont’d)

**NOTE**
When replacing broken rim stud(s), replace studs on both sides of the broken stud(s).

4. Drive studs (1) out of inner rim (2). Discard studs (1).
5. Disassemble wheel and runflat (para. 8-4).
6. Drive stud (3) out of inner rim half (4). Discard stud (3).

**b. Cleaning and Inspection**

1. Using wire brush, clean studs. Clean all dirt and foreign material from rim with soap and water and allow to air-dry.

**WARNING**
Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which could cause individual fasteners to fail. Any of these situations may result in serious injury or death.

2. Inspect inner rim (4) for cracked, broken, rusted, pitted, bent, or loose studs (3), and studs (3) with damaged, mutilated, or deformed threads.

**c. Installation**

**NOTE**
Perform steps 1 and 2 for stud installation with disassembled wheel. Perform steps 3 through 11 for stud installation without disassembly of wheel.

1. Align splines on stud (3) with splines in inner rim (4) and drive stud (3) into inner rim (4) until stud shoulder seats against inner rim (4).
2. Assemble wheel and runflat (para. 8-4).
3. Align splines on stud (1) with splines in inner rim (2) and drive stud (1) into inner rim (2) until shoulder of stud (1) seats against inner rim (2).
4. Repeat step 3 for all studs (1) being replaced.

**CAUTION**
Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components will result.

5. Install locknuts (6) on studs (1).

**NOTE**
After replacing broken stud(s), all rim nuts must be retorqued.

6. Tighten locknuts (6) to 85 lb-ft (115 N•m) in sequence shown.
7. Tighten locknuts (6) to 125 lb-ft (170 N•m) in sequence shown.
8. Check wheel assembly for gaps at each stud. Use a 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly and recheck for gaps. If gaps are still detected, replace outer rim half (para. 8-4).
9. Install valve core (7) in valve bore (8).
WARNING

- Never inflate a wheel assembly before checking wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation, never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure, using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold inflation pressure. Failure to follow these instructions may result in serious injury or death.

10. Place tire assembly (5) in safety cage and inflate front and rear tires to recommended tire pressure (TM 9-2320-387-10).

11. Check for leaks around rim edges, insert, and valve bore (8) with soapy solution.

FOLLOW-ON TASKS: Balance tire (para. 8-8).
8-7.1. INNER RIM STUD MAINTENANCE (24-STUD)

This task covers:

- a. Removal
- b. Cleaning and Inspection
- c. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Twenty-four locknuts (Appendix G, Item 84)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Wheel removed (para. 8-3).

**General Safety Instructions**
- Always wear eye protection when replacing wheel studs.
- Ensure tire is totally deflated before removing wheel locknuts.
- Never use wheel assemblies with damaged studs.
- Never inflate a wheel assembly without first checking wheel locknut torques.
- Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.

**Maintenance Level**
- Unit

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**WARNING**

- Always wear eye protection when replacing wheel studs. Severe eye injury may result if metal chips contact eyes.
- Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
- Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

**NOTE**

Perform steps 1 through 4 for stud removal without disassembly of wheel. Perform steps 5 and 6 for stud removal with disassembled wheel.

1. Place wheel assembly in OSHA approved tire inflation cage.

   **WARNING**

   In all assembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions may result in serious injury or death.

2. Remove valve core (3) from valve bore (4) and deflate tire (1). Run a wire through valve bore (4) to ensure it is not plugged.

3. When tire (1) is fully deflated, loosen wheel locknut (2) from each side of the broken stud(s) (5). If you hear escaping air, do not proceed. Wait until the sound stops and recheck valve bore (4). When you are certain tire is fully deflated, proceed to remove wheel locknut (2). Discard locknut (2).
8-7.1. INNER RIM STUD MAINTENANCE (24-STUD) (Cont’d)
8-7.1. INNER RIM STUD MAINTENANCE (24-STUD) (Cont’d)

NOTE
When replacing broken rim stud(s), replace studs on both sides of the broken stud(s).

4. Drive studs (1) out of inner rim (2). Discard studs (1).
5. Disassemble wheel and runflat (para. 8-4.1).
6. Drive stud (3) out of inner rim half (4). Discard stud (3).

b. Cleaning and Inspection

1. Using wire brush, clean studs. Clean all dirt and foreign material from rim with soap and water and allow to air-dry.

WARNING
Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which could cause individual fasteners to fail. Any of these situations may result in serious injury or death.

2. Inspect inner rim (4) for cracked, broken, rusted, pitted, bent, or loose studs (3), and studs (3) with damaged, mutilated, or deformed threads.

NOTE
Perform steps 1 and 2 for stud installation with disassembled wheel. Perform steps 3 through 11 for stud installation without disassembly of wheel.

1. Align splines on stud (3) with splines in inner rim (4) and drive stud (3) into inner rim (4) until stud shoulder seats against inner rim (4).
2. Assemble wheel and runflat (para. 8-4.1).
3. Align splines on stud (1) with splines in inner rim (2) and drive stud (1) into inner rim (2) until shoulder of stud (1) seats against inner rim (2).
4. Repeat step 3 for all studs (1) being replaced.

CAUTION
Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components will result.

5. Install locknuts (6) on studs (1).

NOTE
After replacing broken stud(s), all rim nuts must be retorqued.

6. Tighten locknuts (6) to 85 lb-ft (115 N•m) in sequence shown.
7. Tighten locknuts (6) to 110 lb-ft (149 N•m) in sequence shown.
8. Check wheel assembly for gaps at each stud. Use a 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly and recheck for gaps. If gaps are still detected, replace outer rim half (para. 8-4.1).
9. Install valve core (7) in valve bore (8).
8-7.1. INNER RIM STUD MAINTENANCE (24-STUD) (Cont’d)

**WARNING**

- Never inflate a wheel assembly before checking wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.
- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation, never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure, using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold inflation pressure. Failure to follow these instructions may result in serious injury or death.

10. Place tire assembly (5) in safety cage and inflate front and rear tires to recommended tire pressure (TM 9-2320-387-10).

11. Check for leaks around rim edges, insert, and valve bore (8) with soapy solution.

FOLLOW-ON TASKS: • Balance tire (para. 8-8).
8-7.2. INNER RIM STUD MAINTENANCE (PAIRED 24-STUD)

This task covers:

a. Removal  
b. Cleaning and Inspection  
c. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit:  
  - automotive (Appendix B, Item 1)  
  - Torque wrench 1/2 in. drive, 250 lb-ft

**Materials/Parts**
- Twenty-four locknuts (Appendix G, Item 84)

**Manual References**
- TM 9-2320-387-10  
- TM 9-2320-387-24P

**Equipment Condition**
- Wheel removed (para. 8-3).

**General Safety Instructions**
- Always wear eye protection when replacing wheel studs. Severe eye injury may result if metal chips contact eyes.
- Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
- Never use wheel assemblies with damaged studs.
- Never inflate a wheel assembly without first checking wheel locknut torques.
- Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.

**Maintenance Level**

**Unit**

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**WARNING**

- Always wear eye protection when replacing wheel studs. Severe eye injury may result if metal chips contact eyes.
- Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
- Never use wheel assemblies with damaged studs.
- Never inflate a wheel assembly without first checking wheel locknut torques.
- Always use an OSHA approved tire inflation cage and a clip-on air chuck for tire inflation.

**NOTE**

Perform steps 1 through 4 for stud removal without disassembly of wheel. Perform steps 5 and 6 for stud removal with disassembled wheel.

1. Place wheel assembly in OSHA approved tire inflation cage.

   **WARNING**

   In all assembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions may result in serious injury or death.

2. Remove valve core (3) from valve bore (4) and deflate tire (1). Run a wire through valve bore (4) to ensure it is not plugged.

3. When tire (1) is fully deflated, loosen wheel locknut (2) from each side of the broken stud(s) (5). If you hear escaping air, do not proceed. Wait until the sound stops and recheck valve bore (4). When you are certain tire is fully deflated, proceed to remove wheel locknut (2). Discard locknut (2).
8-7.2. INNER RIM STUD MAINTENANCE (PAIRED 24-STUD) (Cont’d)
8-7.2. INNER RIM STUD MAINTENANCE (PAIRED 24-STUD) (Cont’d)

NOTE
When replacing broken rim stud(s), replace studs on both sides of the broken stud(s).

4. Drive studs (1) out of inner rim (2). Discard studs (1).
5. Disassemble wheel and runflat \(\text{(para. 8-4.1)}\).
6. Drive stud (3) out of inner rim half (4). Discard stud (3).

b. Cleaning and Inspection

1. Using wire brush, clean studs. Clean all dirt and foreign material from rim with soap and water and allow to air-dry.

WARNING
Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which could cause individual fasteners to fail. Any of these situations may result in serious injury or death.

2. Inspect inner rim (4) for cracked, broken, rusted, pitted, bent, or loose studs (3), and studs (3) with damaged, mutilated, or deformed threads.

c. Installation

NOTE
Perform steps 1 and 2 for stud installation with disassembled wheel. Perform steps 3 through 11 for stud installation without disassembly of wheel.

1. Align splines on stud (3) with splines in inner rim (4) and drive stud (3) into inner rim (4) until stud shoulder seats against inner rim (4).
2. Assemble wheel and runflat \(\text{(para. 8-4.1)}\).
3. Align splines on stud (1) with splines in inner rim (2) and drive stud (1) into inner rim (2) until shoulder of stud (1) seats against inner rim (2).
4. Repeat step 3 for all studs (1) being replaced.

CAUTION
Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components will result.

5. Install locknuts (6) on studs (1).

NOTE
After replacing broken stud(s), all rim nuts must be retightened to torque limits.

6. Tighten locknuts (6) to 85 lb-ft (115 N•m) in sequence shown.
7. Tighten locknuts (6) to 110 lb-ft (149 N•m) in sequence shown.
8. Check wheel assembly for gaps at each stud. Use a 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly and recheck for gaps. If gaps are still detected, replace outer rim half \(\text{(para. 8-4.1)}\).
9. Install valve core (7) in valve bore (8).
8-7.2. INNER RIM STUD MAINTENANCE (PAIRED 24-STUD) (Cont’d)

**WARNING**

- Never inflate a wheel assembly before checking wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.

- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation, never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure, using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold inflation pressure. Failure to follow these instructions may result in serious injury or death.

10. Place tire assembly (5) in safety cage and inflate front and rear tires to recommended tire pressure (TM 9-2320-387-10).

11. Check for leaks around rim edges, insert, and valve bore (8) with soapy solution.

FOLLOW-ON TASK: Balance tire (para. 8-8).
8-7.3. INNER RIM STUD MAINTENANCE (20-STUD)

This task covers:

- a. Removal
- b. Cleaning and Inspection
- c. Installation

INITIAL SETUP:

**Tools**
- General mechanic’s tool kit: automotive (Appendix B, Item 1)
- Torque wrench 1/2 in. drive, 250 lb-ft

**Materials/Parts**
- Twenty locknuts (Appendix G, Item 84)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Wheel removed (para. 8-3).

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**WARNING**

- Always wear eye protection when replacing wheel studs. Severe eye injury may result if metal chips contact eyes.
- Load Range D valves and tires are not compatible with Load Range E wheels. Load Range E valves and tires are not compatible with Load Range D wheels. Failure to comply may result in damage to equipment and injury or death to personnel.
- Do not mix Load Range D and Load Range E tires on the same vehicle. Failure to comply may result in damage to equipment and injury or death to personnel.

**a. Removal**

Perform steps 1 through 4 for stud removal without disassembly of wheel. Perform steps 5 and 6 for stud removal with disassembled wheel.

1. Place wheel assembly in OSHA approved tire inflation cage.

**WARNING**

In all assembly operations, ensure the tire is totally deflated before removing wheel locknuts. Failure to follow proper safety precautions may result in serious injury or death.

2. Remove valve core (3) from valve bore (4) and deflate tire (1). Run a wire through valve bore (4) to ensure it is not plugged.

3. When tire (1) is fully deflated, loosen wheel locknut (2) from each side of the broken stud(s) (5). If you hear escaping air, do not proceed. Wait until the sound stops and recheck valve bore (4). When you are certain tire is fully deflated, proceed to remove wheel locknut (2). Discard locknut (2).
8-7.3. INNER RIM STUD MAINTENANCE (20-STUD) (Cont’d)
8-7.3. INNER RIM STUD MAINTENANCE (20-STUD) (Cont’d)

**NOTE**
When replacing broken rim stud(s), replace studs on both sides of the broken stud(s).

4. Drive studs (1) out of inner rim (2). Discard studs (1).

5. Disassemble wheel and runflat (para. 8-4.1).

6. Drive stud (3) out of inner rim half (4). Discard stud (3).

### b. Cleaning and Inspection

1. Using wire brush, clean studs. Clean all dirt and foreign material from rim with soap and water and allow to air-dry.

**WARNING**
Never use wheel assemblies with studs which are damaged, loose, or have damaged threads. Damaged studs can cause improper assembly, which could cause individual fasteners to fail. Any of these situations may result in serious injury or death.

2. Inspect inner rim (4) for cracked, broken, rusted, pitted, bent, or loose studs (3), and studs (3) with damaged, mutilated, or deformed threads.

### c. Installation

**NOTE**
Perform steps 1 and 2 for stud installation with disassembled wheel. Perform steps 3 through 11 for stud installation without disassembly of wheel.

1. Align splines on stud (3) with splines in inner rim (4) and drive stud (3) into inner rim (4) until stud shoulder seats against inner rim (4).

2. Assemble wheel and runflat (para. 8-4.1).

3. Align splines on stud (1) with splines in inner rim (2) and drive stud (1) into inner rim (2) until shoulder of stud (1) seats against inner rim (2).

4. Repeat step 3 for all studs (1) being replaced.

**CAUTION**
Tighten locknuts gradually to avoid bent and broken studs or damage to wheel components will result.

5. Install locknuts (6) on studs (1).

**NOTE**
After replacing broken stud(s), all rim nuts must be retightened to torque limits.

6. Tighten locknuts (6) to 85 lb-ft (115 N•m) in sequence shown.

7. Tighten locknuts (6) to 110 lb-ft (149 N•m) in sequence shown.

8. Check wheel assembly for gaps at each stud. Use a 0.0015 in. (0.038 mm) thickness gauge to detect gaps. If gaps are detected, disassemble and reassemble wheel assembly and recheck for gaps. If gaps are still detected, replace outer rim half (para. 8-4.1).

9. Install valve core (7) in valve bore (8).
8-7.3. INNER RIM STUD MAINTENANCE (20-STUD) (Cont’d)

WARNING

- Never inflate a wheel assembly before checking wheel locknut torques to ensure the wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure, resulting in serious injury or death.
- Always use an OSHA approved tire inflation cage for inflation purposes. Stand on one side of the cage during inflation, never directly in front. Keep hands out of cage during inflation. Inflate assembly to recommended pressure, using a clip-on air chuck. Do not exceed 50 psi (345 kPa) cold inflation pressure. Failure to follow these instructions may result in serious injury or death.

10. Place tire assembly (5) in safety cage and inflate front and rear tires to recommended tire pressure (TM 9-2320-387-10).

11. Check for leaks around rim edges, insert, and valve bore (8) with soapy solution.

FOLLOW-ON TASK: Balance tire (para. 8-8).
8-8. WHEEL BALANCING

This task covers:
Balancing

INITIAL SETUP:

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<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit:</td>
<td>TM 9-2320-387-24P</td>
</tr>
<tr>
<td>automotive (Appendix B, item 1)</td>
<td>TM 9-4910-785-10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personnel Required</th>
<th>Equipment Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>One mechanic</td>
<td>Wheel removed (para. 8-3)</td>
</tr>
<tr>
<td>One assistant</td>
<td>Unit</td>
</tr>
</tbody>
</table>

Balancing

For wheel balancing requirements, refer to TM 9-4910-785-10, Operating Instructions for Computer Truck Wheel Balancer.
8-9. FRONT WHEEL TOE-IN ALIGNMENT

This task covers:

a. Preliminary Inspection
b. Toe-in Check
c. Toe-in Adjustment

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
Chalk (Appendix C, Item 20)

Personnel Required
One mechanic
One assistant

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition

• Tires inflated to proper pressure (TM 9-2320-387-10).
• Vehicle on level ground.

Maintenance Level
Unit

NOTE

• It is not necessary to perform front wheel toe-in alignment prior to
the scheduled semiannual or 3,000 mile (4,827 km) maintenance
interval unless abnormal vehicle handling or control is reported,
or it is directed by another maintenance task.

• Front wheel alignment adjustments other than toe-in are
performed by GS maintenance (Chapter 34).

• Ensure M1113, M1152, M1152A1 (if equipped) models have S250
shelter installed before performing front wheel toe-in alignment.

a. Preliminary Inspection

1. Check all tires (6) for uniform tread wear.
2. Raise vehicle and place support under lower control arms (8).
3. Check geared hubs (4) for output spindle end play by grasping edges of tires (6) and attempting to
move tires (6) up and down. Adjust spindle bearings (para. 6-12) if any spindle movement is
apparent.
4. Inspect for looseness of upper ball joint (3) by visually inspecting ball joint boot, and replace upper
ball joint (3) if boot is ripped or torn.
4.1. Grasp top of tire (6) and attempt to move tire IN and OUT. Observe upper control arm (2) and
geared hub (4) where upper ball joint (3) is mounted. If lateral movement is observed, upper ball
joint (3) may be worn. Replace upper ball joint (3) if movement is 1/8 in. (3 mm) or more (refer to
para. 6-23).
5. Check for looseness of lower ball joint (7) by visually inspecting ball joint boot, and replace lower
ball joint (7) if boot is ripped or torn.
5.1. Grasp top of tire (6) and attempt to move tire IN and OUT. Observe lower control arm (8) and gear
hub (4) where lower ball joint (7) is mounted. If lateral movement is observed, lower ball joint (7)
may be worn. Replace lower ball joint (7) if movement is 1/8 in. (3 mm) or more (refer to para. 6-24).
7. Check for looseness of tie rod ends (5) by attempting to move tie rods (9) vertically and horizontally.
Replace tie rod end(s) (5) (para. 8-16) if any movement is apparent.
8. Check for damaged control arm bushings (1). Replace upper control arms (2) (para. 6-25) or lower
control arms (8) (para. 6-26) if bushings (1) are damaged.
8-9. FRONT WHEEL TOE-IN ALIGNMENT (Cont’d)
8-9. FRONT WHEEL TOE-IN ALIGNMENT (Cont’d)

b. Toe-in Check

**NOTE**
- To ensure proper alignment, vehicle must be at curb weight or gross vehicle weight.
- Vehicle must be on level ground with wheels set straight ahead.
- Steps 1 through 3 will determine centerline of tire.
- Point of measurement for checking toe-in will be where lines marked in steps 1 and 3 intersect.

1. Mark line (4) on center tread (1) of tire (2) 16-1/2 in. (42 cm) from ground.
2. Measure total width of tire tread (3) and record.
3. Mark line (5) on center tread (1) at one-half total tread width (3).
4. Repeat steps 1 through 3 for opposite tire.
5. Measure distance between points of measurement on front side of tires (2) and record.
6. Rotate tires (2) by moving vehicle forward until points of measurement are 16-1/2-in. (42 cm) above the ground at rear side of tires (2).
7. Measure distance between points of measurement on rear side of tires (2) and record.

**NOTE**
- If measurement is larger on front side of tires than measurement on rear side of tires, tires have toe-out.
- If toe-in alignment does not meet specifications, repeat checking procedures to eliminate any possible reading errors.

8. Subtract measurement for front side of tires (2), obtained in step 5, from measurement for rear side of tires (2), step 7. The result of this subtraction represents inches of toe-in. Refer to **Table 8-1** for toe-in specifications. If toe-in does not meet specifications, adjust toe-in (task c.).

**Table 8-1. Toe-in Alignment Adjustment Specifications.**

<table>
<thead>
<tr>
<th>TOE-IN (FRONT) ADJUSTMENT SPECIFICATIONS</th>
<th>M1113</th>
<th>M1114</th>
<th>M1151</th>
<th>M1152</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE PAYLOAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle @ curb weight</td>
<td>1/4 in. (± 1/4 in.)</td>
<td>6 mm (± 6 mm)</td>
<td>1/4 in. (± 1/4 in.)</td>
<td>6 mm (± 6 mm)</td>
</tr>
<tr>
<td>Vehicle @ gross vehicle weight (GVW)</td>
<td>1/4 in. (± 1/4 in.)</td>
<td>6 mm (± 6 mm)</td>
<td>1/4 in. (± 1/4 in.)</td>
<td>6 mm (± 6 mm)</td>
</tr>
</tbody>
</table>

9. If toe-in is within specifications, refer to task c. and perform step 5.
8-9. FRONT WHEEL TOE-IN ALIGNMENT (Cont’d)

[Diagram of a tire with markings and a vehicle with points of measurement labeled]
c. Toe-in Adjustment

1. Loosen two locknuts (3) and screws (1.1) securing clamps (1) on each adjusting sleeve (2).

   **NOTE**
   Toe-in can be increased or decreased by changing length of tie rods. A threaded sleeve is provided for this purpose. Both tie rods must be the same length ± 1/8 in. (3 mm) after adjustment.

2. Turn each adjusting sleeve (2) equally, but in opposite directions.
3. Roll vehicle rearward, then forward, to original position.
4. Repeat toe-in check and adjustment procedures until correct adjustment is indicated.

   **CAUTION**
   Ensure bolt and nut on adjusting sleeve clamp nearest to geared hub is facing halfshaft. Bolt and nut on adjusting sleeve clamp nearest to frame must be facing 180° away from stabilizer bar to prevent damage to equipment.

5. Secure two clamps (1) on each adjusting sleeve (2) with two screws (1.1) and locknuts (3). Tighten locknuts (3) to 30 lb-ft (40 N·m).
8-9. FRONT WHEEL TOE-IN ALIGNMENT (Cont’d)

FOLLOW-ON TASK: Operate vehicle (TM 9-2320-387-10) and check for pull or wander.
8-10. REAR WHEEL TOE-OUT ALIGNMENT

This task covers:

- Preliminary Inspection
- Toe-out Check
- Toe-out Adjustment

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-10</td>
</tr>
<tr>
<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>TM 9-2320-387-24P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personnel Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>One mechanic</td>
</tr>
<tr>
<td>One assistant</td>
</tr>
</tbody>
</table>

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Tires inflated to proper pressure (TM 9-2320-387-10).
- Vehicle on level ground.
- Ensure all tires have the same pressure.

Maintenance Level
- Unit

NOTE

- It is not necessary to perform rear wheel toe-out alignment prior to the scheduled semiannual or 3,000 mile (4,827 km) maintenance interval unless abnormal vehicle handling or control is reported, or it is directed by another maintenance task.
- Rear wheel alignment adjustments other than toe-out are performed by DS maintenance (chapter 21).
- Ensure M1113 models have S250 shelter installed before performing rear wheel toe-out alignment.

a. Preliminary Inspection

1. Check all tires (7) for uniform tread wear.
2. Raise vehicle and place support under lower control arms (11).
3. Check geared hubs (5) for output spindle end play by grasping edges of tires (7) and attempting to move tires (7) up and down. Adjust spindle bearings (para. 6-12) if any spindle movement is apparent.
4. Inspect for looseness of upper ball joint (3) by visually inspecting ball joint boot, and replace upper ball joint (3) if boot is ripped or torn.
   4.1. Grasp top of tire (6) and attempt to move tire IN and OUT. Observe upper control arm (2) and gear hub (4) where upper ball joint (3) is mounted. If lateral movement is observed, upper ball joint (3) may be worn.
   4.2. Replace upper ball joint (3) if movement is 1/8 in. (3 mm) or more (refer to para. 6-23).
5. Check for looseness of lower ball joint (7) by visually inspecting ball joint boot, and replace lower ball joint (7) if boot is ripped or torn.
   5.1. Grasp top of tire (6) and attempt to move tire IN and OUT. Observe lower control arm (9) and gear hub (4) where lower ball joint (7) is mounted. If lateral movement is observed, lower ball joint (7) may be worn.
   5.2. Replace lower ball joint (7) if movement is 1/8 in. (3 mm) or more (refer to para. 6-24).
7. Check for looseness of radius rod ends (6) by attempting to move adjusting sleeves (10) vertically and horizontally. Replace radius rod end(s) (6) [para. 6-22] if any movement is apparent.
8. Check for damaged control arm bushings (1). Replace upper control arms (3) [para. 6-25] or lower control arms (11) [para. 6-26] if bushings (1) are damaged.
9. Proceed to task b.
NOTE

• To ensure proper alignment, vehicle must be at curb weight, or gross vehicle weight.
• Vehicle should not be moved during alignment checks.
• Vehicle must be on level ground with wheels set straight ahead.
• Steps 1 through 3 will determine centerline of tire.
• Point of measurement for checking toe-out will be where lines marked in steps 1 and 3 intersect.

1. Mark line (4) on center tread (1) of tire (2) 16-1/2-in. (42 cm) from ground.
2. Measure total width of tire tread (3) and record.
3. Mark line (5) on center tread (1) at one-half total tread width (3).
4. Repeat steps 1 through 3 for opposite tire.
5. Measure distance between points of measurement on front side of tires (2) and record.
6. Rotate tires (2) by moving vehicle forward until points of measurement are 16-1/2 in. (42 cm) above the ground at rear side of tires (2). Repeat steps 1 through 4 for side of tires.
7. Measure distance between points of measurement on rear side of tires (2) and record.

NOTE

• If measurement is larger on rear side of tires than measurement on front side of tires, tires have toe-in.
• If toe-out alignment does not meet specifications, repeat checking procedures to eliminate any possible reading errors.

8. Subtract measurement obtained in step 7 for rear side of tires (2) from measurement obtained in step 5 for front side of tires (2). The result of this subtraction represents inches of toe-out. Refer to Table 8-2 for toe-out specifications. If toe-out does not meet the specifications, adjust toe-out (task c.).

Table 8-2. Toe-out Alignment Adjustment Specifications.

<table>
<thead>
<tr>
<th>TOE-OUT (REAR) ADJUSTMENT SPECIFICATIONS</th>
<th>M1113</th>
<th>M1114</th>
<th>M1151</th>
<th>M1152</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE PAYLOAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle @ curb weight</td>
<td>1/2 in. (± 1/4 in.)</td>
<td>12.7 mm (± 6 mm)</td>
<td>1/2 in. (± 1/4 in.)</td>
<td>12.7 mm (± 6 mm)</td>
</tr>
<tr>
<td>Vehicle @ gross vehicle weight (GVW)</td>
<td>1/2 in. (± 1/4 in.)</td>
<td>12.7 mm (± 6 mm)</td>
<td>1/2 in. (± 1/4 in.)</td>
<td>12.7 mm (± 6 mm)</td>
</tr>
</tbody>
</table>

NOTE

Maximum side-to-side difference 1/4 in. (6mm).

9. If toe-out is within specifications, refer to task c. and perform step 5.
8-10. REAR WHEEL TOE-OUT ALIGNMENT (Cont’d)

TOE-OUT MEASUREMENT

POINT OF MEASUREMENT
c. Toe-out Adjustment

1. Loosen two locknuts (1) and screws (1.1) securing clamps (3) on each adjusting sleeve (2).

**NOTE**

Toe-out can be increased or decreased by changing length of tie rods. A threaded sleeve is provided for this purpose. Both tie rods must be the same length ± 1/8 in. (3 mm) after adjustment.

2. Turn each adjusting sleeve (2) equally, but in opposite directions.
3. Roll vehicle rearward, then forward, to original position.
4. Repeat toe-out check and adjustment procedures until correct adjustment is indicated.

**CAUTION**

Ensure bolt and nut on adjusting sleeve clamp nearest to geared hub is facing halfshaft. Bolt and nut on adjusting sleeve clamp nearest to frame must be facing 180° away from stabilizer bar to prevent damage to equipment.

5. Secure two clamps (3) on each adjusting sleeve (2) with two screws (1.1) and locknuts (1). Tighten locknuts (1) to 30 lb-ft (40 N·m).

FOLLOW-ON TASK: Operate vehicle (TM 9-2320-387-10) and check for pull or wander.
This task covers:

Adjustment

INITIAL SETUP:

Tools
General mechanic’s tool kit: automotive (Appendix B, Item 1)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Wheels chocked and parking brake on (TM 9-2320-387-10).
Steering stop adjusted properly (para. 6-17).

Maintenance Level
Direct support

NOTE
Adjustment procedures for left and right turn radius are the same. This procedure covers the left side.

1. Place the transmission in neutral and start the engine, allowing the engine to operate at idle speed.

CAUTION
If the stop bolt hits the axle under pressure, release the wheel immediately. Damage to steering components may result.

2. Turn the steering wheel to a full left turn.

3. Check clearance between stop bolt and axle. If clearance is not 1/8”, plunger adjustment will be necessary.

4. Turn the steering wheel so tires are straight ahead.

NOTE
• Turning the plunger in will increase the clearance between the stop bolt and axle.
• Turning the plunger out will decrease the clearance between the stop bolt and axle.

WARNING
Never adjust the plunger beyond flush with the end cap. Leakage or personal injury may result.

CAUTION
Do not adjust the plunger with pressure on the steering wheel, seal damage can result.

5. Adjust the plunger for left turn.

6. Turn the steering wheel to a full left turn. Check the clearance between the stop bolt and axle. If clearance is not 1/8”, repeat steps 4 through 6.
8-10.1. STEERING RADIUS ADJUSTMENT
(SERIAL NUMBERS 246890 AND ABOVE) (Cont’d)

LEFT SIDE ADJUSTMENT

RIGHT SIDE ADJUSTMENT
### Section II. STEERING COMPONENTS MAINTENANCE

#### 8-11. STEERING COMPONENTS MAINTENANCE TASK SUMMARY

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<th>TASK PARA.</th>
<th>PROCEDURES</th>
<th>PAGE NO.</th>
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<td>8-36</td>
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<td>Tie Rod Maintenance</td>
<td>8-37</td>
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<td>8-14</td>
<td>Pitman Arm Replacement (Serial Numbers 246889 and Below)</td>
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<td>Tie Rod End Replacement</td>
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<td>Steering Column Replacement</td>
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<td>8-21</td>
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<td>8-22</td>
<td>Intermediate Steering Shaft Close-off and Retainer Replacement</td>
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<td>8-23</td>
<td>Power Steering Pump and Pulley Replacement (Serial Numbers 196900 and Below)</td>
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<tr>
<td>8-23.1</td>
<td>Power Steering Pump and Pulley Replacement (Serial Numbers 196901 and Above)</td>
<td>8-64.2</td>
</tr>
<tr>
<td>8-23.2</td>
<td>Power Steering Pump Pressure Relief Valve Replacement (Serial Numbers 196901 and Above)</td>
<td>8-64.4</td>
</tr>
<tr>
<td>8-24</td>
<td>Power Steering Hydraulic System Pressure and Return Hose Replacement (Serial Numbers 196900 and Below)</td>
<td>8-66</td>
</tr>
<tr>
<td>8-24.1</td>
<td>Power Steering Hydraulic System Pressure Hose Replacement (Serial Numbers 196901 Through 299999)</td>
<td>8-66.4</td>
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<tr>
<td>8-24.2</td>
<td>Power Steering Hydraulic System Pressure and Return Hoses Replacement (Serial Numbers 300000 and Above)</td>
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<td>Power Steering System Hydraulic Control Valve Maintenance</td>
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<td>8-26</td>
<td>Power Steering Cooler Hose and Manifold Valve Hoses Replacement</td>
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<tr>
<td>8-27</td>
<td>Power Steering System Bleeding (RCSK 18330)</td>
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<tr>
<td>8-27.1</td>
<td>Power Steering System Bleeding (P/N 94252A)</td>
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<td>8-28</td>
<td>Power Steering Relief Valve Cartridge Maintenance</td>
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<td>Power Steering Reservoir andBracket Replacement (P/N 94252A)</td>
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<td>8-30</td>
<td>Power Steering Reservoir Filter Replacement (P/N 94252A)</td>
<td>8-82</td>
</tr>
</tbody>
</table>
8-12. STEERING WHEEL REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  automotive (Appendix B, Item 2)
- Steering wheel puller (Appendix D, Fig. 108)

Materials/Parts
- Nut (Appendix G, Item 69)

Equipment Condition
- Horn switch removed (para. 4-24).
- Cancelling ring removed (para 4-64).

Maintenance Level
- Unit

a. Removal

1. Remove nut (2) from steering wheel (1) and shaft (3). Discard nut (2).

2. Install capscrews (4) of steering wheel puller (5) in steering wheel (1) and equally tighten capscrews (4) until steering wheel (1) can be removed from shaft (3).

b. Installation

1. Align splines on steering wheel (1) with splines on shaft (3).

2. Install steering wheel (1) on shaft (3) with nut (2). Tighten nut (2) to 35 lb-ft (47 N•m).

3. Peen nut (2).

FOLLOW-ON TASKS:
- Install horn switch (para. 4-24).
- Install cancelling ring (para. 4-64).
8-13. TIE ROD MAINTENANCE

This task covers:

a. Removal  c. Assembly
b. Disassembly d. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)
Puller kit (Appendix B, Item 157)

Materials/Parts
Two cotter pins (Appendix G, Item 22)
Two locknuts (Appendix G, Item 125)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Front of vehicle raised and supported (para. 8-2).

Maintenance Level
Unit

CAUTION
Using a pickle fork instead of puller kit may damage serviceable components (boots).

a. Removal

1. Remove cotter pin (8) and slotted nut (7) from tie rod (2) and center link (1). Discard cotter pin (8).
2. Remove cotter pin (6), slotted nut (5), washer (4), and tie rod (2) from geared hub (3). Discard cotter pin (6).
### 8-13. TIE ROD MAINTENANCE (Cont'd)

#### b. Disassembly

**NOTE**
- Disassembly procedures for tie rod and radius rod are basically the same. One tie rod end of the radius rod is different.
- Scribe locating marks on adjusting sleeve and clamps for installation.

1. Loosen two capscrews (10), locknuts (13), and clamps (11) securing tie rod ends (9) to adjusting sleeve (12).

**NOTE**
Note number of threads exposed on each tie rod end for installation. Approximately the same number of threads should be exposed on each tie rod end.

2. Remove two tie rod ends (9) from adjusting sleeve (12).
3. Remove two locknuts (13), capscrews (10), and clamps (11) from adjusting sleeve (12). Discard locknuts (13).

#### c. Assembly

1. Install two clamps (11), capscrews (10), and nuts (13) on adjusting sleeve (12).
2. Install two tie rod ends (9) into adjusting sleeve (12), turning tie rod ends (9) equally but in opposite directions.

#### d. Installation

1. Install tie rod (2) on center link (1) with slotted nut (7). Tighten slotted nut (7) to 70 lb-ft (95 N•m).

**CAUTION**
Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

2. Install tie rod (2) on geared hub (3) with washer (4) and slotted nut (5). Tighten slotted nut (5) to 70 lb-ft (95 N•m).
3. Install cotter pin (8) in slotted nut (7).
4. Install cotter pin (6) in slotted nut (5).

**CAUTION**
Ensure the outboard clamp faces the halfshaft and the inboard clamp faces away from the stabilizer bar (front only) or damage to equipment may result.

5. Tighten two locknuts (13).
FOLLOW-ON TASKS: • Lubricate tie rod end (TM 9-2320-387-10).
• Remove supports and lower front of vehicle [para. 8-2].
• Align toe-in [para. 8-9].
8-14. PITMAN ARM REPLACEMENT (SERIAL NUMBERS 246889 AND BELOW)

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)
- Puller kit (Appendix B, Item 157)

Materials/Parts

- Cotter pin (Appendix G, Item 22)
- Lockwasher (Appendix G, Item 186)

Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition

Front of vehicle raised and supported (para. 8-2).

Maintenance Level

Unit

NOTE

Ensure front wheels are in straight-ahead position while pitman arm is removed and installed.

a. Removal

1. Remove nut (1) and lockwasher (2) from steering gear shaft (4). Discard lockwasher (2).
2. Using puller, remove pitman arm (3) from steering gear shaft (4).
3. Remove cotter pin (6) and slotted nut (7) from pitman arm (3) and center link (5). Discard cotter pin (6).
4. Using puller, remove pitman arm (3) from center link (5).

b. Installation

1. Install pitman arm (3) on steering gear shaft (4) with lockwasher (2) and nut (1).
2. Install pitman arm (3) on center link (5) with slotted nut (7). Tighten slotted nut (7) to 80 lb-ft (108 N•m).
3. Tighten nut (1) to 185 lb-ft (251 N•m).

CAUTION

Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

4. Install cotter pin (6) in slotted nut (7).
FOLLOW-ON TASKS:  
- Lubricate pitman arm (TM 9-2320-387-10).
- Remove supports and lower front of vehicle \(\text{para. 8-2}\).
8-15. CENTER LINK REPLACEMENT (SERIAL NUMBERS 246889 AND BELOW)

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)
  - Puller kit (Appendix B, Item 157)

Materials/Parts
- Four cotter pins (Appendix G, Item 22)

Manual References
- TM 9-2320-387-24P

Equipment Condition
- Front of vehicle raised and supported (para. 8-2).

Maintenance Level
- Unit

CAUTION
Using a pickle fork instead of puller kit may damage serviceable components (boots).

a. Removal

1. Remove cotter pin (5) and slotted nut (4) from idler arm (8) and center link (3).
   Discard cotter pin (5).
2. Remove cotter pin (9) and slotted nut (10) from pitman arm (2) and center link (3).
   Discard cotter pin (9).
3. Remove two cotter pins (1) and slotted nuts (6) from two tie rods (7) and center link (3).
   Discard cotter pins (1).
4. Using puller, remove center link (3) from two tie rods (7), idler arm (8), and pitman arm (2).

b. Installation

CAUTION
Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

1. Install center link (3) on pitman arm (2) and idler arm (8) with slotted nuts (4) and (10). Tighten slotted nuts (4) and (10) to 80 lb-ft (108 N•m).
2. Install cotter pins (5) and (9) in slotted nuts (4) and (10).
3. Install two tie rods (7) on center link (3) with two slotted nuts (6). Tighten slotted nuts (6) to 70 lb-ft (95 N•m).
4. Install two cotter pins (1) in slotted nuts (6).
FOLLOW-ON TASK: Remove supports and lower front of vehicle [para. 8-2].
8-16. TIE ROD END REPLACEMENT

This task covers:

a. Removal
b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
</tr>
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<tbody>
<tr>
<td>General mechanic’s tool kit:</td>
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</tr>
<tr>
<td>automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
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<td>Maintenance and repair shop equipment:</td>
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<tr>
<td>Puller kit (Appendix B, Item 157)</td>
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<tr>
<td>Materials/Parts</td>
<td></td>
</tr>
<tr>
<td>Cotter pin (Appendix G, Item 22)</td>
<td></td>
</tr>
</tbody>
</table>

Equipment Condition

Front of vehicle raised and supported [para. 8-2].

Maintenance Level

Unit

a. Removal

1. Remove cotter pin (8), slotted nut (7), and washer (6) from tie rod end (4) and geared hub (5).
   Discard cotter pin (8).
2. Using puller, remove tie rod end (4) from geared hub (5).

   **NOTE**

   Note number of threads exposed on each tie rod end for installation. Approximately the same number of threads should be exposed on each tie rod end.

3. Loosen nut (9), capscrew (3), clamp (2), and tie rod end (4) from adjusting sleeve (1).

b. Installation

   **CAUTION**

   Ensure clamp faces halfshaft or damage to equipment may result.
1. Install tie rod end (4) into sleeve (1) with clamp (2), capscrew (3), and nut (9).

   **CAUTION**

   Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

2. Install tie rod end (4) on geared hub (5) with washer (6) and slotted nut (7). Tighten slotted nut (7) to 70 lb-ft (95 N·m).
3. Install cotter pin (8) in slotted nut (7).
FOLLOW-ON TASKS:  
• Lubricate tie rod end (TM 9-2320-387-10).  
• Remove supports and lower front of vehicle [para. 8-2].  
• Align toe-in [para. 8-9].
8-17. IDLER ARM MAINTENANCE

This task covers:

a. Inspection  
b. Removal  
c. Installation

INITIAL SETUP:

Tools

- General mechanic’s tool kit:  
  automotive (Appendix B, Item 1)  
- Maintenance and repair shop equipment:  
  automotive (Appendix B, Item 2)  
- Puller kit (Appendix B, Item 157)  
- Spring scale, dial indicating  
  (Appendix B, Item 2)

Materials/Parts

- Cotter pin (Appendix G, Item 22)

Manual References

- TM 9-2320-387-10  
- TM 9-2320-387-24P

Equipment Condition

- Front of vehicle raised and supported (para. 8-2)

Maintenance Level

- Unit

NOTE

Set front wheels in a straight-ahead position.

1. Check idler arm (5) for visible damage, such as breaks and cracks. If damaged, replace idler arm (5).
2. Check capscrews (4) for looseness of idler arm bracket (3) on frame (6). Tighten capscrews (4) if loose.

A flat steel plate or piece of scrap metal is required for step 3.

3. Secure a flat steel plate or piece of scrap metal to front crossmember (2).
4. Pull center link (1) downward to seat ball and socket of idler arm (5).
5. Using flat surface on center link (1) as a guide, mark first reference line on steel plate or scrap metal, as shown in figure A.
6. Position spring scale (7) on center link (1) and pull in an upward direction to obtain a 25 lb (11 kg) reading on spring scale (7).

Maintain 25 lb (11 kg) reading on spring scale to perform step 7.

7. Using flat surface on center link (1) as a guide, mark second reference line on steel plate or scrap metal, as shown in figure B.
8. Remove spring scale (7) from center link (1).
9. Remove clamp and steel plate or scrap metal from front crossmember (2).
10. Measure distance between first and second reference lines on steel plate or scrap metal. If measurement exceeds 0.25 in. (6mm), replace idler arm (5).
b. Removal

1. Remove cotter pin (1) and slotted nut (8) from idler arm (7) and center link (2). Discard cotter pin (1).
2. Using puller, disconnect center link (2) from idler arm (7).
3. Remove two nuts (6), washers (4), capscrews (3), washers (4), and idler arm (7) from frame (5).

C. Installation

1. Install idler arm (7) on frame (5) with two washers (4), capscrews (3), washers (4), and nuts (6). Tighten nuts (6) to 60 lb-ft (81 N•m).
2. Install idler arm (7) on center link (2) with slotted nut (8). Tighten slotted nut (8) to 80 lb-ft (108 N•m).

**CAUTION**

Do not loosen slotted nut to install cotter pin. Doing this may result in damage to equipment.

3. Install cotter pin (1) in slotted nut (8).
FOLLOW-ON TASKS: • Lubricate idler arm (TM 9-2320-387-10).
• Remove supports and lower front of vehicle (para. 8-2).
8-18. STEERING COLUMN REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
      automotive (Appendix B, Item 2)

Materials/Parts
   Two locknuts (Appendix G, Item 82)
   Locknut (Appendix G, Item 106)
   Locknut (Appendix G, Item 101)
   Locknut (Appendix G, Item 90)
   Lockwasher (Appendix G, Item 144)
   Nut and lockwasher assembly
      (Appendix G, Item 197)

Manual References
   TM 9-2320-387-24P

Equipment Condition
   • Steering wheel removed [para. 8-12].
   • Directional signal control removed [para. 4-63].

Maintenance Level
   Unit

---

a. Removal

1. Remove locknut (1), lockwasher (2), washer (3), and pin (5) from steering column (6) and mounting bracket (4). Discard lockwasher (2) and locknut (1).
2. Remove nut and lockwasher assembly (17), screw (7), and ground wire 57C (8) from steering column (6). Discard nut and lockwasher assembly (17).
3. Remove locknut (10), washer (11), capscrew (13), washer (11), and two brackets (9) from steering column (6). Discard locknut (10).
4. Disconnect lead 25A (21) from steering column (6).

**NOTE**

When performing step 5, temporarily install steering wheel and turn steering column to gain access to steering column intermediate shaft mounting hardware.

5. Remove locknut (12), washer (14), capscrew (15), washer (14), and intermediate shaft (16) from steering column (6). Discard locknut (12).
6. Remove two locknuts (20), washers (18), screws (19), washers (18), and steering column (6) from mounting bracket (4). Discard locknuts (20).
8-52 Change 2

8-18. STEERING COLUMN REPLACEMENT (Cont’d)

b. Installation

1. Install steering column (6) on mounting bracket (4) with two washers (18), screws (19), washers (18), and locknuts (20). Tighten locknuts (20) finger-tight.

2. Install intermediate shaft (16) on steering column (6) with washer (14), capscrew (15), washer (14), and locknut (12). Tighten locknut (12) to 40-50 lb-ft (54-68 N·m).

3. Connect lead 25A (21) to steering column (6).

4. Install two brackets (9) on steering column (6) with washer (11), capscrew (13), washer (11), and locknut (10).

5. Install ground wire 57C (8) on steering column (6) with screw (7) and nut and lockwasher assembly (17).

**NOTE**

Ensure washer and pin locking tabs are in the UP position.

6. Install steering column (6) on mounting bracket (4) with pin (5), washer (3), lockwasher (2), and locknut (1). Tighten locknut (1) finger-tight.

7. Position steering column (6) in upright position and tighten locknut (1) to 12-15 lb-ft (16-20 N·m).

8. Tighten two locknuts (20) to 12-15 lb-ft (16-20 N·m).
FOLLOW-ON TASKS:

- Install directional signal control [para. 4-63].
- Install steering wheel [para. 8-12].
8-19. INTERMEDIATE STEERING SHAFT REPLACEMENT

This task covers:

a. Removal  b. Installation

INITIAL SETUP:

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<th>Manual References</th>
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<td>General mechanic’s tool kit:</td>
<td>TM 9-2320-387-10</td>
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<td>automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
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<tr>
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<td>Maintenance Level</td>
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<table>
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<tr>
<th>Materials/Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two locknuts (Appendix G, Item 90)</td>
</tr>
</tbody>
</table>

NOTE

Ensure front wheels are in straight-ahead position while removing and installing intermediate steering shaft.

a. Removal

1. Remove locknut (6), washer (5), capscrew (8), and washer (5) from intermediate steering shaft (4) and steering gear (7). Discard locknut (6).
2. Remove locknut (2), washer (3), capscrew (9), washer (3), and steering shaft (4) from steering column (1). Discard locknut (2).

b. Installation

1. Install intermediate steering shaft (4) on steering gear (7) with washer (5), capscrew (8), washer (5), and locknut (6). Tighten locknut (6) to 40-50 lb-ft (54-68 N·m).
2. Install steering shaft (4) on steering column (1) with washer (3), capscrew (9), washer (3), and locknut (2). Tighten locknut (2) to 40-50 lb-ft (54-68 N·m).
FOLLOW-ON TASK: Lubricate steering shaft (TM 9-2320-387-10).
8-20. STEERING GEAR MAINTENANCE (SERIAL NUMBERS 246889 AND BELOW)

This task covers:

a. Removal
   a1. Steering Gear Mounting Area
       Inspection (M1114 only)

b. Installation

INITIAL SETUP:

Tools

- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

Materials/Parts

- Locknut (Appendix G, Item 133.17)
- Three lockwashers (Appendix G, Item 182)
- Lockwasher (Appendix G, Item 186)

Manual References

- TM 9-2320-387-10
- TM 9-2320-387-24P
- TM 43-0139

Equipment Condition

- Hood raised and secured (TM 9-2320-387-10).
- Battery ground cables disconnected (para. 4-68).

Maintenance Level

Unit

CAUTION

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

NOTE

- Ensure front wheels are in the straight-ahead position.
- Have drainage container ready to catch fluid.

1. Disconnect two power steering lines (4) from steering gear (10).
2. Turn steering wheel left and right several times to bleed off power steering fluid.
3. Remove intermediate shaft locknut (1), washer (2), capscrew (5), and washer (2) and disconnect intermediate shaft (3) from steering gear (10). Discard locknut (1).
4. Remove nut (14) and lockwasher (13) from pitman arm (12). Discard lockwasher (13).
5. Remove pitman arm (12) from shaft (11).
6. Remove three capscrews (8), lockwashers (7), washers (6), and steering gear (10) from frame (9). Discard lockwashers (7).
8-20. STEERING GEAR MAINTENANCE (SERIAL NUMBERS 246889 AND BELOW) (Cont’d)

a.1. Steering Gear Mounting Area Inspection (M1114 only)

NOTE
The inspection is focused on the area surrounding the steering gear mounting tubes, commonly referred to as bosses. They are located on the front left-hand frame rail. Tubes are welded in holes through the frame rail, accommodating the steering gear mounting bolts. Inside and outside frame rails have experienced stress-cracking stemming from the steering gear mounting tubes. Stress cracks can be radial, tangential, transverse, and/or longitudinal. In some cases, stress cracks can be in the boss welds themselves.

Inspect steering gear mounting area as follows:

NOTE
It may be necessary to remove all paint on suspected area.

(a) Inspect all welds around bosses on inside and outside frame rails.

(b) Inspect for cracks on all surfaces between all bosses on inside, outside, top, and bottom of frame rails.

NOTE
Most cracks in boss welds and frame rails are repairable. Upon identification, notify general support maintenance for repairs.

(c) Unless follow-on repairs are required, if paint was removed during inspection, spot-paint using Chemical Agent Resistant Coating (CARC). Follow TM 43-0139, Painting Instructions for Field Use.
8-20. STEERING GEAR MAINTENANCE (SERIAL NUMBERS 246889 AND BELOW) (Cont’d)

OUTSIDE OF FRAME RAIL

INSIDE OF FRAME RAIL
8-20. STEERING GEAR MAINTENANCE (SERIAL NUMBERS 246889 AND BELOW) (Cont’d)

b. Installation

1. Install steering gear (12) on frame (11) with three washers (8), lockwashers (9), and capscrews (10). Tighten capscrews (10) to 54–66 lb-ft (73–89 N·m).

2. Align hole in yoke (3) with notch on steering gear splines (7) and slide intermediate shaft (4) on steering gear splines (7).

3. Install intermediate shaft (4) to steering gear splines (7) with washer (2), capscrew (6), washer (2), and locknut (1). Tighten locknut (1) to 40–50 lb-ft (54–68 N·m).

4. Connect two power steering lines (5) to steering gear (12).

**NOTE**

Ensure front wheels are in the straight-ahead position.

5. Install pitman arm (14) on shaft (13) with lockwasher (15) and nut (16). Tighten nut (16) to 185 lb-ft (251 N·m).
8-20. STEERING GEAR MAINTENANCE (SERIAL NUMBERS 246889 AND BELOW) (Cont’d)

FOLLOW-ON TASKS:
• Fill power steering reservoir (TM 9-2320-387-10).
• Connect battery ground cables (para. 4-68).
• Bleed power steering system (para. 8-27).
8-20.1. STEERING GEAR, CENTER LINK, AND PITMAN ARM REPLACEMENT (SERIAL NUMBERS 246890 AND ABOVE)

This task covers:
  a. Removal
  b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Four cotter pins (Appendix G, Item 22)
- Two locknuts (Appendix G, Item 114.4)
- Locknut (Appendix G, Item 133.17)
- Three lockwashers (Appendix G, Item 190.8)
- Two O-rings (Appendix G, Item 220)
- Sealing compound (Appendix C, Item 63)
- Anti-seize compound (Appendix C, Item 16)

Personnel Required
- One mechanic
- One assistant

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

Equipment Condition
- Hood raised and secured (TM 9-2320-387-10).
- Left splash shield removed (para. 10-23.1).
- Left front wheel removed (para. 8-3).
- Stabilizer bar removed (para. 6-20.1).

General Safety Instructions
- Do not use hammer or apply heat to the pitman arm.
- Proper pitman arm installation is critical to safe operation of vehicle.
- Do not back off torque value to align locking tabs.

Maintenance Level
- Unit

a. Removal

**CAUTION**
- Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.
- Using a pickle fork instead of a puller may damage serviceable components.

**NOTE**
Use suitable container to catch power steering fluid.

1. Remove two cotter pins (2) and slotted nuts (3) from two tie rods (4) and center link (1). Discard cotter pins (2).
2. Disconnect two tie rods (4) from center link (1).
3. Remove two locknuts (6), washers (5), capscrews (10), washers (9), and idler arm (8) from frame (7). Discard locknuts (6).
4. Remove two power steering lines (15) from steering gear (24).
5. Remove two power steering lines adapters (17) and O-rings (18) from steering gear (24). Discard O-rings (18).
6. Remove lower steering shaft locknut (11), washer (12), capscrew (16), and washer (14) and disconnect lower steering shaft (13) from steering gear (24). Discard locknut (11).
7. Remove three capscrews (22), lockwashers (21), washers (20), bracket (19), and steering gear (24) from frame (23). Discard lockwashers (20).
8-20.1. STEERING GEAR, CENTER LINK, AND PITMAN ARM REPLACEMENT (SERIAL NUMBERS 246890 AND ABOVE) (Cont’d)
8-20.1. STEERING GEAR, CENTER LINK, AND PITMAN ARM REPLACEMENT
(SERIAL NUMBERS 246890 AND ABOVE) (Cont’d)

**WARNING**
Do not use a hammer or apply heat to the pitman arm. Failure to comply may result in injury to personnel or damage to equipment.

8. Remove two cotter pins (2) and slotted nuts (3) from idler arm (5), pitman arm (4), and center link (1). Discard cotter pins (2).
9. Disconnect center link (1) from idler arm (5) and pitman arm (4).
10. Using screwdriver, bend locking tab (9) on lock ring (10) away from slot (7) in bolt (8).
11. Remove bolt (8) and lock ring (10) from pitman arm (4).
12. Using press (11) and support plate (12) remove pitman arm (4) from steering gear (13).

**WARNING**
Proper pitman arm installation is critical to safe operation of vehicle.

1. Install pitman arm (4) onto the steering gear (13) taking care to match alignment marks (14).

**WARNING**
Do not back off torque value to align locking tabs.

2. Secure pitman arm (4) to steering gear (13) with bolt (8) and lock ring (10). Tighten bolt (8) to 225 lb-ft (305 N•m).
3. Continue to torque bolt (8) past specified value until one locking tab (9) aligns with pitman arm (4) and one locking tab (9) aligns with bolt (8).
4. Bend locking tabs (9) into the slot (7) of bolt (8).
5. Install center link (1) on pitman arm (4) and idler arm (5) with two slotted nuts (3). Tighten slotted nuts (3) to 110–130 lb-ft (149–176 N•m).

**CAUTION**
Do not loosen slotted nuts to install cotter pins. Doing this may result in damage to equipment.

6. Install two cotter pins (2) in slotted nuts (3).

---

**Diagram:**
- Pitman arm (4)
- Idler arm (5)
- Center link (1)
- Cotter pins (2)
- Slotted nuts (3)
- Lock ring (10)
- Bolt (8)
- Locking tabs (9)
- Slot (7) in bolt (8)
- Alignment marks (14)
- Steering gear (13)

---

8-58.4 Change 6
8-20.1. STEERING GEAR, CENTER LINK, AND PITMAN ARM REPLACEMENT (SERIAL NUMBERS 246890 AND ABOVE) (Cont’d)
7. Apply sealing compound to three capscrews (12).
8. Install steering gear (14) on frame (13) with three washers (10), lockwashers (11), bracket (9), and capscrews (12). Tighten capscrews (12) to 160–195 lb-ft (217–264 N·m).
9. Install idler arm (21) on frame (20) with two washers (22), capscrews (23), washers (18), and locknuts (19). Tighten capscrews (23) to 85 lb-ft (115 N·m).
10. Install two tie rods (26) on center link (17) with two slotted nuts (25). Tighten slotted nuts (25) to 70 lb-ft (95 N·m).
11. Install two cotter pins (24) on slotted nuts (25).
12. Align hole in yoke (16) with notch on steering gear splines (15) and slide lower steering shaft (3) on steering gear splines (15).
13. Install lower steering shaft (3) on steering gear (14) with washer (4), capscrew (6), washer (2), and lower steering shaft locknut (1). Tighten locknut (1) to 40–50 lb-ft (54–68 N·m).
14. Install two power steering lines adapters (7) on steering gear (14).
15. Install two power steering lines (5) and O-rings (8) on two adapters (8).
8-20.1. STEERING GEAR, CENTER LINK, AND PITMAN ARM REPLACEMENT
(SERIAL NUMBERS 246890 AND ABOVE) (Cont’d)

FOLLOW-ON TASKS:  
- Fill power steering reservoir (TM 9-2320-387-10).
- Bleed power steering system [para. 8-27.1].
- Install stabilizer bar [para. 6-20.1].
- Install front wheel [para. 8-3].
- Install left splash shield (para. 10-23.1).
- Close and secure hood (TM 9-2320-387-10).
**8-21. STEERING SHAFT U-JOINT REPLACEMENT**

This task covers:

<table>
<thead>
<tr>
<th>a. Removal</th>
<th>b. Installation</th>
</tr>
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**INITIAL SETUP:**

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<tr>
<th>Tools</th>
<th>Manual References</th>
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<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
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<tr>
<td>Universal joint bearing kit (Appendix B, Item 19)</td>
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<th>Equipment Condition</th>
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<tbody>
<tr>
<td>Center parts kit (Appendix G, Item 10)</td>
<td>Intermediate steering shaft removed (para. 8-19).</td>
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<tbody>
<tr>
<td>Unit</td>
<td></td>
</tr>
</tbody>
</table>

**CAUTION**

Do not drop bearing cups. Needle bearings can be easily lost.

**NOTE**

Removal and installation procedures are basically the same for both U-joints. This procedure covers the U-joint attached to steering gear.

1. Remove grease fitting (6) from cross (1).
2. Remove two snaprings (3) from bearing cups (4) in steering gear yoke (5).
3. Position steering gear yoke (5) in vise with 1-1/8-in. socket between vise jaw and bearing cup (4) being removed. Ensure open end of socket is facing bearing cup (4).
4. Place 11/16-in. socket between opposite bearing cup (4) and vise jaw. Ensure open end of socket is facing vise jaw.
5. Press bearing cup (4) out of steering gear yoke (5) and remove bearing cup (4) from cross (1).
6. Reverse position of sockets and press remaining bearing cup (4) out of steering gear yoke (5).
7. Remove steering gear yoke (5) from cross (1).
8. Repeat steps 2 through 6 for steering shaft yoke (2).
9. Remove cross (1) from steering shaft yoke (2).

**b. Installation**

1. Install cross (1) into steering shaft yoke (2).
2. Install bearing cup (4) into steering shaft yoke (2).

**CAUTION**

Ensure bearing cup is aligned with steering shaft yoke before pressing in with vise. Damage to cross and bearing cups will result if forced into yoke.

3. Place steering shaft yoke (2) in vise with 11/16-in. socket between vise jaw and bearing cup (4).
4. Press bearing cup (4) into steering shaft yoke (2) far enough to install snapring (3) and install snapring (3) on bearing cup (4).
5. Install other bearing cup (4) into steering shaft yoke (2).
6. Place steering shaft yoke (2) in vise with 11/16-in. socket between bearing cup (4) and vise jaw.
7. Press bearing cup (4) into steering shaft yoke (2) far enough to install snapring (3) and install snapring (3) on bearing cup (4).
8-21. STEERING SHAFT U-JOINT REPLACEMENT (Cont’d)

8. Repeat steps 2 through 7 to install steering gear yoke (5) on cross (1).

**CAUTION**

Ensure grease fitting on cross faces steering shaft. Damage to equipment will result if improperly installed.

9. Install grease fitting (6) into cross (1).

FOLLOW-ON TASK: Install intermediate steering shaft (para. 8-19).
8-22. INTERMEDIATE STEERING SHAFT CLOSE-OFF AND RETAINER REPLACEMENT

This task covers:

a. Removal b. Installation

INITIAL SETUP:

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<tr>
<th>Tools</th>
<th>Personnel Required</th>
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<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>One mechanic</td>
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<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
<td>One assistant</td>
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<th>Manual References</th>
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<td>Four locknuts (Appendix G, Item 77)</td>
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<td>Maintenance Level</td>
</tr>
<tr>
<td></td>
<td>Unit</td>
</tr>
</tbody>
</table>

**NOTE**

Perform steps a.1 and b.2 only when replacing close-off retainer. Close-off may be replaced without disconnecting intermediate steering shaft.

---

**a. Removal**

1. Remove locknut (8), washer (9), capscrew (11), and washer (9) and disconnect intermediate steering shaft (10) from steering column (2). Discard locknut (8).

2. Remove four locknuts (12), washers (6), capscrews (5), and washers (6) from hand throttle bracket (7), close-off retainer (4), close-off (3), and cowl panel (1). Remove close-off retainer (4) and close-off (3) from steering shaft (10). Discard locknuts (12).

---

**b. Installation**

1. Install close-off (3) and close-off retainer (4) on cowl panel (1) and hand throttle bracket (7) with four washers (6), capscrews (5), washers (6), and locknuts (12). Tighten locknuts (12) to 8 lb-ft (11 N·m).

2. Install intermediate steering shaft (10) through close-off (3) on steering column (2) with washer (9), capscrew (11), washer (9), and locknut (8). Tighten locknut (8) to 40-50 lb-ft (54-68 N·m).
8-22. INTERMEDIATE STEERING SHAFT CLOSE-OFF AND RETAINER REPLACEMENT (Cont’d)
This task covers:

a. Removal

b. Installation

INITIAL SETUP:

**Tools**
- General mechanic’s tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

**Special Tools**
- Pulley installer (Appendix B, Item 121)

**Materials/Parts**
- Lockwasher (Appendix G, Item 183)
- O-ring (Appendix G, Item 220)

**Manual References**
- TM 9-2320-387-24P

**Equipment Condition**
- Serpentine drivebelt removed (para. 3-81).

**Maintenance Level**
- Unit

---

**a. Removal**

**CAUTION**
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

1. Loosen two clamps (2) and disconnect return lines (1) and high-pressure line (5) from power steering pump (3). Remove O-ring (4) from high-pressure line (5). Discard O-ring (4).
2. Remove nut (7), clamp (8), and wiring harness (6) from power steering pump (3).
3. Remove nut (15), lockwasher (14), washer (13), capscrew (9), washer (10), and idler pulley (11) from bracket (12). Discard lockwasher (14).
4. Remove two capscrews (17), capscrew (18), and power steering pump (3) from mounting bracket (16).
5. Remove capscrew (19), washer (20), and power steering pulley (21) from power steering pump (3).

---

**b. Installation**

**CAUTION**
Serpentine belt failure (abnormal wear or drive belt dislodgement) can be caused by misalignment of pulleys, improper installation, or foreign objects introduced into belt path. Inspect power steering pump pulley for proper installation and ease of rotation. Any wobble or misalignment will cause belt failure. Refer to para. 3-81 for pulley alignment procedures.

**NOTE**
Ensure flat surface of pulley is facing out and is flush with pump shaft.

1. Using pulley installer, install pulley (21) on power steering pump (3).
2. Secure pulley (21) to power steering pump (3) with washer (20) and capscrew (19). Tighten capscrew (19) to 37 lb-ft (50 N-m).
3. Install power steering pump (3) on mounting bracket (16) with capscrew (18) and two capscrews (17).
4. Install idler pulley (11) on bracket (12) with washer (10), capscrew (9), washer (13), lockwasher (14), and nut (15).
5. Install O-ring (4) on high-pressure line (5) and install high-pressure line (5) on power steering pump (3).
6. Install two return lines (1) on power steering pump (3) and tighten clamps (2).
7. Install wiring harness (6) and clamp (8) on power steering pump (3) with nut (7).
FOLLOW-ON TASKS:

- Install serpentine drivebelt (para. 3-81).
- Bleed power steering system (para. 8-27).
8-23.1. POWER STEERING PUMP AND PULLEY REPLACEMENT (SERIAL NUMBERS 196901 AND ABOVE)

This task covers:

a. Removal  

b. Installation

INITIAL SETUP:

<table>
<thead>
<tr>
<th>Tools</th>
<th>Manual References</th>
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<tr>
<td>General mechanic's tool kit: automotive (Appendix B, Item 1)</td>
<td>TM 9-2320-387-24P</td>
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<td>Maintenance and repair shop equipment: automotive (Appendix B, Item 2)</td>
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<thead>
<tr>
<th>Materials/Parts</th>
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</thead>
<tbody>
<tr>
<td>Three lockwashers (Appendix G, Item 162)</td>
<td>Serpentine drivebelt removed (para. 3-81.1 or 3-81.2).</td>
</tr>
<tr>
<td>Lockwasher (Appendix G, Item 190.1)</td>
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<tbody>
<tr>
<td>Unit</td>
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</tbody>
</table>

a. Removal

1. Remove screw (10), spacer (12), lockwasher (11), and pulley (9) from power steering pump (5). Discard lockwasher (11).

   **NOTE**
   Use a suitable container to catch power steering fluid.

2. Disconnect hose (13) from elbow (1) on power steering pump (5).
3. Loosen two hose clamps (3) and slide hose (2) off tube (4) on power steering pump (5).
4. Remove three screws (8), lockwashers (7), and power steering pump (5) from alternator/pump support (6). Discard lockwashers (7).

b. Installation

1. Position power steering pump (5) on alternator/pump support (6) and secure with three lockwashers (7) and screws (8). Tighten screws (8) to 21-25 lb-ft (28-34 N•m).
2. Slide hose (2) with two hose clamps (3) on tube (4) on power steering pump (5) and tighten hose clamps (3).
3. Connect hose (13) to elbow (1) on power steering pump (5).
4. Install pulley (9) on shaft of power steering pump (5) with spacer (12), lockwasher (11), and screw (10). Tighten screw (10) to 21-25 lb-ft (28-34 N•m).
8-23.1. POWER STEERING PUMP AND PULLEY REPLACEMENT (SERIAL NUMBERS 196901 AND ABOVE) (Cont'd)

FOLLOW-ON TASKS:
- Install serpentine belt (para. 3-81.1 or para. 3-81.2).
- Bleed power steering system (para. 8-27.1).
This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic’s tool kit:
automotive (Appendix B, Item 1)

Materials/Parts
O-ring (Appendix G, Item 220)
Power steering fluid (Appendix C, Item 37)

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

CAUTION
Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

NOTE
Use suitable container to catch power steering fluid.

a. Removal

1. Disconnect pressure hose (3) from elbow (1) on power steering pump (2). Drain power steering fluid.
2. Disconnected pressure hose (3) from adapter (4) on hydro-boost (6).
3. Remove adapter (4) and O-ring (5) from hydro-boost (6). Discard O-ring (5).

b. Installation

1. Lubricate O-ring (5) with power steering fluid and install O-ring (5) on adapter (4).
2. Install adapter (4) with O-ring (5) on hydro-boost (6).
3. Connect pressure hose (3) to adapter (4) on hydro-boost (6). Do not tighten nut on hose (3).
4. Connect pressure hose (3) to elbow (1) on power steering pump (2). Tighten nuts on hose (3).
FOLLOW-ON TASKS:

- Install serpentine belt (para. 3-81).
- Bleed power steering system (para. 8-27.1).
- Close and secure hood (TM 9-2320-387-10).
This task covers:

a. Removal
b. Installation

**INITIAL SETUP:**

**Tools**

General mechanic's tool kit:
- automotive (Appendix B, Item 1)

**Materials/Parts**

- Locknut (Appendix G, Item 77)
- Six O-rings (Appendix G, Item 220)
- Nut and lockwasher assembly (Appendix G, Item 197)

**Equipment Condition**

- Hood raised and secured (TM 9-2320-387-10).
- Battery ground cables disconnected (para. 4-68).

**General Safety Instructions**

Do not drain fluid when engine is hot.

**Maintenance Level**

Unit

---

**NOTE**

The replacement procedure is basically the same for all hydraulic system pressure and return hoses.

---

**a. Removal**

**WARNING**

Do not drain fluid when engine is hot. Severe injury to personnel will result.

**CAUTION**

Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

**NOTE**

Have drainage container ready to catch fluid.

1. Remove locknut (1), washer (2), and bolt (4) from clamp (3). Discard locknut (1).
2. Remove clamp (3) from bypass hose (5).
3. Loosen three clamps (6) on tee (7).
4. Disconnect two bypass hoses (5) and return hose (8) from tee (7).
5. Remove nut and lockwasher assembly (19), capscrew (15), washer (16), two clamps (18), harness clamp (17), return hose (9), and O-ring (17.1) from power steering lines bracket (20). Discard nut and lockwasher assembly (19).
6. Loosen clamp (12) on return hose (8) and remove return hose (8) and clamp (12) from hydro-boost (11).
7. Remove pressure hose (13) from hydro-boost (11) and steering gear (21).
8. Remove two O-rings (10) from pressure hose (13). Discard O-rings (10).
9. Remove pressure hose (9) from hydro-boost (11) and power steering pump (14).
10. Remove two O-rings (10) from pressure hose (9). Discard O-rings (10).
8-24. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSE REPLACEMENT (SERIAL NUMBERS 196900 AND BELOW) (Cont'd)

NOTE

Perform steps 11 thru 14 if vehicle is equipped with winch.

11. Disconnect pressure hose (3) from hydro-boost (5) and valve assembly (2).
12. Remove O-ring (4) from pressure hose (3). Discard O-ring (4).
13. Disconnect pressure hose (1) from valve assembly (2) and steering gear (6).

NOTE

Perform steps 1 thru 4 if vehicle is equipped with winch.

1. Install O-ring (4) on pressure hose (1).
2. Connect pressure hose (1) to valve assembly (2) and steering gear (6).
3. Install O-ring (4) on pressure hose (3).
4. Connect pressure hose (3) to hydro-boost (5) and valve assembly (2).
5. Install two O-rings (4) on pressure hose (10).
6. Install pressure hose (10) on hydro-boost (5) and power steering pump (14).
7. Install two O-rings (4) on pressure (1).
8. Install pressure hose (1) on hydro-boost (5) and steering gear (6).
9. Install return hose (22) and clamp (23) on hydro-boost (5) and tighten clamp (23).
10. Install washer (8), capscrew (7), two clamps (11), harness clamp (9), return hose (10), O-ring (9.1), and nut and lockwasher assembly (12) on power steering lines bracket (13).
11. Connect two bypass hoses (19) and return hose (22) to tee (21).
12. Tighten three clamps (20) and tee (21).
13. Install clamp (17) on bypass hose (19).
14. Install bolt (18), washer (16), and locknut (15) on clamp (17).
FOLLOW-ON TASKS:  
- Connect battery ground cables (para. 4-68).
- Bleed power steering system (para. 8-27).
- Lower and secure hood (TM 9-2320-387-10).
8-24.1. POWER STEERING HYDRAULIC SYSTEM PRESSURE HOSE REPLACEMENT
(SERIAL NUMBERS 196901 THROUGH 299999)

This task covers:
  a. Removal
  b. Installation

INITIAL SETUP:

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<thead>
<tr>
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<tr>
<td>General mechanic's tool kit:</td>
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<td>automotive (Appendix B, Item 1)</td>
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<th>Materials/Parts</th>
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</table>

**CAUTION**

Cover or plug all open lines and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

**NOTE**

Use suitable container to catch power steering fluid.

a. Removal

1. Disconnect pressure hose (3) from elbow (1) on power steering pump (2). Drain power steering fluid.
2. Disconnected pressure hose (3) from adapter (4) on hydro-boost (6).
3. Remove adapter (4) and O-ring (5) from hydro-boost (6). Discard O-ring (5).

b. Installation

1. Lubricate O-ring (5) with power steering fluid and install O-ring (5) on adapter (4).
2. Install adapter (4) with O-ring (5) on hydro-boost (6).
3. Connect pressure hose (3) to adapter (4) on hydro-boost (6). Do not tighten nut on hose (3).
4. Connect pressure hose (3) to elbow (1) on power steering pump (2). Tighten nuts on hose (3).
FOLLOW-ON TASKS:  
- Bleed power steering system (para. 8-27.1).
- Lower and secure hood (TM 9-2320-387-10).
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
   automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
   automotive (Appendix B, Item 2)

Materials/Parts
   Four O-rings (Appendix G, Item 220)
   Two lockwashers (Appendix G, Item 145)
   Nut and washer assembly
   (Appendix G, Item 194)

Manual References
   TM 9-2320-387-10
   TM 9-2320-387-24P

Equipment Condition
   Engine left splash shield removed (para. 10-23.1).

General Safety Instructions
   Do not drain fluid when engine is hot.

Maintenance Level
   Unit

a. Removal

1. Remove nut (1), lockwasher (2), washer (3), capscrew (6), washer (5), and bracket (4) from airlift bracket (7). Discard lockwasher (2).
2. Remove capscrew (14) and clamp (13) from frame (8).
3. Remove capscrew (12), lockwasher (11), washer (10), and bracket (9) from frame (8). Discard lockwasher (11).
4. Remove nut and washer assembly (15), capscrew (21), washers (16) and (20), and clamps (17), (18), and (19) from bracket (9).
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES
REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

**WARNING**

Do not drain fluid when engine is hot. Severe injury to personnel may result.

**CAUTION**

Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

**NOTE**

- Use suitable container to catch power steering fluid.
- Mark return hoses for installation.

5. Loosen nut (7) and disconnect pressure hose (6) from elbow (8) on power steering pump (5). Drain power steering fluid.
6. Loosen clamp (3) and disconnect return hose (2) from tube (4) on power steering pump (5).
7. Loosen clamp (1) and disconnect return hose (2) from return tube (17).
8. Loosen clamp (10) and remove return hose (11) from reservoir (9).
9. Loosen clamp (15) and remove return hose (14) from reservoir (9).
10. Loosen clamps (16) and (19) and remove return hose (18) from reservoir (9) and return tube (17).
11. Remove tie strap (13) from return hose (11), return hose (14), and wiring harness (12).
12. Loosen nut (20) and disconnect pressure hose (6) from hydro-boost (25).
13. Remove tie strap (27) from pressure hoses (6) and (22).
15. Loosen nut (23) and disconnect pressure hose (22) from hydro-boost (25).
17. Loosen clamp (26) and remove return hose (14) from hydro-boost (25).
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

18. Loosen clamp (2) and remove return hose (3) from outlet tube (1) of oil cooler (7).
19. Loosen clamp (5) and remove return hose (4) from inlet tube (6) of oil cooler (7).
20. Loosen nut (17) and disconnect pressure hose (8) from steering gear inlet adapter (16).
21. Remove steering gear inlet adapter (16) and O-ring (15) from steering gear (14). Discard O-ring (15).
22. Loosen nut (11) and disconnect return hose (3) from steering gear outlet adapter (12).
23. Remove steering gear outlet adapter (12) and O-ring (13) from steering gear (14). Discard O-ring (13).
24. Loosen clamp (9) and disconnect return hose (3) from 90° fitting (10).

b. Installation

1. Connect return hose (3) on 90° fitting (10) with clamp (9).
2. Install steering gear outlet adapter (12) and O-ring (13) on steering gear (14).
3. Connect return hose (3) on steering gear outlet adapter (12) and tighten nut (11).
4. Install steering gear inlet adapter (16) and O-ring (15) on steering gear (14).
5. Connect pressure hose (8) on steering gear inlet adapter (16) and tighten nut (17).
6. Install return hose (4) on inlet tube (6) of oil cooler (7) and tighten clamp (5).
7. Install return hose (3) on outlet tube (1) of oil cooler (7) and tighten clamp (2).
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

8. Install return hose (4) on hydro-boost (8) and tighten clamp (9).
9. Install O-ring (7) on hydro-boost (8).
10. Connect pressure hose (5) on hydro-boost (8) and tighten nut (6).
11. Install O-ring (11) and adapter (3) on hydro-boost (8).
12. Connect pressure hose (1) on adapter (3) and tighten nut (2).
13. Install tie strap (10) on pressure hoses (1) and (5).
14. Install tie strap (15) on return hoses (4) and (17) and harness (14).
15. Install return hose (22) on reservoir (12) and return tube (21) and tighten clamps (18) and (23).
16. Install return hose (4) on reservoir (12) and tighten clamp (13).
17. Install return hose (17) on reservoir (12) and tighten clamp (16).
18. Connect return hose (19) to return tube (21) and return tube (25) of power steering pump (26) and tighten clamps (20) and (24).
19. Connect pressure hose (1) to elbow (28) of power steering pump (26) and tighten nut (27).
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)
20. Install clamps (6), (4), and (3) on bracket (5) with cap screw (8), washers (7) and (2), and nut and washer assembly (1).

21. Install bracket (5) on frame (4) with washer (10), lock washer (11), and cap screw (12).

22. Install clamp (13) on frame (9) with cap screw (14).

13. Install bracket (18) on airlift bracket (21) with washer (19), cap screw (20), washer (17), lock washer (16), and nut (15).
8-24.2. POWER STEERING HYDRAULIC SYSTEM PRESSURE AND RETURN HOSES REPLACEMENT (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASKS: Bleed power steering system (para. 8-27).
8-25. POWER STEERING SYSTEM HYDRAULIC CONTROL VALVE MAINTENANCE

This task covers:

a. Removal
b. Back Flush Procedure
c. Inspection
d. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Equipment Condition
- Battery ground cables disconnected (para. 4-68).
- Hood raised and secured (TM 9-2320-387-10).

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

General Safety Instructions
- Do not drain fluid when engine is hot.

Maintenance Level
- Unit

NOTE
If referred here from troubleshooting instructions to perform back flush procedure, follow steps 1 through 4 and then proceed to task b.

a. Removal

WARNING
Do not drain fluid when engine is hot. Severe injury to personnel will result.

CAUTION
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all plugs prior to connection.

NOTE
- Note location of hoses for installation
- Have drainage container ready to catch fluid.

1. Loosen clamp (2) and disconnect power steering return line hose (1) from control valve elbow (4).
2. Loosen clamp (11) and disconnect fan clutch hose (12) from control valve fitting (10).
3. Loosen clamp (14) and disconnect steering gear hose (13) from control valve elbow (3).
4. Disconnect time-delay module connector (6) from control valve connector (7).
5. Loosen clamp (5) and remove control valve (8) from bracket (9).

b. Back Flush Procedure

NOTE
If vehicle is equipped with bleeder tee, perform steps 1.1 and 1.2.

1. Connect battery ground cables (para. 4-68).
1.1. Remove bleeder tee (10.1) from control valve (8).
1.2. Install control valve fitting (10) on control valve (8).
2. Install steering gear hose (13) on control valve fitting (10).
3. Remove control valve elbow (4) from control valve (8) and install pipe plug (15) (NSN 4730-00-011-2578) on control valve (8).
4. Install drain hose (16) (make from NSN 4720-01-186-2358, 36 in. (91.4 cm) long) on control valve elbow (3).
8-25. POWER STEERING SYSTEM HYDRAULIC CONTROL VALVE MAINTENANCE (Cont'd)
5. Place drainage container underneath drain hose (16) to catch fluid.

   **CAUTION**
   - To ensure there is no load on the steering gear, position front wheels straight ahead before starting engine. Failure to do this may cause damage to the control valve.
   - Maintain power steering fluid level at all times while performing back flush procedure to prevent air from entering power steering system. Failure to do this may result in damage to equipment.

6. Start engine and allow to run for about two or three seconds and stop, check, and fill power steering reservoir. Repeat the process once.

7. Remove pipe plug (2) from control valve (7).

8. Install control valve elbow (1) on control valve (7).

9. Remove steering gear hose (4) from control valve fitting (3) and install on control valve elbow (1).

10. Remove control valve fitting (3) from control valve (7) and install pipe plug (2) on control valve (7).

   **CAUTION**
   - To ensure there is no load on the steering gear, position front wheels straight ahead before starting engine. Failure to do this may cause damage to the control valve.
   - Maintain power steering fluid level at all times while performing back flush procedure to prevent air from entering power steering system. Failure to do this may result in damage to equipment.

11. Start engine and allow to run for about two to three seconds and stop, check, and fill power steering reservoir. Repeat the process once.

12. Remove drain hose (5) from control valve elbow (6).

13. Remove steering gear hose (4) from control valve elbow (1).

14. Remove pipe plug (2) from control valve (7).

   **NOTE**
   If vehicle is equipped with bleeder tee, perform step 14.1.

14.1. Install bleeder tee (7.1) on control valve (7).

15. Install control valve fitting (3) on control valve (7).

16. Disconnect battery ground cables (para. 4-68).

### c. Inspection

1. Inspect elbows (6) and (1) for damage. Replace elbows (6) or (1) if damaged.

2. Inspect valve fitting (3) for damage. Replace valve fitting (3) if damaged.

### d. Installation

   **NOTE**
   Perform step 1 if hydraulic control valve was removed.

1. Install control valve (7) on bracket (13) with clamp (10).

2. Connect steering gear hose (4) to control valve elbow (6) and tighten clamp (16) to 30-40 lb-in. (3.4-4.5 N·m).

3. Connect fan clutch hose (15) to control valve fitting (3) and tighten clamp (14) to 30-40 lb-in. (3.4-4.5 N·m).

   **NOTE**
   If vehicle is equipped with bleeder tee, perform step 3.1.

3.1 Connect fan clutch hose (15) to bleeder tee (7.1).

4. Connect power steering return line hose (8) to control valve elbow (1) and tighten clamp (9) to 30-40 lb-in. (3.4-4.5 N·m).
FOLLOW-ON TASKS:

- Connect battery ground cables [para. 4-68].
- Bleed power steering system [para. 8-27].
8-26. POWER STEERING COOLER HOSE AND MANIFOLD VALVE HOSES REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

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<thead>
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<th>Material/Parts</th>
<th>Manual References</th>
<th>Equipment Condition</th>
<th>General Safety Instructions</th>
<th>Maintenance Level</th>
</tr>
</thead>
</table>
• Brake protection guards removed (para. 7-11).  
• Rear propeller shaft removed (para. 6-4).  
• Left splash shield removed (para. 10-23). | Do not drain fluid when engine is hot. | Unit |

a. Removal

WARNING
Do not drain fluid when engine is hot. Severe injury to personnel will result.

CAUTION
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

NOTE
Have drainage container ready to catch fluid.

1. Remove tiedown strap (1) from hose (3) and elbow (4) on fan shroud (2). Discard tiedown strap (1).
2. Remove clamp (11) from hose (6), and disconnect hose (6) from tee (12).
3. Remove clamp (11) from hose (13), and disconnect hose (13) from tee (12).
4. Remove two clamps (11) from hose (14) and disconnect hose (14) from tee (12) and hydro-boost (15).
5. Disconnect hose (3) from adapter (5).
6. Disconnect hose (6) from adapter (5).
7. Remove two adapters (5) and O-rings (8) from manifold valve (18). Discard O-rings (8).
8. Remove two screws (10), washers (9), manifold valve (18), and reinforcement plate (17) from left splash shield (16).
8-26. POWER STEERING COOLER HOSE AND MANIFOLD VALVE HOSES REPLACEMENT (Cont'd)
b. Installation

1. Install manifold valve (14) on left splash shield (12) with two screws (6), washers (5), and reinforcement plate (13).
2. Install two O-rings (4) and adapters (3) on manifold valve (14).
3. Connect hose (1) to adapter (3).
4. Connect hose (2) to adapter (3).
5. Connect hose (10) to hydro-boost (11) and tee (8) with two clamps (7).
6. Install clamp (7) and hose (9) on tee (8).
7. Install clamp (7) and hose (1) on tee (8).
8. Secure hose (2) to elbow (17) on fan shroud (16) with tiedown strap (15).
FOLLOW-ON TASKS:

- Connect battery ground cables (para. 4-68).
- Install brake protection guards (para. 7-11).
- Install rear propeller shaft (para. 6-4).
- Bleed power steering system (para. 8-27).
- Install left splash shield (para. 10-23).
- Lower and secure hood (TM 9-2320-387-10).
8-27. POWER STEERING SYSTEM BLEEDING (RCSK18330)

This task covers:

Bleeding

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Personnel Required
One mechanic
One assistant

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

1. Ensure engine is shut off (TM 9-2320-387-10) and turn wheels all the way to the left.
2. Add power steering fluid (TM 9-2320-387-10) to FULL COLD level on reservoir. Leave reservoir cap off.
3. Raise front wheels off ground (para. 8-2).
4. Turn steering wheel left and right, holding wheels at steering stops for five seconds, for at least 40 times.

**NOTE**
- Power steering fluid must be free of bubbles and foam. If bubbles or foam are noted, it could be an indication of a loose connection or leaky O-ring.
- Fluid with air in it will have a milky appearance. Air must be eliminated from system before normal steering action can be obtained.
5. Check power steering fluid level (TM 9-2320-387-10). If any bubbles are seen, repeat step 4.
6. Start engine (TM 9-2320-387-10) and with engine idling, add power steering fluid (TM 9-2320-387-10) if necessary. Install reservoir cap.
7. Turn wheels to center, shut off engine, and lower front wheels to ground (para. 8-2).
8. Start engine (TM 9-2320-387-10) and run engine for two or three minutes, turning wheels left and right.

**NOTE**
If pump is noisy, recheck hoses for possible contact with vehicle body or engine. If no contact is found and noise continues, turn engine off and repressurize system by following steps 9 and/or 10.
9. Remove reservoir cap. Wait for system to cool. Reinstall reservoir cap. Start engine (TM 9-2320-387-10) and check pump for noise. If noise is still present, continue to step 10. If noise stopped, proceed to step 11.
10. Turn engine off (TM 9-2320-387-10). Remove fluid from reservoir using a suction device. Refill reservoir with clean, cool fluid. Install reservoir cap. Start engine (TM 9-2320-387-10) and check pump for noise. If noise is still present, replace power steering pump (para. 8-23).
11. Turn engine off (TM 9-2320-387-10).

FOLLOW-ON TASKS:
- Check power steering fluid level (TM 9-2320-387-10).
- Lower and secure hood (TM 9-2320-387-10).
- Operate vehicle and check for proper steering operation (TM 9-2320-387-10).
This task covers:

Bleeding

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)

Personnel Required
One mechanic
One assistant

Manual References
TM 9-2320-387-10
TM 9-2320-387-24P

Equipment Condition
Hood raised and secured (TM 9-2320-387-10).

Maintenance Level
Unit

Bleeding

1. Remove fill cap (1) on power steering reservoir (2) and fill with power steering fluid (TM 9-2320-387-10) until fluid is in center of sightglass (3) and replace fill cap (1) on power steering reservoir (2).

2. Start and shut off engine several times to remove air from power steering system.

3. Disconnect glow plug controller[para. 4-33].

   **NOTE**
   - Inspect power steering fluid in sightglass for bubbles or foam. Fluid must be free of bubbles and foam. If bubbles or foam are noted, it could be an indication of a loose connection.
   - Inspect power steering fluid in sightglass for air. Fluid with air in it will have a milky appearance. Air must be eliminated from system before normal steering action can be obtained.

4. Start and run engine (TM 9-2320-387-10) until fluid level is below sightglass (3).

5. Shut off engine (TM 9-2320-387-10).

6. Check power steering fluid level. Add power steering fluid as necessary until fluid level is at center of sightglass (3) when cold and top of sightglass (3) when hot. Do not overfill.

7. Raise front wheels off ground[para. 8-2].

8. Start engine and check power steering system for leaks. Turn steering wheel full left and then full right.

9. Repeat steps 6 through 8 until power steering system fluid is at proper fluid level and is free of air.

10. If proper fluid level cannot be obtained through this procedure, refer to [para. 8-27.1] task b.
FOLLOW-ON TASK: Lower and secure hood (TM 9-2320-387-10).
8-28. POWER STEERING RELIEF VALVE CARTRIDGE MAINTENANCE

This task covers:

a. Removal
b. Inspection
c. Installation

INITIAL SETUP:

**Tools**
General mechanic’s tool kit:
- automotive (Appendix B, Item 1)

**Materials/Parts**
- O-ring (Appendix G, Item 222)
- O-ring (Appendix G, Item 236)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Hood raised and secured (TM 9-2320-387-10).
- Battery ground cables disconnected (para. 4-68).

**Maintenance Level**
Unit support

---

**a. Removal**

**CAUTION**
Cover or plug all hoses and connections immediately after disconnection to prevent contamination. Remove all covers or plugs prior to connection.

**NOTE**
Have drainage container ready to catch fluid.

1. Disconnect high-pressure line (1) from power steering pump (7). Remove O-ring (2) from high-pressure line (1). Discard O-ring (2).

**NOTE**
Fitting assembly is spring-loaded. Remove carefully to avoid losing parts.

2. Remove fitting assembly (3) and O-ring (4) from pump (7). Discard O-ring (4).

3. Remove relief valve (5) and valve spring (6) from pump (7).
c. Installation

1. Install valve spring (6) and relief valve (5) in pump (7).
2. Install O-ring (4) and fitting (3) in pump (7). Tighten fitting (3) in pump (7) to 37 lb-ft (50 N·m).
3. Install O-ring (2) on high-pressure line (1) and install high-pressure line (1) on pump (7).

FOLLOW-ON TASKS: • Connect battery ground cables (para. 4-68).
• Bleed power steering system (para. 8-27).
This task covers:

| a. Removal | b. Installation |}

**INITIAL SETUP:**

**Tools**
- General mechanic's tool kit: automotive (Appendix B, Item 1)

**Materials/Parts**
- Two lockwashers (Appendix G, Item 190.1)
- Two lockwashers (Appendix G, Item 185)
- Lockwasher (Appendix G, Item 190.3)

**Manual References**
- TM 9-2320-387-10
- TM 9-2320-387-24P

**Equipment Condition**
- Hood raised and secured (TM 9-2320-387-10).

**Maintenance Level**
- Unit

---

**a. Removal**

**NOTE**

Have drainage container ready to catch power steering fluid.

1. Loosen clamps (18) and (21) from hoses (19) and (20) on power steering reservoir (16).
2. Disconnect hoses (19) and (20) from front and rear ports (22) and (17) on power steering reservoir (16). Drain power steering reservoir (16).
3. Loosen two clamps (24) on hose (25) and remove from lower port (23) on power steering reservoir (16) and hose (30).
4. Disconnect vent tube (14) and fill cap (15) on power steering reservoir (16).
5. Remove screw (7), lockwasher (6), clamp (8), and fuel inlet tube (5) from bracket (3). Discard lockwasher (6).
6. Remove screw (9), clamp (10), fuel return tube (11), spacer (12), and lockwasher (13) from stud (26) on intake manifold (27). Discard lockwasher (13).
7. Remove screw (4), nut (29), lockwasher (28), bracket (3), and power steering reservoir (16) from intake manifold (27). Discard lockwasher (28).
8. Remove two nuts (1), lockwashers (2), and power steering reservoir (16) from bracket (3). Discard lockwashers (2).
8-29. POWER STEERING RESERVOIR AND BRACKET REPLACEMENT (P/N 94252A) (Cont'd)
8-29. POWER STEERING RESERVOIR AND BRACKET REPLACEMENT
(P/N 94252A) (Cont’d)

b. Installation

1. Position power steering reservoir (16) on bracket (3) and secure with two lockwashers (2) and nuts (1).
2. Install bracket (3) and power steering reservoir (16) on two intake manifold studs (26) with lockwasher (28), nut (29), lockwasher (13), and spacer (12).
3. Secure bracket (3) on intake manifold (27) with screw (4).
4. Install fuel return tube (11) on spacer (12) with clamp (10) and screw (9).
5. Install fuel inlet tube (5) on bracket (3) with clamp (8), lockwasher (6), and screw (7).
6. Install fill cap (15) on power steering reservoir (16), and connect vent tube (14) to fill cap (15).
7. Connect hose (25) to lower front port (23) of power steering reservoir (16) and hose (30) and tighten two clamps (24).
8. Connect hoses (20) and (19) to front port (22) and rear port (17) on power steering reservoir (16) and tighten clamps (21) and (18).
8-29. POWER STEERING RESERVOIR AND BRACKET REPLACEMENT
(P/N 94252A) (Cont'd)

FOLLOW-ON TASK: Bleed power steering system (para. 8-27.1).
8-30. POWER STEERING RESERVOIR FILTER REPLACEMENT (P/N 94252A)

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit: automotive (Appendix B, Item 1)

Materials/Parts
Filter (Appendix G, Item 32.1)

Manual References
TM 9-2320-387-24-1  
TM 9-2320-387-24P

NOTE

Use suitable container to catch power steering fluid.

1. Loosen band clamp (1) and remove lid (2), band clamp (1), and spring (5) from power steering reservoir (4).
2. Remove filter (3) from power steering reservoir (4). Discard filter (3).

b. Installation

1. Install filter (3) inside power steering reservoir (4).
2. Position spring (5), band clamp (1), and lid (2) on power steering reservoir (4) and secure lid (2) with band clamp (1) on power steering reservoir (4).
FOLLOW-ON TASK: Bleed power steering system (para. 8-27.1).
## CHAPTER 9
### FRAME (UNIT) MAINTENANCE

### 9-1. FRAME MAINTENANCE TASK SUMMARY

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9-2. FRONT BUMPER AND TOWING BRACKETS REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:
automotive (Appendix B, Item 1)

Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts

Two spring washers (Appendix G, Item 318.1)
Ten locknuts (Appendix G, Item 85)
Two cotter pins (Appendix G, Item 22)

Manual References

TM 9-2320-387-24P

Equipment Condition

Winch removed (all except M1114) (para. 12-27).

Maintenance Level

Unit

a. Removal

1. Remove two cotter pins (12), nuts (11), spring washers (10), capscrews (8), and shackles (9) from towing brackets (7). Discard cotter pins (12) and spring washers (10).

2. Remove four locknuts (5), washers (6), capscrews (13), washers (6), and two towing brackets (7) from bumper (1). Discard locknuts (5).

3. Remove six locknuts (3), washers (4), capscrews (14), washers (4), and front bumper (1) from two mounting brackets (2). Discard locknuts (3).

b. Installation

1. Install front bumper (1) on two mounting brackets (2) with six washers (4), capscrews (14), washers (4), and locknuts (3). Tighten locknuts (3) to 90 lb-ft (122 N·m).

2. Install two towing brackets (7) on bumper (1) with four washers (6), capscrews (13), washers (6), and locknuts (5). Tighten locknuts (5) to 90 lb-ft (122 N·m).

3. Install two shackles (9) on towing brackets (7) with two capscrews (8), spring washers (10), nuts (11), and cotter pins (12).

FOLLOW-ON TASK: Install winch (all except M1114) (para. 12-27).
9-3. FRAME EXTENSION REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

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**a. Removal**

Remove three locknuts (2), washers (3), capscrews (5), washers (3), mounting bracket (1), and frame extension (6) from frame (4). Discard locknuts (2).

**b. Installation**

Install mounting bracket (1) and frame extension (6) on frame (4) with three washers (3), capscrews (5), washers (3), and locknuts (2). Tighten locknuts (2) to 90 lb-ft (122 N·m).

![Diagram of frame extension replacement](image)

**FOLLOW-ON TASKS:**

- Install tiedown ring [para. 9-4].
- Install headlight housing (para. 10-18).
- Install hood and hinge (para. 10-7).
- Install front bumper [para. 9-2].
9-4. TIEDOWN RING REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

Materials/Parts
- Cotter pin (Appendix G, Item 24)

Manual References
- TM 9-2320-387-24P

Maintenance Level
- Unit

a. Removal

Remove cotter pin (2), nut (3), and tiedown ring (1) from mounting bracket (4). Discard cotter pin (2).

b. Installation

Install tiedown ring (1) on mounting bracket (4) with nut (3). Tighten nut (3) to 16 lb-ft (22 N·m), back off to nearest cotter pin (2) slot, and install cotter pin (2).
# 9-5. RADIATOR FRONT MOUNT BRACKET REPLACEMENT
(SERIAL NUMBERS 299999 AND BELOW)

This task covers:

<table>
<thead>
<tr>
<th>a. Removal</th>
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## INITIAL SETUP:

### Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

### Materials/Parts
- Two locknuts (Appendix G, Item 85)
- Locknut (Appendix G, Item 92)

### Manual References
- TM 9-2320-387-24P

### Equipment Condition
- Headlight housing removed (para. 10-18).

### Maintenance Level
- Unit

## a. Removal

1. Remove locknut (2), two washers (3), capscrew (11), washer (3), spacer (10), mount (4), and radiator (1) from front mount bracket (9). Discard locknut (2).

2. Remove two locknuts (12), washers (7), capscrews (6), washers (7), spacers (5), and bracket (9) from front suspension crossmember (8). Discard locknuts (12).

## b. Installation

1. Install bracket (9) on front suspension crossmember (8) with two spacers (5), washers (7), capscrews (6), washers (7), and locknuts (12). Tighten locknuts (12) to 90 lb-ft (122 N•m).

2. Install mount (4) and radiator (1) on front mount bracket (9) with washer (3), spacer (10), capscrew (11), two washers (3), and locknut (2). Tighten locknut (2) to 30 lb-ft (41 N•m).

## FOLLOW-ON TASK:
- Install headlight housing (para. 10-18).
9-5.1. RADIATOR FRONT MOUNT BRACKET REPLACEMENT
(SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

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a. Removal

1. Remove locknut (15), capscrew (7), washer (8), washer (9), insulator (10), washer (14), and insulator (13) from radiator (1) and front mount bracket (6). Discard locknut (15).
2. Remove two locknuts (11), washers (12), capscrews (2), washers (3), front mount bracket (6), and bracket (4) from front suspension crossmember (5). Discard locknuts (11).

b. Installation

1. Install bracket (4) and front mount bracket (6) on front suspension crossmember (5) with two washers (3), capscrews (2), washers (12), and locknuts (11). Tighten locknut (11) to 90 lb-ft (122 N•m).
2. Secure front mount bracket (6) to radiator (1) with insulator (10), washer (9), washer (8), capscrew (7), insulator (13), washer (14), and locknut (15). Tighten locknut (15) to 30 lb-ft (41 N•m).

FOLLOW-ON TASK: Install horn [para. 4-26.1].
9-6. REAR BUMPER BRACE REPLACEMENT

This task covers:

a. Removal

b. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Three locknuts (Appendix G, Item 114.4)

NOTE
Replacement procedures for inner and outer bumper braces are basically the same. This procedure covers the outer bumper brace.

a. Removal

1. Remove locknut (5), washer (2), capscrew (1), and washer (2) from rear bumper brace (3) and frame rail (4). Discard locknut (5).

2. Remove two locknuts (9), washers (7), capscrews (6), washers (7), and rear bumper brace (3) from rear bumper (8). Discard locknuts (9).

b. Installation

1. Install rear bumper brace (3) on rear bumper (8) with two washers (7), capscrews (6), washers (7), and locknuts (9).

2. Install rear bumper brace (3) on frame rail (4) with washer (2), capscrew (1), washer (2), and locknut (5). Tighten locknuts (5) and (9) to 90 lb-ft (122 N•m).
9-7. REAR BUMPER REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

Tools

General mechanic's tool kit:  
automotive (Appendix B, Item 1)  
Maintenance and repair shop equipment:  
automotive (Appendix B, Item 2)

Materials/Parts

Sixteen locknuts (Appendix G, Item 85)  
Six assembled locknuts (Appendix G, Item 134)  
Two cotter pins (Appendix G, Item 22)  
Two cotter pins (Appendix G, Item 24)  
Two spring washers (Appendix G, Item 318.1)

Personnel Required

One mechanic  
One assistant

Manual References

TM 9-2320-387-24P

Equipment Condition

- Spare tire carrier removed (para. 10-96).
- Towing pintle removed (para. 9-9 or para. 9-9.1).

Maintenance Level

Unit

a. Removal

1. Remove four assembled locknuts (7), capscrews (13), and trailer receptacle cover (14) from trailer receptacle (8). Discard assembled locknuts (7).
2. Remove two assembled locknuts (9), capscrews (12), plate (11), and trailer receptacle (8) from rear bumper (10). Discard assembled locknuts (9).
3. Remove four locknuts (23), washers (20), capscrews (19), and washers (20) from rear bumper (10) and two braces (22). Discard locknuts (23).
4. Remove two cotter pins (1), nuts (2), and tiedown rings (16) from rear bumper (10) and two mounting brackets (3). Discard cotter pins (1).
5. Remove two cotter pins (28), nuts (27), spring washers (24), capscrews (26), and shackles (25) from rear bumper (10). Discard cotter pins (28) and spring washers (24).
6. Remove eight locknuts (21), washers (18), capscrews (17), and washers (18) from rear bumper (10) and two mounting brackets (3). Discard locknuts (21).
7. Remove four locknuts (4), washers (5), capscrews (15), washers (5), and rear bumper (10) from two inner mounting brackets (6). Discard locknuts (4).

b. Installation

1. Install rear bumper (10) on two inner mounting brackets (6) with four washers (5), capscrews (15), washers (5), and locknuts (4). Tighten locknuts (4) to 90 lb-ft (122 N•m).
2. Install rear bumper (10) on two mounting brackets (3) with eight washers (18), capscrews (17), washers (18), and locknuts (21). Tighten locknuts (21) to 90 lb-ft (122 N•m).
3. Install two shackles (25) on rear bumper (10) with two capscrews (26), spring washers (24), and slotted nuts (27). Tighten slotted nuts (27) to 15-20 lb-ft (20-27 N•m).
4. Back off two slotted nuts (27) to align with hole in capscrews (26) and install two cotter pins (28) in slotted nuts (27).
5. Install two tiedown rings (16) on rear bumper (10) and two mounting brackets (3) with nuts (2). Tighten nuts (2) to 16 lb-ft (22 N·m), back off to the nearest cotter pin (1) slot, and install two cotter pins (1).

6. Install rear bumper (10) on two braces (22) with four washers (20), capscrews (19), washers (20), and locknuts (23). Tighten locknuts (23) to 90 lb-ft (122 N·m).

7. Install plate (11) and trailer receptacle (8) on rear bumper (10) with two capscrews (12) and assembled locknuts (9). Tighten assembled locknuts (9) to 8 lb-ft (11 N·m).

8. Install trailer receptacle cover (14) on trailer receptacle (8) and rear bumper (10) with four capscrews (13) and assembled locknuts (7). Tighten assembled locknuts (7) to 8 lb-ft (11 N·m).

FOLLOW-ON TASKS: • Install towing pintle (para 9-9 or para. 9-9.1).
• Install spare tire carrier (para. 10-96).
9-8. REAR BUMPER INNER MOUNTING BRACKET REPLACEMENT

This task covers:
   a. Removal
   b. Installation

INITIAL SETUP:

Tools
   General mechanic's tool kit:
      automotive (Appendix B, Item 1)
   Maintenance and repair shop equipment:
      automotive (Appendix B, Item 2)

Materials/Parts
   Six locknuts (Appendix G, Item 85)

Manual References
   TM 9-2320-387-24P

Maintenance Level
   Unit

a. Removal

1. Remove two locknuts (3), washers (4), capscrews (9), and washers (4) from bracket (7) and rear bumper (1). Discard locknuts (3).

   **NOTE**
   Spacer is present on M1114 vehicle only.

2. Remove four locknuts (10), washers (6), capscrews (5), washers (6), bracket (7), and spacer (8) from frame rail (2). Discard locknuts (10).

b. Installation

   **NOTE**
   • Spacer is present on M1114 vehicle only.
   • Ensure spacer on outer side of frame rail is in position before installing spacer and bracket.

1. Install spacer (8) and bracket (7) on frame rail (2) with four washers (6), capscrews (5), washers (6), and locknuts (10). Tighten capscrews (5) to 90 lb-ft (122 N·m).

2. Install bracket (7) on rear bumper (1) with two washers (4), capscrews (9), washers (4), and locknuts (3). Tighten locknuts (3) to 90 lb-ft (122 N·m).
9-9. TOWING PINTLE MAINTENANCE (SERIAL NUMBERS 299999 AND BELOW)

This task covers:

a. Removal  
b. Disassembly  
c. Cleaning  
d. Assembly  
e. Installation

INITIAL SETUP:

Tools
- General mechanic's tool kit: automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment: automotive (Appendix B, Item 2)

Materials/Parts
- Two cotter pins (Appendix G, Item 25)
- Drivescrew (Appendix G, Item 30)
- Two locknuts (Appendix G, Item 86)
- Four locknuts (Appendix G, Item 133.1)
- Drycleaning solvent (Appendix C, Item 26)

Manual References
- TM 9-2320-387-10
- TM 9-2320-387-24P

General Safety Instructions
- Drycleaning solvent is flammable and will not be used near an open flame.

Maintenance Level
- Unit

NOTE

- Contact DS maintenance for fabrication instructions of optional towing pintle.

a. Removal

NOTE

- Perform steps 1 and 2 for rear-mounted towing pintle.
- Perform steps 3 and 4 for optional towing pintle mounted to the front bumper.

1. Remove cotter pin (3), slotted nut (2), washer (4), and towing pintle (9) from rear bumper (7). Discard cotter pin (3).
2. Remove four nuts (1), washers (11), capscrews (10), washers (11), two support plates (6), backing plate (5), and safety chain plate (8) from rear bumper (7).
3. Remove cotter pin (4), slotted nut (6), washer (5), and towing pintle (3) from front bumper (1). Discard cotter pin (4).
4. Remove four locknuts (9), washers (8), capscrews (10), washers (8), front plate (2), and back plate (7) from front bumper (1). Discard locknuts (9).

**NOTE**

Perform step 1 for rear-mounted towing pintle.

1. Remove grease fitting (12) from backing plate (11).
2. Remove cotter pin (15) from towing pintle latch (20).
3. Remove locknut (21), capscrew (19), pintle latch lock (17), and spring (16) from towing pintle latch (20). Discard locknut (21).
4. Remove locknut (24), capscrew (18), and towing pintle latch (20) from towing pintle hook (22). Discard locknut (24).
5. Remove cotter pin (15) from pintle lock chain hook (14). Discard cotter pin (15).
6. Remove drivescrew (23) and pintle lock chain (13) from towing pintle hook (22). Discard drivescrew (23).

**WARNING**

Drycleaning solvent is flammable and will not be used near an open flame. A fire extinguisher will be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to do this may result in injury to personnel and/or damage to equipment.

Clean all metallic parts with drycleaning solvent.
9-9. TOWING PINTLE MAINTENANCE (SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

**d. Assembly**

1. Install pintle lock chain (13) on towing pintle hook (22) with drivescrew (23).
2. Install cotter pin (15) on pintle lock chain (13) with pintle lock chain hook (14).
3. Install towing pintle latch (20) on towing pintle hook (22) with capscrew (18) and locknut (24). Tighten locknut (24) to 15 lb-ft (20 N·m).
4. Install spring (16) and pintle latch lock (17) on towing pintle latch (20) with capscrew (19) and locknut (21). Tighten locknut (21) to 15 lb-ft (20 N·m).
5. Install cotter pin (15) in pintle latch (20).

**NOTE**

Perform step 6 for rear-mounted towing pintle.

6. Install grease fitting (12) in backing plate (11).
9-9. TOWING PINTLE MAINTENANCE (SERIAL NUMBERS 299999 AND BELOW) (Cont’d)

e. Installation

**NOTE**
- Perform steps 1 through 3 for rear-mounted towing pintle.
- Perform steps 4 through 6 for optional towing pintle mounted to the front bumper.
- Grease fitting on backing plate must face downward.

1. Install safety chain plate (8), two support plates (6), and backing plate (11) on rear bumper (7) with four washers (2), capscrews (10), washers (2), and nuts (1).
2. Install towing pintle (9) on rear bumper (7) and tighten nuts (1) to 90 lb-ft (122 N·m).
3. Secure towing pintle (9) to backing plate (11) with washer (5) and slotted nut (3). Loosen slotted nut (3) slightly if towing pintle (9) will not rotate easily. Install cotter pin (4) in slotted nut (3).
4. Install front plate (13) and back plate (18) on front bumper (12) with four washers (19), capscrews (21), washers (19), and locknuts (20). Tighten locknuts (20) to 90 lb-ft (122 N·m). 
5. Install towing pintle (14) on front plate (13) and back plate (18) with washer (16) and slotted nut (17).
6. Tighten slotted nut (17) until towing pintle (14) is tight. Back off nut (17) until towing pintle (14) rotates freely and hole in towing pintle (14) shaft aligns with slot in nut (17). Install cotter pin (15).
FOLLOW-ON TASK: Lubricate rear-mounted towing pintle (TM 9-2320-387-10).
9-9.1. TOWING PINTLE MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE)

This task covers:

a. Removal
b. Disassembly
c. Cleaning
d. Assembly
e. Installation

INITIAL SETUP:

Tools
General mechanic's tool kit:
automotive (Appendix B, Item 1)
Maintenance and repair shop equipment:
automotive (Appendix B, Item 2)

Materials/Parts
Two locknuts (Appendix G, Item 86)
Two cotter pins (Appendix G, Item 25)
Drivescrew (Appendix G, Item 30)
Eight locknuts (Appendix G, Item 114.4)
Drycleaning solvent (Appendix C, Item 26)

a. Removal

1. Remove cotter pin (18), slotted nut (17), washer (16), and towing pintle (7) from rear bumper (3).
   Discard cotter pin (18).
2. Remove four locknuts (15), washers (14), cap screws (8), washers (9), two support plates (12) and (6),
   backing plate (13), and safety chain plate (5) from rear bumper (3). Discard locknuts (15).
3. Remove four locknuts (1), washers (2), cap screws (10), washers (11), and reinforcement plate (4)
   from rear bumper (3). Discard locknuts (1).

b. Disassembly

1. Remove grease fitting (19) from backing plate (13).
2. Remove cotter pin (21) from towing pintle latch (26).
3. Remove locknut (27), cap screw (25), pintle latch lock (23), and spring (22) from towing pintle latch
   (26). Discard locknut (27).
4. Remove locknut (31), cap screw (24), and pintle latch (26) from towing pintle hook (28).
   Discard locknut (31).
5. Remove cotter pin (21) from pintle lock chain hook (20). Discard cotter pin (21).
6. Remove drivescrew (30) and pintle lock chain (29) from towing pintle hook (28).
   Discard drivescrew (30).

c. Cleaning

WARNING
Drycleaning solvent is flammable and must not be used near an open flame. A fire extinguisher must be kept nearby when the solvent is used. Use only in well-ventilated places. Failure to comply may result in injury to personnel or damage to equipment.

Clean all metallic parts with drycleaning solvent.
9-9.1. TOWING PINTLE MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

REAR OF VEHICLE
9-9.1. TOWING PINTLE MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

d. Assembly

1. Install pintle lock chain (12) on towing pintle hook (11) with drivescrew (13).
2. Install cotter pin (4) on pintle lock chain hook (3).
3. Install towing pintle latch (9) on towing pintle hook (11) with capscrew (8) and locknut (14).
   Tighten locknut (14) to 15 lb-ft (20 N•m).
4. Install pintle latch lock (6) on towing pintle latch (9) with spring (5), capscrew (7), and locknut (10).
   Tighten locknut (10) to 15 lb-ft (20 N•m).
5. Install pintle lock chain hook (3) on towing pintle latch (9) with cotter pin (4).
6. Install grease fitting (2) on backing plate (1).

e. Installation

1. Install reinforcement plate (18) on rear bumper (17) with four washers (25), capscrews (24),
   washers (16), and locknuts (15).
2. Install safety chain plate (19), support plate (20), support plate (26), and backing plate (1) on rear
   bumper (17) with four washers (25), capscrews (24), washers (27), and locknuts (28). Tighten
   locknuts (28) to 90 lb-ft (122 N•m).
3. Install towing pintle (21) on rear bumper (17) with washer (29), and slotted nut (30).
4. Loosen slotted nut (30) if towing pintle (21) will not rotate easily. Install cotter pin (31) in
   slotted nut (30).
9-9.1. TOWING PINTLE MAINTENANCE (SERIAL NUMBERS 300000 AND ABOVE) (Cont’d)

FOLLOW-ON TASK: Lubricate rear-mounted towing pintle (TM 9-2320-387-10).
9-10. TRANSMISSION MOUNT CROSSMEMBER REPLACEMENT

This task covers:

a. Removal  
b. Installation

INITIAL SETUP:

**Tools**
- General mechanic's tool kit:
  - automotive (Appendix B, Item 1)
- Maintenance and repair shop equipment:
  - automotive (Appendix B, Item 2)

**Materials/Parts**
- Two locknuts (Appendix G, Item 102)
- Two locknuts (Appendix G, Item 106)

**Manual References**
- TM 9-2320-387-24P

**Maintenance Level**
- Unit

---

**CAUTION**

Transmission must be supported during removal and installation of transmission mount crossmember to prevent damage to equipment.

---

**a. Removal**

1. Place support under transmission (2) and remove two locknuts (6), washers (5), capscrew (4), and washer (5) from crossmember (7) and two support brackets (1). Discard locknuts (6).
2. Remove two locknuts (9), washers (8), and crossmember (7) from transmission mount (3). Discard locknuts (9).

**b. Installation**

1. Install crossmember (7) on transmission mount (3) with two washers (8) and locknuts (9). Tighten locknuts (9) to 28 lb-ft (38 N•m).
2. Install crossmember (7) on two support brackets (1) with washer (5), capscrew (4), two washers (5), and locknuts (6). Tighten locknuts (6) to 90 lb-ft (122 N•m).
3. Remove support from under transmission (2).
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TANK VENT and FILTER allow air to enter and leave fuel tank while keeping contaminants out.

FUEL TANK STRAINER prevents the larger particles of dirt and rust from being pulled into the fuel lines.

FUEL PUMP pulls fuel from the tank and pumps it under low pressure to the injection pump.

FUEL FILTER/WATER SEPARATOR filters fine particles and water from the fuel.

FUEL SOLENOID opens to admit fuel to the injection pump for engine run and closes to stop fuel flow when shutting down engine.

INJECTION PUMP delivers high pressure fuel to each injector in its proper turn.

FUEL INJECTORS spray high pressure fuel into the cylinders at the proper time for combustion.

DRUMS FUEL FROM FUEL TANK THROUGH THE SUPPLY LINE AND PUMPS IT TO THE FUEL FILTER
DIRECTS UNSOURED FUEL FROM THE INJECTION PUMP BACK TO THE FUEL TANK
DIRECTS FUEL FROM FUEL TANK TO THE SYSTEM
STO PES 25 GALLONS OF DIESEL FUEL
LOCATED AT RIGHT REAR SIDE OF VEHICLE, THE CAP IS REMOVED TO PERMIT FUEL TANK SERVICING
RECEIVES MEASURED FUEL FROM THE INJECTION PUMP AND SPRAYS FUEL INTO THE COMBUSTION CHAMBER
FILTERS WATER AND SEDIMENT FROM FUEL BEFORE FUEL ENTERS THE INJECTION PUMP
DIRECTS METRED AND PRESSURIZED FUEL TO THE EIGHT INJECTOR NEEDLES, IT IS MOUNTED ON TOP OF THE ENGINE UNDER THE INTAKE MANIFOLD
NOT APPLICABLE TO THIS SYSTEM
FO-4.1 Cooling Functional Flow and Location of Parts Diagrams (Serial Numbers 300000 and Above)
HEAVIER LINES INDICATE OIL FLOW AND LIGHTER LINES ARE WIRES
The shunt is used to measure current in the battery circuit. The voltage across the shunt is proportional to the current flowing through it. 100 millivolts corresponds to a current of 1,000 amperes.

Power stud is a connection through the battery box for the battery cables.

Batteries provide power to start engine and run accessories.

Starters solenoid switches on the starter to crank the engine.

All circuits must return through vehicle ground.
The batteries provide power for the starter motor to turn the engine so it can start. The battery circuit tests, p. 13-1, check out the batteries and their connections to the starter (wires 6A and 7A).

The PROTECTIVE CONTROL BOX makes the vehicle "smart." With the transmission in neutral or park and the rotary switch turned to start, the PCS turns the dash lamps on and checks to see if the engine is running. The starter control and lockout circuit will not allow the solenoid to energize if the engine is running.

NEUTRAL SAFETY SWITCH: Prevents the engine from starting if the transmission is not in neutral or park.
NOTES ABOUT THERMAL CIRCUIT BREAKERS

Thermal circuit breakers act like switches that open when their temperature goes above a set temperature. They are closed below that temperature.

Each of these thermal circuit breakers also has a small heater, shown as a resistor. The temperature the breaker feels is the heat of the engine coolant plus the heat of the heater.

Glow plug afterglow timer
thermal circuit breaker: 160°F (71°C) turns glow plugs on and off after a cold start. Engine temp, and the alternator a.c. tap signal control the cycling.

Glow plug cycle timer
circuit breaker: 120°F (49°C) turns the glow plugs on for no more than 9 seconds, then cycles the glow plugs (on for 1 sec., off for 15) until the engine is started.

Glow plug thermal protection breaker
circuit breaker: 300°F (149°C) protects glow plugs from overheating in the case of failure of the afterglow and cycle timers.

Instrument power

Glow plug relay
in Protective Control Box: applies battery power to glow plugs when all three thermal breakers are closed. You can hear the relay clicking as the glow plugs cycle.

Wait-to-start lamp control relay
in Protective Control Box: when the glow plug cycle timer trips, this relay forces the wait-to-start lamp to stay off until the vehicle is turned off.

Wait-to-start lamp (next to the rotary switch on dash): comes on when the rotary switch is turned to 'run'. The colder the engine, the longer the lamp will stay on, but never more than 9 seconds. The lamp will not come on if all the engine temperature is above 120°F (49°C). The lamp should not come on again unless the switch is turned to the 'stop' position and then back to 'run'.
FO-12 Brakes Functional Flow and Location of Parts Diagrams (Serial Numbers 299999 and Below)
FO-12.1 Brakes Functional Flow and Location of Parts Diagrams (Serial Numbers 300000 and Above)

- Brake Light Circuit
- Parking Brake Lever
- Parking Brake Cable
- Parking Brake Caliper
- Brake Warning Lamp
- Hydro-Booster
- Master Cylinder
- Service Brake Pedal
- Service Brake Caliper
- Service Brake Calipers
- Engine
- Power Steering Pump
- Brake Line
- Master Cylinder Reservoir
- Brake Pressure Limiter Valve
- Parking Brake Caliper
- Service Brake Rotor

TM 9-2320-387-24-1
FO-13 Steering Functional Flow

and Location of Parts Diagrams
(Serial Numbers 299999 and Below)

Change 6     FP-24.1/FP-24.2 Blank
FO-13.1 Steering functional flow and Location of Parts Diagrams (Serial Numbers 300000 and Above.)

Change 6 FP-25/(FP-26 Blank)
NOT APPLICABLE TO THIS SYSTEM
FO-14.1 Drivetrain Functional Flow and Location of Parts Diagram
(Serial Numbers 300000 and Above)

Change 6  FP-27/(FP-28 Blank)

NOT APPLICABLE TO THIS SYSTEM
DCA TO TK CROSS REFERENCE

This table assumes that the VTM is powered by the WS cable. For additional information on any of these tests, see para. 2-41 or TM 9-4910-571-12&P. Tests 72, 73, 74, and 75 are known as a first peak series, and data for all four of these tests are taken simultaneously.

<table>
<thead>
<tr>
<th>DCA TEST</th>
<th>PARAMETER</th>
<th>USE TK ITEM</th>
<th>TEST NO.</th>
<th>MEASUREMENT POINTS</th>
</tr>
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<tbody>
<tr>
<td>10</td>
<td>RPM</td>
<td>34-PULSE TACH. WITH A W4 CABLE</td>
<td>10</td>
<td>PUT IN PLACE OF VEHICLE TACH.</td>
</tr>
<tr>
<td>12</td>
<td>POWER (RPM/SEC)</td>
<td>34-PULSE TACH. WITH A W4 CABLE</td>
<td>12</td>
<td>PUT IN PLACE OF VEHICLE TACH.</td>
</tr>
<tr>
<td>13</td>
<td>POWER (PERCENT)</td>
<td>34-PULSE TACH. WITH A W4 CABLE</td>
<td>13</td>
<td>PUT IN PLACE OF VEHICLE TACH.</td>
</tr>
<tr>
<td>14</td>
<td>COMPRESSION UNBALANCE</td>
<td>NONE</td>
<td>14</td>
<td>VTM TAKES DATA THROUGH WS (POWER) CABLE.</td>
</tr>
<tr>
<td>24</td>
<td>FUEL PRESSURE</td>
<td>22-RED PRESSURE TRANSDUCER</td>
<td>49</td>
<td>INSTALL IN PLACE OF VEHICLE FUEL PRESSURE TRANSDUCER</td>
</tr>
<tr>
<td>67</td>
<td>BATTERY VOLTAGE</td>
<td>NONE</td>
<td>67</td>
<td>VTM TAKES DATA THROUGH WS (POWER) CABLE.</td>
</tr>
<tr>
<td>68</td>
<td>STARTER MOTOR VOLTS</td>
<td>W2 CABLE</td>
<td>89</td>
<td>ATTACH RED CLIP TO STARTER POSITIVE TERMINAL (WIRE 6A), BLACK TO BATTERY SIDE OF SHUNT.</td>
</tr>
<tr>
<td>69</td>
<td>STARTER NEG. CABLE DROP</td>
<td>W2 CABLE</td>
<td>89</td>
<td>ATTACH RED CLIP TO STARTER GROUND TERMINAL (WIRE 7A), BLACK TO BATTERY SIDE OF SHUNT.</td>
</tr>
<tr>
<td>70</td>
<td>STARTER SOL. VOLTS</td>
<td>W2 CABLE</td>
<td>89</td>
<td>ATTACH RED CLIP TO STARTER SOLENOID TERMINAL (WIRE 7A), BLACK TO STARTER GROUND TERMINAL.</td>
</tr>
<tr>
<td>71</td>
<td>STARTER CURRENT</td>
<td>11- CURRENT PROBE</td>
<td>90</td>
<td>PUT PROBE AROUND NEGATIVE BATTERY CABLE BETWEEN THE SHUNT AND THE BATTERY PACK.</td>
</tr>
<tr>
<td>72</td>
<td>CURRENT FIRST PEAK</td>
<td>11- CURRENT PROBE</td>
<td>72</td>
<td>PUT PROBE AROUND NEGATIVE BATTERY CABLE BETWEEN THE SHUNT AND THE BATTERY PACK.</td>
</tr>
<tr>
<td>73</td>
<td>BATTERY RESISTANCE</td>
<td>11- CURRENT PROBE</td>
<td>73</td>
<td>PUT PROBE AROUND NEGATIVE BATTERY CABLE BETWEEN THE SHUNT AND THE BATTERY PACK.</td>
</tr>
<tr>
<td>74</td>
<td>STARTER CIRCUIT RESISTANCE</td>
<td>11- CURRENT PROBE</td>
<td>74</td>
<td>PUT PROBE AROUND NEGATIVE BATTERY CABLE BETWEEN THE SHUNT AND THE BATTERY PACK.</td>
</tr>
<tr>
<td>75</td>
<td>BATTERY RESISTANCE CHANGE</td>
<td>11- CURRENT PROBE</td>
<td>75</td>
<td>PUT PROBE AROUND NEGATIVE BATTERY CABLE BETWEEN THE SHUNT AND THE BATTERY PACK.</td>
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<tr>
<td>80</td>
<td>BATTERY CURRENT</td>
<td>11- CURRENT PROBE</td>
<td>90</td>
<td>PUT PROBE AROUND NEGATIVE BATTERY CABLE BETWEEN THE SHUNT AND THE BATTERY PACK.</td>
</tr>
</tbody>
</table>

FO-15 DCA Functional Flow
and Location of Parts Diagrams
FP-29(FP-30 Blank)
FO-16 Electronic Speedometer Wiring Chart

Change 6  FP-31/(FP-32 Blank)
By Order of the Secretary of the Army:

DENNIS J. REIMER
General, United States Army
Chief of Staff

Official:

JOEL B. HUDSON
Administrative Assistant to the Secretary of the Army
04972

By Order of the Secretary of the Air Force:

RONALD R. FOGLEMAN
General, United States Air Force
Chief of Staff

Official:

HENRY VICCELLO, JR.
General, United States Air Force
Commander, Air Force Material Command

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SAMPLE
## PART II - REPAIR PARTS AND SPECIAL TOOLS LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

<table>
<thead>
<tr>
<th>PAGE NO.</th>
<th>COLUMN NO.</th>
<th>LINE NO.</th>
<th>NATIONAL STOCK NUMBER</th>
<th>REFERENCE NO.</th>
<th>FIGURE NO.</th>
<th>ITEM NO.</th>
<th>TOTAL NO. OF MAJOR ITEMS SUPPORTED</th>
<th>RECOMMENDED ACTION</th>
</tr>
</thead>
</table>

## PART III - REMARKS
(Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.)

---

**SAMPLE**
**RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS**
For use of this form, see AR 25-30; the proponent agency is ODISC4.

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>PAGE NO.</th>
<th>PARAGRAPH</th>
<th>LINE NO.*</th>
<th>FIGURE NO.</th>
<th>TABLE NO.</th>
<th>RECOMMENDED CHANGES AND REASON (Provide exact wording of recommended changes, if possible).</th>
</tr>
</thead>
</table>

**TO:** (Forward to proponent of publication or form) (include ZIP code)
AMSTA-LC-CI Tech Pubs, TACOM-RI
1 Rock Island Arsenal
Rock Island, IL 61299-7630

**FROM:** (Activity and location) (include ZIP code)

**DATE:**

**PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS**

**PUBLICATION/FORM NUMBER**
TM 9-2320-387-24-1

**DATE**
31 DEC 97

**TITLE**
TECHNICAL MANUAL, VOLUME 1 OF 2, UNIT, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE

**DA FORM 2028, FEB 74**
REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

USAPPC V3.00
TO: (Forward direct to addressee listed in publication)  
AMSTA-LC-CI Tech Pubs, TACOM-RI  
1 Rock Island Arsenal  
Rock Island, IL 61299-7630

FROM: (Activity and location)  
(include ZIP code)

DATE:

| PART II - REPAIR PARTS AND SPECIAL TOOLS LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS |
|---------------------------------|-----------------|-----------------|
| PUBLICATION/FORM NUMBER | DATE | TITLE |

<table>
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<th>PAGE</th>
<th>COLUMN</th>
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<th>REFERENCE NO.</th>
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</table>

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<tr>
<th>TYPED NAME, GRADE, OR TITLE</th>
<th>TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION</th>
<th>SIGNATURE</th>
</tr>
</thead>
</table>

USAPPC V3.00
**THE METRIC SYSTEM AND EQUIVALENTS**

**LINEAR MEASURE**
- 1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
- 1 Meter = 100 Centimeters = 1,000 Millimeters = 39.37 Inches
- 1 Kilometer = 1,000 Meters = 0.621 Miles

**SQUARE MEASURE**
- 1 Sq Centimeter = 100 Sq Millimeters = 0.155 Sq Inches
- 1 Sq Meter = 10,000 Sq Centimeters = 10.76 Sq Feet
- 1 Sq Kilometer = 1,000,000 Sq Meters = 0.386 Sq Miles

**CUBIC MEASURE**
- 1 Cu Centimeter = 1,000 Cu Millimeters = 0.06 Cu Inches
- 1 Cu Meter = 1,000,000 Cu Centimeters = 33.82 Cu Feet

**APPARTOXIMATE CONVERSION FACTORS**

<table>
<thead>
<tr>
<th>TO CHANGE</th>
<th>TO</th>
<th>MULTIPLY BY</th>
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<td>Millimeters</td>
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<td>Inches</td>
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<td>Feet</td>
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<td>Yards</td>
<td>Meters</td>
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<tr>
<td>Miles</td>
<td>Kilometers</td>
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<td>Fluid Ounces</td>
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<td>Liters</td>
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<td>Pound-Feet</td>
<td>Newton-Meters</td>
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<td>Pounds Per Square Inch</td>
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<td>6.895</td>
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<td>Miles Per Gallon</td>
<td>Kilometers Per Liter</td>
<td>0.425</td>
</tr>
<tr>
<td>Miles Per Hour</td>
<td>Kilometers Per Hour</td>
<td>1.609</td>
</tr>
</tbody>
</table>

**LIQUID MEASURE**
- 1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
- 1 Liter = 1,000 Milliliters = 33.82 Fluid Ounces

**TEMPERATURE**
- Degrees Fahrenheit (°F) = °C \( \times \frac{9}{5} + 32 \)
- Degrees Celsius (°C) = °F - 32 \( \times \frac{5}{9} \)
- 212° Fahrenheit is equivalent to 100° Celsius
- 90° Fahrenheit is equivalent to 32.2° Celsius
- 32° Fahrenheit is equivalent to 0° Celsius

**WEIGHTS**
- 1 Gram = 0.001 Kilograms = 1,000 Milligrams = 0.035 Ounces
- 1 Kilogram = 1,000 Grams = 2.2 Lb
- 1 Metric Ton = 1,000 Kilograms = 1 Megagram = 1.1 Short Tons