Volume No. 1

TECHNICAL MANUAL
UNIT MAINTENANCE

TRUCK, UTILITY: CARGO/TROOP CARRIER, 1-1/4 TON, 4X4, M998
(2320-01-107-7155) [EIC: BBD]; M998A1 (2320-01-371-9577) [EIC: BBN];

TRUCK, UTILITY: CARGO/TROOP CARRIER, 1-1/4 TON, 4X4, W/WINCH,
M1038 (2320-01-107-7156) [EIC: BBE]; M1038A1 (2320-01-371-9578) [EIC: BBP];

TRUCK, UTILITY: HEAVY VARIANT, 4X4, M1097 (2320-01-346-9317) [EIC:BBM];
M1097A1 (2320-01-371-9583) [EIC: BBU]; M1097A2 (2320-01-380-8604) [EIC: BB6];
M1123 (2320-01-455-9593) [EIC: BBG];

TRUCK, UTILITY: TOW CARRIER, ARMORED, 1-1/4 TON, 4X4,
M966 (2320-01-107-7153) [EIC: BBC]; M966A1 (2320-01-372-3932) [EIC: BBX];
M1121 (2320-01-456-1282) [EIC: B6H];

TRUCK, UTILITY: TOW CARRIER, ARMORED, 1-1/4 TON, 4X4,
W/WINCH, M1036 (2320-01-107-7154) [EIC: B6H];

TRUCK, UTILITY: TOW CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4,
M1045 (2320-01-146-7191); M1045A1 (2320-01-371-9580) [EIC: BB1];
M1045A2 (2320-01-380-8229) [EIC: BB5];

TRUCK, UTILITY: TOW CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4,
W/WINCH, M1046 (2320-01-146-7188); M1046A1 (2320-01-371-9582) [EIC: BB7];

TRUCK, UTILITY: ARMAMENT CARRIER, ARMORED, 1-1/4 TON, 4X4,
M1025 (2320-01-128-9551) [EIC: BBF]; M1025A1 (2320-01-371-9584) [EIC: BBV];
M1025A2 (2320-01-380-8233) [EIC: BB3];

TRUCK, UTILITY: ARMAMENT CARRIER, ARMORED, 1-1/4 TON, 4X4, W/WINCH,
M1026 (2320-01-128-9552) [EIC: BBG]; M1026A1 (2320-01-371-9579) [EIC: BBQ];

TRUCK, UTILITY: ARMAMENT CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4,
M1043 (2320-01-146-7190); M1043A1 (2320-01-372-3933) [EIC: BBY];
M1043A2 (2320-01-380-8213) [EIC: BB4];

TRUCK, UTILITY: ARMAMENT CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4,
W/WINCH, M1044 (2320-01-146-7189); M1044A1 (2320-01-371-9581) [EIC: BB5];

TRUCK, UTILITY: S250 SHELTER CARRIER, 4X4, M1037 (2320-01-146-7193) [EIC: BBK];

TRUCK, UTILITY: S250 SHELTER CARRIER, 4X4, W/WINCH, M1042 (2320-01-146-7187);

TRUCK, AMBULANCE, 2-LITTER, ARMORED, 4X4, M996 (2310-01-111-2275)
[EIC: BB8]; M996A1 (2310-01-372-3935) [EIC: BB2];

TRUCK, AMBULANCE, 4-LITTER, ARMORED, 4X4, M997 (2310-01-111-2274) [EIC: BBA];
M997A1 (2310-01-372-3934) [EIC: BB2];
M997A2 (2310-01-380-8225) [EIC: BB8];

TRUCK, AMBULANCE, 2-LITTER, SOFT TOP, 4X4, M1035 (2310-01-146-7194);
M1035A1 (2310-01-371-9585) [EIC: BBW]; M1035A2 (2310-01-380-8290) [EIC: BB9].

Approved for public release; distribution is unlimited.

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

JANUARY 1996
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. they are:
   - 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.
• 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
190°F (88°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 equip-
ment.

• 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 posi-
tion before disconnecting ground cable. Do not allow tools to come in contact with vehicle when discon-
necting 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.

• Opening one end of cargo door without ensuring opposite end is securely closed will cause both ends to
open simultaneously, resulting in injury to personnel or damage to equipment.

• Direct all personnel to stand clear during engine hoisting operations. Failure to do this may cause injury
to personnel.

• 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.
WARNING SUMMARY (Cont’d)

- 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.

- 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 9-2320-280-24P. 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 to ensure wheel locknuts are tightened to specifications. An assembly with improperly tightened locknuts could separate under pressure resulting in serious injury or death.

- Always use a 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.

- Never mix radial tires and bias ply tires on the same vehicle. Injury to personnel or damage to equipment may result.

- Rear steps must be raised before disconnecting retractor lever from rear steps. Failure to do this may cause injury to personnel and damage to equipment.

- 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.
TECHNICAL MANUAL
VOLUME 1 OF 3
UNIT MAINTENANCE

TRUCK, UTILITY: CARGO/TROOP CARRIER, 1-1/4 TON, 4X4, M998 (2320-01-107-7155) (EIC: BBD); M998A1 (2320-01-371-9577) (EIC: BBN);

TRUCK, UTILITY: CARGO/TROOP CARRIER, 1-1/4 TON, 4X4, W/WINCH, M1038 (2320-01-107-7156) (EIC: BBE); M1038A1 (2320-01-371-9578) (EIC: BBP);

TRUCK, UTILITY: HEAVY VARIANT, 4X4, M1097 (2320-01-346-9317) (EIC: BBM); M1097A1 (2320-01-371-9583) (EIC: BBU); M1097A2 (2320-01-380-8604) (EIC: BB6); M1123 (2320-01-455-9593) (EIC: B6G);

TRUCK, UTILITY: TOW CARRIER, ARMORED, 1-1/4 TON, 4X4, M966 (2320-01-107-7153) (EIC: BBC); M966A1 (2320-01-372-3932) (EIC: BBX); M1121 (2320-01-456-1282) (EIC: B6H);

TRUCK, UTILITY: TOW CARRIER, ARMORED, 1-1/4 TON, 4X4, W/WINCH, M1036 (2320-01-107-7154) (EIC: BBH);

TRUCK, UTILITY: TOW CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, M1045 (2320-01-146-7191); M1045A1 (2320-01-371-9580) (EIC: BBR); M1045A2 (2320-01-380-8229) (EIC: BB5);

TRUCK, UTILITY: TOW CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, W/WINCH, M1046 (2320-01-146-7188); M1046A1 (2320-01-371-9582) (EIC: BB1);

TRUCK, UTILITY: ARMAMENT CARRIER, ARMORED, 1-1/4 TON, 4X4, M1025 (2320-01-128-9551) (EIC: BBF); M1025A1 (2320-01-371-9584) (EIC: BBV); M1025A2 (2320-01-380-8233) (EIC: BB3);

TRUCK, UTILITY: ARMAMENT CARRIER, ARMORED, 1-1/4 TON, 4X4, W/WINCH, M1026 (2320-01-128-9552) (EIC: BBG); M1026A1 (2320-01-371-9579) (EIC: BBQ);

TRUCK, UTILITY: ARMAMENT CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, M1043 (2320-01-146-7190); M1043A1 (2320-01-372-3933) (EIC: BBY); M1043A2 (2320-01-380-8213) (EIC: BB4);

TRUCK, UTILITY: ARMAMENT CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, W/WINCH, M1044 (2320-01-146-7189); M1044A1 (2320-01-371-9581) (EIC: BB5);

TRUCK, UTILITY: S250 SHELTER CARRIER, 4X4, M1037 (2320-01-146-7193) (EIC: BKK);

TRUCK, UTILITY: S250 SHELTER CARRIER, 4X4, W/WINCH, M1042 (2320-01-146-7187);

TRUCK, AMBULANCE, 2-LITTER, ARMORED, 4X4, M996 (2310-01-111-2275) (EIC: BBA); M996A1 (2310-01-372-3935) (EIC: BB2);

TRUCK, AMBULANCE, 4-LITTER, ARMORED, 4X4, M997 (2310-01-111-2274) (EIC: BBA); M997A1 (2310-01-372-3934) (EIC: BBZ); M997A2 (2310-01-380-8225) (EIC: BB8);

TRUCK, AMBULANCE, 2-LITTER, SOFT TOP, 4X4, M1035 (2310-01-146-7194); M1035A1 (2310-01-371-9585) (EIC: BBW); M1035A2 (2310-01-380-8290) (EIC: BB9).

TM 9-2320-280-20-1, 31 January 1996, is changed as follows:
1. Remove old pages and insert new pages as indicated below.
2. New or changed material is indicated by a vertical bar in the margin of the page.

<table>
<thead>
<tr>
<th>Remove pages</th>
<th>Insert page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A through E/(F blank)</td>
<td>A through J</td>
</tr>
<tr>
<td>i and ii</td>
<td>i and ii</td>
</tr>
<tr>
<td>1-1 and 1-2</td>
<td>1-1 and 1-2</td>
</tr>
<tr>
<td>1-31 and 1-32</td>
<td>1-31 and 1-32</td>
</tr>
<tr>
<td>1-49 and 1-50</td>
<td>1-49 and 1-50</td>
</tr>
<tr>
<td>2-13 and 2-14</td>
<td>2-13 and 2-14</td>
</tr>
<tr>
<td>2-17 through 2-20</td>
<td>2-17 through 2-20</td>
</tr>
<tr>
<td>2-23 and 2-24</td>
<td>2-23 and 2-24</td>
</tr>
<tr>
<td>2-29 and 2-30</td>
<td>2-29 and 2-30</td>
</tr>
<tr>
<td>2-33 and 2-34</td>
<td>2-33 and 2-34</td>
</tr>
<tr>
<td>2-107 through 2-110</td>
<td>2-107 through 2-110</td>
</tr>
<tr>
<td>2-189 and 2-190</td>
<td>2-189 and 2-190</td>
</tr>
<tr>
<td>2-193 and 2-194</td>
<td>2-193 and 2-194</td>
</tr>
<tr>
<td>2-217 through 2-224</td>
<td>2-217 through 2-224</td>
</tr>
<tr>
<td>2-433 and 2-434</td>
<td>2-433 and 2-434</td>
</tr>
<tr>
<td>2-447 and 2-448</td>
<td>2-447 and 2-448</td>
</tr>
<tr>
<td>2-467 through 470</td>
<td>2-467 through 470</td>
</tr>
<tr>
<td>Index 1 through Index 3/(Index 4 blank)</td>
<td>Index 1 through Index 3/(Index 4 blank)</td>
</tr>
</tbody>
</table>

3. File this change sheet in front of the publication for reference purposes.

Approved for public release; distribution is unlimited.
By Order of the Secretary of the Army:

Peter J. Schoomaker  
*General, United States Army*  
*Chief of Staff*

Official:

JOEL B. HUDSON  
*Administrative Assistant to the Secretary of the Army*  
0223404

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*

By Order of the Marine Corps:

R. P. SHOCKEY  
*Director, Program Support*  
*Marine Corps Systems Command*

Distribution:

To be distributed in accordance with the initial distribution number (IDN) 380900, requirements for TM 9-2320-280-20-1.
TM 9-2320-280-20-1, 31 January 1996, 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.

2. Remove old pages and insert new pages as indicated below.

3. New or changed material is indicated by a vertical bar in the margin of the page.

<table>
<thead>
<tr>
<th>Remove pages</th>
<th>Insert page</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>A through E/(F blank)</td>
</tr>
<tr>
<td>i through iv</td>
<td>i through iv</td>
</tr>
<tr>
<td>1-1 through 1-8</td>
<td>1-1 through 1-8</td>
</tr>
<tr>
<td>1-13 and 1-14</td>
<td>1-13 and 1-14</td>
</tr>
<tr>
<td>1-23 and 1-24</td>
<td>1-23 and 1-24</td>
</tr>
<tr>
<td>1-29 through 1-38</td>
<td>1-29 through 1-38</td>
</tr>
<tr>
<td>None</td>
<td>1-42.1 through 1-42.3/(1-42.4 blank)</td>
</tr>
<tr>
<td>1-51 and 1-52</td>
<td>1-51 and 1-52</td>
</tr>
<tr>
<td>1-55 through 1-58</td>
<td>1-55 through 1-58</td>
</tr>
</tbody>
</table>

Approved for public release; distribution is unlimited.
<table>
<thead>
<tr>
<th>Remove pages</th>
<th>Insert pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1 through 2-34</td>
<td>2-1 through 2-34</td>
</tr>
<tr>
<td>2-67 and 2-68</td>
<td>2-67 and 2-68</td>
</tr>
<tr>
<td>2-77 through 2-82</td>
<td>2-77 through 2-82</td>
</tr>
<tr>
<td>2-105 through 2-108</td>
<td>2-105 through 2-108</td>
</tr>
<tr>
<td>2-145 through 2-148</td>
<td>2-145 through 2-148</td>
</tr>
<tr>
<td>2-155 and 2-156</td>
<td>2-155 and 2-156</td>
</tr>
<tr>
<td>2-159 and 2-160</td>
<td>2-159 and 2-160</td>
</tr>
<tr>
<td>2-169 and 2-170</td>
<td>2-169 and 2-170</td>
</tr>
<tr>
<td>2-173 through 2-178</td>
<td>2-173 through 2-178</td>
</tr>
<tr>
<td>2-193 through 2-210</td>
<td>2-193 through 2-210</td>
</tr>
<tr>
<td>2-213 and 2-214</td>
<td>2-213 and 2-214</td>
</tr>
<tr>
<td>2-217 through 2-249/(2-250 blank)</td>
<td>2-217 through 2-249/(2-250 blank)</td>
</tr>
<tr>
<td>2-261 through 2-268</td>
<td>2-261 through 2-268</td>
</tr>
<tr>
<td>2-271 and 2-272</td>
<td>2-271 and 2-272</td>
</tr>
<tr>
<td>2-275 through 2-284</td>
<td>2-275 through 2-284</td>
</tr>
<tr>
<td>2-289 through 2-304</td>
<td>2-289 through 2-304</td>
</tr>
<tr>
<td>2-311 and 2-312</td>
<td>2-311 and 2-312</td>
</tr>
<tr>
<td>None</td>
<td>2-318.1 through 2-318.15/(2-318.16 blank)</td>
</tr>
<tr>
<td>2-331 through 2-344</td>
<td>2-331 through 2-344</td>
</tr>
<tr>
<td>2-401 through 2-404</td>
<td>2-401 through 2-404</td>
</tr>
<tr>
<td>2-427 through 2-430</td>
<td>2-427 through 2-430</td>
</tr>
<tr>
<td>2-437 and 2-438</td>
<td>2-437 and 2-438</td>
</tr>
<tr>
<td>2-445 and 2-446</td>
<td>2-445 and 2-446</td>
</tr>
<tr>
<td>2-449 and 2-450</td>
<td>2-449 and 2-450</td>
</tr>
<tr>
<td>2-469 and 2-470</td>
<td>2-469 and 2-470</td>
</tr>
<tr>
<td>2-473 and 2-474</td>
<td>2-473 and 2-474</td>
</tr>
<tr>
<td>2-477/(2-478 blank) through 2-480</td>
<td>2-477/(2-478 blank) through 2-480</td>
</tr>
<tr>
<td>2-761 and 2-762</td>
<td>2-761 and 2-762</td>
</tr>
<tr>
<td>Index 1 through Index 3</td>
<td>Index 1 through Index 3/(Index 4 blank)</td>
</tr>
<tr>
<td>cover</td>
<td>cover</td>
</tr>
</tbody>
</table>

4. File this change sheet in front of the publication for reference purposes.
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*  
05692

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*

By Order of the Marine Corps:

D.R. BLOOMER  
*Colonel, USMC*  
*Director, Program Support*  
*Marine Corps Systems Command*

Distribution:

To be distributed in accordance with the initial distribution number (IDN) 380900, requirements for TM 9-2320-280-20-1.
### LIST OF EFFECTIVE PAGES

**NOTE:** The portion of the text affected by the changes is indicated by a vertical line in the outer margins of the page.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLUME 1</td>
<td></td>
<td>VOLUME 2</td>
<td></td>
<td>VOLUME 3</td>
<td></td>
</tr>
<tr>
<td>a - c</td>
<td>0</td>
<td>2-1</td>
<td>.0</td>
<td>2-136</td>
<td>.0</td>
</tr>
<tr>
<td>d Blank</td>
<td>0</td>
<td>2-2-2-3</td>
<td>1</td>
<td>2-137</td>
<td>2-141</td>
</tr>
<tr>
<td>A - E</td>
<td>2</td>
<td>2-4</td>
<td>.0</td>
<td>2-142</td>
<td>.0</td>
</tr>
<tr>
<td>F - J Added</td>
<td>2</td>
<td>2-5</td>
<td>1</td>
<td>2-143</td>
<td>2-145</td>
</tr>
<tr>
<td>i</td>
<td>2</td>
<td>2-6</td>
<td>.0</td>
<td>2-146</td>
<td>2-147</td>
</tr>
<tr>
<td>ii</td>
<td>1</td>
<td>2-7</td>
<td>1</td>
<td>2-148</td>
<td>2-153</td>
</tr>
<tr>
<td>iii</td>
<td>0</td>
<td>2-8-2-9</td>
<td>.0</td>
<td>2-154</td>
<td>.0</td>
</tr>
<tr>
<td>iv</td>
<td>1</td>
<td>2-10-2-11</td>
<td>1</td>
<td>2-155</td>
<td>2-156</td>
</tr>
<tr>
<td>v - xi</td>
<td>0</td>
<td>2-12</td>
<td>.0</td>
<td>2-157</td>
<td>2-158</td>
</tr>
<tr>
<td>xii Blank</td>
<td>0</td>
<td>2-13</td>
<td>.2</td>
<td>2-159</td>
<td>.1</td>
</tr>
<tr>
<td>1-1 - 1-2</td>
<td>0</td>
<td>2-14-2-17</td>
<td>.1</td>
<td>2-160</td>
<td>2-169</td>
</tr>
<tr>
<td>1-3</td>
<td>0</td>
<td>2-18-2-19</td>
<td>.2</td>
<td>2-170</td>
<td>.1</td>
</tr>
<tr>
<td>1-4 - 1-7</td>
<td>1</td>
<td>2-20</td>
<td>.0</td>
<td>2-171</td>
<td>2-173</td>
</tr>
<tr>
<td>1-8 - 1-12</td>
<td>0</td>
<td>2-21-2-22</td>
<td>.1</td>
<td>2-174</td>
<td>.1</td>
</tr>
<tr>
<td>1-13 - 1-14</td>
<td>1</td>
<td>2-23</td>
<td>.2</td>
<td>2-175</td>
<td>.0</td>
</tr>
<tr>
<td>1-15 - 1-23</td>
<td>0</td>
<td>2-24-2-28</td>
<td>.1</td>
<td>2-176</td>
<td>2-177</td>
</tr>
<tr>
<td>1-24</td>
<td>1</td>
<td>2-29-2-30</td>
<td>.2</td>
<td>2-178</td>
<td>2-185</td>
</tr>
<tr>
<td>1-25 - 1-29</td>
<td>0</td>
<td>2-31-2-32</td>
<td>.1</td>
<td>2-186</td>
<td>.0</td>
</tr>
<tr>
<td>1-30 - 1-31</td>
<td>1</td>
<td>2-32</td>
<td>.0</td>
<td>2-187</td>
<td>2-188</td>
</tr>
<tr>
<td>1-32</td>
<td>2</td>
<td>2-34-2-45</td>
<td>.0</td>
<td>2-189</td>
<td>.2</td>
</tr>
<tr>
<td>1-33 - 1-35</td>
<td>1</td>
<td>2-46</td>
<td>.0</td>
<td>2-190</td>
<td>2-192</td>
</tr>
<tr>
<td>1-36 - 1-37</td>
<td>0</td>
<td>2-47-2-55</td>
<td>.0</td>
<td>2-193</td>
<td>.2</td>
</tr>
<tr>
<td>1-38</td>
<td>1</td>
<td>2-56</td>
<td>.0</td>
<td>2-194</td>
<td>2-205</td>
</tr>
<tr>
<td>1-39 - 1-42</td>
<td>0</td>
<td>2-57-2-63</td>
<td>.0</td>
<td>2-206</td>
<td>.0</td>
</tr>
<tr>
<td>1-42.1 - 1-42.3</td>
<td>1</td>
<td>2-64 Blank</td>
<td>.0</td>
<td>2-207</td>
<td>.1</td>
</tr>
<tr>
<td>1-42.4 Blank</td>
<td>1</td>
<td>2-65 - 2-66</td>
<td>.0</td>
<td>2-208</td>
<td>.0</td>
</tr>
<tr>
<td>1-43 - 1-48</td>
<td>0</td>
<td>2-67</td>
<td>1</td>
<td>2-209</td>
<td>2-210</td>
</tr>
<tr>
<td>1-49</td>
<td>2</td>
<td>2-68-2-69</td>
<td>.0</td>
<td>2-211</td>
<td>2-212</td>
</tr>
<tr>
<td>1-50</td>
<td>2</td>
<td>2-70 Blank</td>
<td>.0</td>
<td>2-213</td>
<td>.1</td>
</tr>
<tr>
<td>1-51</td>
<td>.1</td>
<td>2-71-2-77</td>
<td>.0</td>
<td>2-214</td>
<td>2-217</td>
</tr>
<tr>
<td>1-52 - 1-54</td>
<td>0</td>
<td>2-78-2-81</td>
<td>1</td>
<td>2-218</td>
<td>.2</td>
</tr>
<tr>
<td>1-55</td>
<td>1</td>
<td>2-82-2-105</td>
<td>.0</td>
<td>2-218.1 - 2-218.2 Added</td>
<td>.2</td>
</tr>
<tr>
<td>1-56 - 1-57</td>
<td>0</td>
<td>2-83-2-106</td>
<td>.1</td>
<td>2-219-2-220</td>
<td>.2</td>
</tr>
<tr>
<td>1-58</td>
<td>1</td>
<td>2-106</td>
<td>.2</td>
<td>2-221</td>
<td>.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-110-2-135</td>
<td>.0</td>
<td>2-222</td>
<td>.2</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.*
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2-223</td>
<td>1</td>
<td>2-398</td>
<td>0</td>
<td>2-762</td>
<td>0</td>
</tr>
<tr>
<td>2-224</td>
<td>2</td>
<td>2-399 - 2-400</td>
<td>0</td>
<td>2-766</td>
<td>0</td>
</tr>
<tr>
<td>2-224.1</td>
<td>2</td>
<td>2-401</td>
<td>1</td>
<td>Index-1 - Index-3</td>
<td>2</td>
</tr>
<tr>
<td>2-224.2</td>
<td>1</td>
<td>2-402</td>
<td>0</td>
<td>Index 4 Blank</td>
<td>2</td>
</tr>
<tr>
<td>2-224.3 - 2-224.12</td>
<td>1</td>
<td>2-403</td>
<td>1</td>
<td>FP-1</td>
<td>0</td>
</tr>
<tr>
<td>2-225</td>
<td>1</td>
<td>2-404 - 2-409</td>
<td>0</td>
<td>FP-2 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-226 Blank</td>
<td>1</td>
<td>2-410 Blank</td>
<td>0</td>
<td>FP-3</td>
<td>0</td>
</tr>
<tr>
<td>2-227 - 2-249</td>
<td>1</td>
<td>2-411 - 2-427</td>
<td>0</td>
<td>FP-4 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-250 Blank</td>
<td>1</td>
<td>2-428 - 2-429</td>
<td>1</td>
<td>FP-5</td>
<td>0</td>
</tr>
<tr>
<td>2-251 - 2-259</td>
<td>0</td>
<td>2-430 - 2-433</td>
<td>0</td>
<td>FP-6 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-260 Blank</td>
<td>0</td>
<td>2-434</td>
<td>2</td>
<td>FP-7</td>
<td>0</td>
</tr>
<tr>
<td>2-261 - 2-264</td>
<td>1</td>
<td>2-435 - 2-436</td>
<td>0</td>
<td>FP-8 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-265</td>
<td>0</td>
<td>2-437</td>
<td>1</td>
<td>FP-9</td>
<td>0</td>
</tr>
<tr>
<td>2-266</td>
<td>1</td>
<td>2-438 - 2-443</td>
<td>0</td>
<td>FP-10 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-267</td>
<td>0</td>
<td>2-444 Blank</td>
<td>0</td>
<td>FP-11</td>
<td>0</td>
</tr>
<tr>
<td>2-268</td>
<td>1</td>
<td>2-445</td>
<td>1</td>
<td>FP-12 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-269 - 2-271</td>
<td>0</td>
<td>2-446</td>
<td>0</td>
<td>FP-13</td>
<td>0</td>
</tr>
<tr>
<td>2-272</td>
<td>2</td>
<td>2-447</td>
<td>1</td>
<td>FP-14 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-273 - 2-275</td>
<td>0</td>
<td>2-448</td>
<td>0</td>
<td>FP-15</td>
<td>0</td>
</tr>
<tr>
<td>2-276</td>
<td>1</td>
<td>2-449</td>
<td>0</td>
<td>FP-16 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-277</td>
<td>0</td>
<td>2-450 - 2-457</td>
<td>0</td>
<td>FP-17</td>
<td>0</td>
</tr>
<tr>
<td>2-278 - 2-281</td>
<td>1</td>
<td>2-458 Blank</td>
<td>0</td>
<td>FP-18 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-282 - 2-283</td>
<td>0</td>
<td>2-459 - 2-467</td>
<td>0</td>
<td>FP-19</td>
<td>0</td>
</tr>
<tr>
<td>2-284</td>
<td>1</td>
<td>2-468</td>
<td>2</td>
<td>FP-20 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-285 - 2-289</td>
<td>0</td>
<td>2-468.1 - 2-468.2 Added</td>
<td>2</td>
<td>FP-21</td>
<td>0</td>
</tr>
<tr>
<td>2-290 - 2-295</td>
<td>1</td>
<td>2-469</td>
<td>2</td>
<td>FP-22 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-296 - 2-297</td>
<td>0</td>
<td>2-470 - 2-472</td>
<td>0</td>
<td>FP-23</td>
<td>0</td>
</tr>
<tr>
<td>2-298</td>
<td>1</td>
<td>2-473</td>
<td>1</td>
<td>FP-24 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-299</td>
<td>0</td>
<td>2-474 - 2-476</td>
<td>0</td>
<td>FP-25</td>
<td>0</td>
</tr>
<tr>
<td>2-300 - 2-301</td>
<td>1</td>
<td>2-477</td>
<td>1</td>
<td>FP-26 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-302 Blank</td>
<td>1</td>
<td>2-478 Blank</td>
<td>1</td>
<td>FP-27</td>
<td>0</td>
</tr>
<tr>
<td>2-303</td>
<td>1</td>
<td>2-479</td>
<td>0</td>
<td>FP-28 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-304 - 2-310</td>
<td>0</td>
<td>2-480</td>
<td>1</td>
<td>FP-29</td>
<td>0</td>
</tr>
<tr>
<td>2-311</td>
<td>1</td>
<td>2-481 - 2-495</td>
<td>0</td>
<td>FP-30 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-312 - 2-317</td>
<td>0</td>
<td>2-496 Blank</td>
<td>0</td>
<td>FP-31</td>
<td>0</td>
</tr>
<tr>
<td>2-318 Blank</td>
<td>0</td>
<td>2-497 - 2-683</td>
<td>0</td>
<td>FP-32 Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-318.1 - 2-318.15</td>
<td>1</td>
<td>2-684 Blank</td>
<td>0</td>
<td>a-b</td>
<td>0</td>
</tr>
<tr>
<td>2-318.16 Blank</td>
<td>1</td>
<td>2-685 - 2-691</td>
<td>0</td>
<td>c</td>
<td>3</td>
</tr>
<tr>
<td>2-319 - 2-331</td>
<td>0</td>
<td>2-692 Blank</td>
<td>0</td>
<td>d Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-332 - 2-337</td>
<td>1</td>
<td>2-693 - 2-713</td>
<td>0</td>
<td>A-B</td>
<td>3</td>
</tr>
<tr>
<td>2-338</td>
<td>0</td>
<td>2-714 Blank</td>
<td>0</td>
<td>C-D Added</td>
<td>3</td>
</tr>
<tr>
<td>2-339</td>
<td>1</td>
<td>2-715 - 2-721</td>
<td>0</td>
<td>i</td>
<td>3</td>
</tr>
<tr>
<td>2-340</td>
<td>0</td>
<td>2-719 Blank</td>
<td>0</td>
<td>ii</td>
<td>2</td>
</tr>
<tr>
<td>2-341 - 2-344</td>
<td>1</td>
<td>2-723 - 2-731</td>
<td>0</td>
<td>iii</td>
<td>2</td>
</tr>
<tr>
<td>2-345 - 2-387</td>
<td>0</td>
<td>2-732 Blank</td>
<td>0</td>
<td>iv Blank</td>
<td>0</td>
</tr>
<tr>
<td>2-388 Blank</td>
<td>0</td>
<td>2-733 - 2-760</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>2-389 - 2-397</td>
<td>0</td>
<td>2-761</td>
<td>1</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.
**LIST OF EFFECTIVE PAGES (Contd)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>0</td>
<td>3-72</td>
<td>3</td>
<td>3-140</td>
<td>3</td>
</tr>
<tr>
<td>3-2</td>
<td>3</td>
<td>3-73</td>
<td>0</td>
<td>3-141</td>
<td>2</td>
</tr>
<tr>
<td>3-3 - 3-4</td>
<td>0</td>
<td>3-74</td>
<td>2</td>
<td>3-142</td>
<td>3</td>
</tr>
<tr>
<td>3-5 - 3-6</td>
<td>3</td>
<td>3-75 - 3-77</td>
<td>0</td>
<td>3-142.1 - 3-142.2</td>
<td>2</td>
</tr>
<tr>
<td>3-7</td>
<td>3</td>
<td>3-78</td>
<td>3</td>
<td>3-143</td>
<td>2</td>
</tr>
<tr>
<td>3-8</td>
<td>0</td>
<td>3-79</td>
<td>0</td>
<td>3-144</td>
<td>3</td>
</tr>
<tr>
<td>3-9</td>
<td>0</td>
<td>3-80</td>
<td>3</td>
<td>3-145</td>
<td>2</td>
</tr>
<tr>
<td>3-10</td>
<td>3</td>
<td>3-81</td>
<td>0</td>
<td>3-146</td>
<td>0</td>
</tr>
<tr>
<td>3-11 - 3-12</td>
<td>0</td>
<td>3-82 - 3-86</td>
<td>3</td>
<td>4-1 - 4-2</td>
<td>3</td>
</tr>
<tr>
<td>3-13</td>
<td>2</td>
<td>3-87</td>
<td>0</td>
<td>4-3 - 4-6</td>
<td>2</td>
</tr>
<tr>
<td>3-14 - 3-19</td>
<td>0</td>
<td>3-88</td>
<td>3</td>
<td>4-6.1</td>
<td>2</td>
</tr>
<tr>
<td>3-20</td>
<td>2</td>
<td>3-89</td>
<td>2</td>
<td>4-6.2</td>
<td>3</td>
</tr>
<tr>
<td>3-21</td>
<td>0</td>
<td>3-90 - 3-92</td>
<td>3</td>
<td>4-6.3</td>
<td>2</td>
</tr>
<tr>
<td>3-22</td>
<td>2</td>
<td>3-93</td>
<td>2</td>
<td>4-6.4</td>
<td>3</td>
</tr>
<tr>
<td>3-23 - 3-25</td>
<td>0</td>
<td>3-94 - 3-96</td>
<td>3</td>
<td>4-6.5 - 4-6.14</td>
<td>2</td>
</tr>
<tr>
<td>3-26</td>
<td>3</td>
<td>3-97</td>
<td>2</td>
<td>4-7</td>
<td>2</td>
</tr>
<tr>
<td>3-27</td>
<td>3</td>
<td>3-98</td>
<td>3</td>
<td>4-8</td>
<td>3</td>
</tr>
<tr>
<td>3-28</td>
<td>2</td>
<td>3-99</td>
<td>2</td>
<td>4-9</td>
<td>0</td>
</tr>
<tr>
<td>3-29 - 3-30</td>
<td>3</td>
<td>3-100</td>
<td>3</td>
<td>4-10</td>
<td>3</td>
</tr>
<tr>
<td>3-31 - 3-35</td>
<td>0</td>
<td>3-101</td>
<td>0</td>
<td>4-10.1 - 4-10.2</td>
<td>3</td>
</tr>
<tr>
<td>3-36</td>
<td>3</td>
<td>3-102 - 3-104</td>
<td>3</td>
<td>4-11</td>
<td>2</td>
</tr>
<tr>
<td>3-37</td>
<td>2</td>
<td>3-105</td>
<td>0</td>
<td>4-12</td>
<td>3</td>
</tr>
<tr>
<td>3-38</td>
<td>3</td>
<td>3-106</td>
<td>3</td>
<td>4-12.1 - 4-12.3</td>
<td>3</td>
</tr>
<tr>
<td>3-39 - 3-41</td>
<td>0</td>
<td>3-107</td>
<td>2</td>
<td>4-12.4 Blank</td>
<td>2</td>
</tr>
<tr>
<td>3-42 - 3-46</td>
<td>2</td>
<td>3-108 - 3-109</td>
<td>2</td>
<td>4-12.5</td>
<td>2</td>
</tr>
<tr>
<td>3-46.1</td>
<td>2</td>
<td>3-110</td>
<td>3</td>
<td>4-12.6</td>
<td>3</td>
</tr>
<tr>
<td>3-46.2</td>
<td>3</td>
<td>3-111 - 3-112</td>
<td>2</td>
<td>4-12.7 - 4-12.9</td>
<td>2</td>
</tr>
<tr>
<td>3-47</td>
<td>0</td>
<td>3-113</td>
<td>0</td>
<td>4-12.10</td>
<td>3</td>
</tr>
<tr>
<td>3-48</td>
<td>3</td>
<td>3-114 - 3-115</td>
<td>2</td>
<td>4-12.11</td>
<td>2</td>
</tr>
<tr>
<td>3-49</td>
<td>0</td>
<td>3-116</td>
<td>0</td>
<td>4-12.12</td>
<td>3</td>
</tr>
<tr>
<td>3-50</td>
<td>3</td>
<td>3-117</td>
<td>3</td>
<td>4-12.13 - 4-12.15</td>
<td>2</td>
</tr>
<tr>
<td>3-51</td>
<td>0</td>
<td>3-118 - 3-124</td>
<td>2</td>
<td>4-12.16</td>
<td>2</td>
</tr>
<tr>
<td>3-52</td>
<td>3</td>
<td>3-125</td>
<td>3</td>
<td>4-12.17</td>
<td>2</td>
</tr>
<tr>
<td>3-53</td>
<td>0</td>
<td>3-126 - 3-128</td>
<td>2</td>
<td>4-12.18</td>
<td>3</td>
</tr>
<tr>
<td>3-54</td>
<td>3</td>
<td>3-129</td>
<td>0</td>
<td>4-12.19 - 4-12.21</td>
<td>2</td>
</tr>
<tr>
<td>3-55</td>
<td>2</td>
<td>3-130</td>
<td>3</td>
<td>4-12.22 - 4-12.24</td>
<td>3</td>
</tr>
<tr>
<td>3-56</td>
<td>3</td>
<td>3-130.1</td>
<td>2</td>
<td>4-12.25</td>
<td>2</td>
</tr>
<tr>
<td>3-57 - 3-58</td>
<td>0</td>
<td>3-130.2</td>
<td>3</td>
<td>4-12.26</td>
<td>3</td>
</tr>
<tr>
<td>3-59 - 3-60</td>
<td>3</td>
<td>3-130.3</td>
<td>2</td>
<td>4-12.27</td>
<td>2</td>
</tr>
<tr>
<td>3-61</td>
<td>2</td>
<td>3-130.4</td>
<td>3</td>
<td>4-12.28</td>
<td>3</td>
</tr>
<tr>
<td>3-62</td>
<td>3</td>
<td>3-131</td>
<td>2</td>
<td>4-12.29</td>
<td>2</td>
</tr>
<tr>
<td>3-63</td>
<td>0</td>
<td>3-132</td>
<td>3</td>
<td>4-12.30</td>
<td>2</td>
</tr>
<tr>
<td>3-64</td>
<td>3</td>
<td>3-133</td>
<td>0</td>
<td>4-12.31 - 4-12.37</td>
<td>2</td>
</tr>
<tr>
<td>3-65</td>
<td>2</td>
<td>3-134</td>
<td>3</td>
<td>4-12.38</td>
<td>3</td>
</tr>
<tr>
<td>3-66 - 3-68</td>
<td>0</td>
<td>3-135</td>
<td>2</td>
<td>4-13 - 4-14</td>
<td>3</td>
</tr>
<tr>
<td>3-69</td>
<td>2</td>
<td>3-136</td>
<td>0</td>
<td>4-15</td>
<td>0</td>
</tr>
<tr>
<td>3-70 - 3-71</td>
<td>0</td>
<td>3-137 - 3-139</td>
<td>2</td>
<td>4-16 - 4-20</td>
<td>3</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4-21</td>
<td>0</td>
<td>4-93</td>
<td>0</td>
<td>4-166</td>
<td>3</td>
</tr>
<tr>
<td>4-22</td>
<td>0</td>
<td>4-94 - 4-96</td>
<td>3</td>
<td>4-167</td>
<td>0</td>
</tr>
<tr>
<td>4-23 - 4-25</td>
<td>3</td>
<td>4-97</td>
<td>0</td>
<td>4-168</td>
<td>3</td>
</tr>
<tr>
<td>4-26 - 4-27</td>
<td>3</td>
<td>4-98</td>
<td>0</td>
<td>4-169</td>
<td>0</td>
</tr>
<tr>
<td>4-28</td>
<td>3</td>
<td>4-99</td>
<td>0</td>
<td>4-170</td>
<td>3</td>
</tr>
<tr>
<td>4-28.1</td>
<td>2</td>
<td>4-100</td>
<td>3</td>
<td>4-171</td>
<td>0</td>
</tr>
<tr>
<td>4-28.2 - 4-28.4</td>
<td>3</td>
<td>4-101</td>
<td>2</td>
<td>4-172</td>
<td>3</td>
</tr>
<tr>
<td>4-29 - 4-30</td>
<td>2</td>
<td>4-102</td>
<td>3</td>
<td>4-173</td>
<td>0</td>
</tr>
<tr>
<td>4-31</td>
<td>0</td>
<td>4-103</td>
<td>2</td>
<td>4-174</td>
<td>3</td>
</tr>
<tr>
<td>4-32</td>
<td>3</td>
<td>4-104</td>
<td>3</td>
<td>4-175</td>
<td>0</td>
</tr>
<tr>
<td>4-32.1 - 4-32.3</td>
<td>3</td>
<td>4-105 - 4-107</td>
<td>2</td>
<td>4-176 - 4-180</td>
<td>3</td>
</tr>
<tr>
<td>4-32.4 - 4-32.5</td>
<td>0</td>
<td>4-108</td>
<td>0</td>
<td>4-181</td>
<td>0</td>
</tr>
<tr>
<td>4-32.6</td>
<td>3</td>
<td>4-109 - 4-110</td>
<td>3</td>
<td>4-182</td>
<td>3</td>
</tr>
<tr>
<td>4-33 - 4-35</td>
<td>0</td>
<td>4-111</td>
<td>2</td>
<td>4-183</td>
<td>0</td>
</tr>
<tr>
<td>4-36</td>
<td>2</td>
<td>4-112</td>
<td>3</td>
<td>4-184 - 4-186</td>
<td>3</td>
</tr>
<tr>
<td>4-36.1 - 4-36.2</td>
<td>2</td>
<td>4-113</td>
<td>2</td>
<td>4-187</td>
<td>0</td>
</tr>
<tr>
<td>4-37</td>
<td>2</td>
<td>4-114 - 4-115</td>
<td>0</td>
<td>4-188 - 4-189</td>
<td>3</td>
</tr>
<tr>
<td>4-38 - 4-41</td>
<td>0</td>
<td>4-116</td>
<td>3</td>
<td>4-190 - 4-191</td>
<td>0</td>
</tr>
<tr>
<td>4-42 - 4-43</td>
<td>3</td>
<td>4-117 - 4-121</td>
<td>0</td>
<td>4-192</td>
<td>3</td>
</tr>
<tr>
<td>4-44 - 4-47</td>
<td>0</td>
<td>4-122</td>
<td>3</td>
<td>4-193</td>
<td>0</td>
</tr>
<tr>
<td>4-48</td>
<td>3</td>
<td>4-123</td>
<td>0</td>
<td>4-194</td>
<td>3</td>
</tr>
<tr>
<td>4-49</td>
<td>0</td>
<td>4-124</td>
<td>3</td>
<td>4-195 - 4-199</td>
<td>0</td>
</tr>
<tr>
<td>4-50 - 4-51</td>
<td>3</td>
<td>4-125 - 4-126</td>
<td>0</td>
<td>4-200</td>
<td>3</td>
</tr>
<tr>
<td>4-52 - 4-57</td>
<td>0</td>
<td>4-127 - 4-128</td>
<td>3</td>
<td>4-201</td>
<td>0</td>
</tr>
<tr>
<td>4-58</td>
<td>2</td>
<td>4-129</td>
<td>0</td>
<td>4-202 - 4-204</td>
<td>3</td>
</tr>
<tr>
<td>4-59</td>
<td>0</td>
<td>4-130</td>
<td>3</td>
<td>4-205</td>
<td>0</td>
</tr>
<tr>
<td>4-60 - 4-61</td>
<td>3</td>
<td>4-131 - 4-135</td>
<td>0</td>
<td>4-206 - 4-208</td>
<td>3</td>
</tr>
<tr>
<td>4-62 - 4-66</td>
<td>0</td>
<td>4-136</td>
<td>3</td>
<td>4-209</td>
<td>0</td>
</tr>
<tr>
<td>4-66.1 - 4-66.2</td>
<td>2</td>
<td>4-137</td>
<td>0</td>
<td>4-210 - 4-214</td>
<td>3</td>
</tr>
<tr>
<td>4-67 - 4-68</td>
<td>2</td>
<td>4-138</td>
<td>3</td>
<td>4-215</td>
<td>0</td>
</tr>
<tr>
<td>4-69</td>
<td>0</td>
<td>4-139</td>
<td>2</td>
<td>4-216 - 4-218</td>
<td>3</td>
</tr>
<tr>
<td>4-70</td>
<td>3</td>
<td>4-140</td>
<td>3</td>
<td>4-219</td>
<td>0</td>
</tr>
<tr>
<td>4-71</td>
<td>0</td>
<td>4-141</td>
<td>2</td>
<td>4-220</td>
<td>3</td>
</tr>
<tr>
<td>4-72 - 4-73</td>
<td>2</td>
<td>4-142</td>
<td>3</td>
<td>4-221</td>
<td>0</td>
</tr>
<tr>
<td>4-74</td>
<td>3</td>
<td>4-143</td>
<td>0</td>
<td>4-222 - 4-224</td>
<td>3</td>
</tr>
<tr>
<td>4-75</td>
<td>0</td>
<td>4-144</td>
<td>3</td>
<td>4-225</td>
<td>0</td>
</tr>
<tr>
<td>4-76 Blank</td>
<td>0</td>
<td>4-145</td>
<td>0</td>
<td>4-226 - 4-228</td>
<td>3</td>
</tr>
<tr>
<td>4-77 - 4-79</td>
<td>2</td>
<td>4-146 - 4-148</td>
<td>3</td>
<td>4-229</td>
<td>0</td>
</tr>
<tr>
<td>4-80 - 4-82</td>
<td>3</td>
<td>4-149</td>
<td>0</td>
<td>4-230</td>
<td>3</td>
</tr>
<tr>
<td>4-83</td>
<td>0</td>
<td>4-150</td>
<td>3</td>
<td>4-231</td>
<td>0</td>
</tr>
<tr>
<td>4-84 - 4-86</td>
<td>3</td>
<td>4-151</td>
<td>0</td>
<td>4-232 - 4-233</td>
<td>3</td>
</tr>
<tr>
<td>4-87</td>
<td>0</td>
<td>4-152</td>
<td>3</td>
<td>4-234 - 4-235</td>
<td>0</td>
</tr>
<tr>
<td>4-88</td>
<td>3</td>
<td>4-153 - 4-156</td>
<td>0</td>
<td>4-236</td>
<td>3</td>
</tr>
<tr>
<td>4-89</td>
<td>0</td>
<td>4-157 - 4-158</td>
<td>3</td>
<td>4-237</td>
<td>0</td>
</tr>
<tr>
<td>4-90</td>
<td>3</td>
<td>4-159</td>
<td>0</td>
<td>4-238</td>
<td>3</td>
</tr>
<tr>
<td>4-91</td>
<td>0</td>
<td>4-160</td>
<td>3</td>
<td>4-238.1</td>
<td>2</td>
</tr>
<tr>
<td>4-92</td>
<td>3</td>
<td>4-161 - 4-165</td>
<td>0</td>
<td>4-238.2</td>
<td>3</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.
### LIST OF EFFECTIVE PAGES (Contd)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4-239</td>
<td>2</td>
<td>4-304</td>
<td>3</td>
<td>5-43 - 5-44</td>
<td>0</td>
</tr>
<tr>
<td>4-240</td>
<td>3</td>
<td>4-305 - 4-307</td>
<td>0</td>
<td>5-45</td>
<td>3</td>
</tr>
<tr>
<td>4-241</td>
<td>2</td>
<td>4-308</td>
<td>3</td>
<td>5-46</td>
<td>0</td>
</tr>
<tr>
<td>4-242</td>
<td>3</td>
<td>4-309</td>
<td>3</td>
<td>5-47</td>
<td>2</td>
</tr>
<tr>
<td>4-243</td>
<td>0</td>
<td>4-310</td>
<td>3</td>
<td>5-48</td>
<td>3</td>
</tr>
<tr>
<td>4-244 - 4-246</td>
<td>3</td>
<td>4-311 - 4-312</td>
<td>0</td>
<td>5-49</td>
<td>0</td>
</tr>
<tr>
<td>4-247</td>
<td>0</td>
<td>4-313</td>
<td>3</td>
<td>5-50</td>
<td>3</td>
</tr>
<tr>
<td>4-248</td>
<td>3</td>
<td>4-314</td>
<td>0</td>
<td>5-51</td>
<td>2</td>
</tr>
<tr>
<td>4-249</td>
<td>2</td>
<td>4-315</td>
<td>3</td>
<td>5-52</td>
<td>3</td>
</tr>
<tr>
<td>4-250</td>
<td>3</td>
<td>4-316 - 4-318</td>
<td>0</td>
<td>5-52.1 - 5-52.4</td>
<td>3</td>
</tr>
<tr>
<td>4-251</td>
<td>2</td>
<td>4-319</td>
<td>3</td>
<td>5-53</td>
<td>3</td>
</tr>
<tr>
<td>4-252</td>
<td>3</td>
<td>4-320 - 4-325</td>
<td>0</td>
<td>5-55</td>
<td>0</td>
</tr>
<tr>
<td>4-253</td>
<td>2</td>
<td>4-326 Blank</td>
<td>0</td>
<td>5-56 Blank</td>
<td>0</td>
</tr>
<tr>
<td>4-254 - 4-255</td>
<td>3</td>
<td>5-1</td>
<td>0</td>
<td>5-6</td>
<td>3</td>
</tr>
<tr>
<td>4-256</td>
<td>3</td>
<td>5-2</td>
<td>3</td>
<td>5-6 - 6-4</td>
<td>0</td>
</tr>
<tr>
<td>4-256.1</td>
<td>2</td>
<td>5-3</td>
<td>0</td>
<td>5-6</td>
<td>2</td>
</tr>
<tr>
<td>4-256.2</td>
<td>3</td>
<td>5-4</td>
<td>3</td>
<td>5-6</td>
<td>3</td>
</tr>
<tr>
<td>4-257 - 4-258</td>
<td>3</td>
<td>5-5</td>
<td>0</td>
<td>5-6</td>
<td>3</td>
</tr>
<tr>
<td>4-259 - 4-260</td>
<td>2</td>
<td>5-6</td>
<td>0</td>
<td>5-6</td>
<td>3</td>
</tr>
<tr>
<td>4-260.1</td>
<td>2</td>
<td>5-7</td>
<td>0</td>
<td>5-6</td>
<td>3</td>
</tr>
<tr>
<td>4-260.2 - 4-260.4</td>
<td>3</td>
<td>5-8</td>
<td>3</td>
<td>5-6</td>
<td>3</td>
</tr>
<tr>
<td>4-261 - 4-262</td>
<td>3</td>
<td>5-9 - 5-12</td>
<td>2</td>
<td>5-6 - 6-11</td>
<td>0</td>
</tr>
<tr>
<td>4-263</td>
<td>2</td>
<td>5-13</td>
<td>0</td>
<td>5-6 - 6-11</td>
<td>0</td>
</tr>
<tr>
<td>4-264 - 4-266</td>
<td>3</td>
<td>5-14</td>
<td>3</td>
<td>5-6 - 6-11</td>
<td>0</td>
</tr>
<tr>
<td>4-267 - 4-269</td>
<td>0</td>
<td>5-15</td>
<td>0</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-270 - 4-272</td>
<td>3</td>
<td>5-16</td>
<td>3</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-273</td>
<td>0</td>
<td>5-17</td>
<td>2</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-274</td>
<td>3</td>
<td>5-18</td>
<td>3</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-275</td>
<td>0</td>
<td>5-19 - 5-20</td>
<td>2</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-276</td>
<td>3</td>
<td>5-21</td>
<td>0</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-277</td>
<td>3</td>
<td>5-22 - 5-26</td>
<td>3</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-278</td>
<td>3</td>
<td>5-27</td>
<td>2</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-279 - 4-281</td>
<td>0</td>
<td>5-28</td>
<td>3</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-282</td>
<td>2</td>
<td>5-29</td>
<td>2</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-283</td>
<td>0</td>
<td>5-30</td>
<td>3</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-284</td>
<td>3</td>
<td>5-31</td>
<td>0</td>
<td>5-6 - 6-16</td>
<td>0</td>
</tr>
<tr>
<td>4-285</td>
<td>0</td>
<td>5-32</td>
<td>3</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-286 - 4-288</td>
<td>3</td>
<td>5-33</td>
<td>0</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-289</td>
<td>0</td>
<td>5-34</td>
<td>3</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-290 - 4-292</td>
<td>3</td>
<td>5-35</td>
<td>0</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-293</td>
<td>0</td>
<td>5-36</td>
<td>3</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-294</td>
<td>3</td>
<td>5-37</td>
<td>0</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-295 - 4-297</td>
<td>0</td>
<td>5-38</td>
<td>3</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-298</td>
<td>3</td>
<td>5-39</td>
<td>0</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-299</td>
<td>0</td>
<td>5-40</td>
<td>3</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-300</td>
<td>3</td>
<td>5-41</td>
<td>2</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
<tr>
<td>4-301 - 4-303</td>
<td>0</td>
<td>5-42</td>
<td>3</td>
<td>5-6 - 6-30</td>
<td>2</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.*
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6-55 - 6-58</td>
<td>3</td>
<td>7-43</td>
<td>0</td>
<td>8-31</td>
<td>0</td>
</tr>
<tr>
<td>6-59</td>
<td>2</td>
<td>7-44</td>
<td>3</td>
<td>8-32</td>
<td>2</td>
</tr>
<tr>
<td>6-60</td>
<td>3</td>
<td>7-45</td>
<td>0</td>
<td>8-33 - 8-42</td>
<td>0</td>
</tr>
<tr>
<td>6-61</td>
<td>0</td>
<td>7-46</td>
<td>3</td>
<td>8-43 - 8-44</td>
<td>3</td>
</tr>
<tr>
<td>6-62</td>
<td>3</td>
<td>7-47</td>
<td>0</td>
<td>8-45</td>
<td>2</td>
</tr>
<tr>
<td>6-63</td>
<td>2</td>
<td>7-48</td>
<td>3</td>
<td>8-46</td>
<td>3</td>
</tr>
<tr>
<td>6-64</td>
<td>3</td>
<td>7-49</td>
<td>0</td>
<td>8-47</td>
<td>0</td>
</tr>
<tr>
<td>6-65</td>
<td>2</td>
<td>7-50</td>
<td>2</td>
<td>8-48</td>
<td>3</td>
</tr>
<tr>
<td>6-66</td>
<td>3</td>
<td>7-50.1</td>
<td>2</td>
<td>8-49</td>
<td>0</td>
</tr>
<tr>
<td>6-67</td>
<td>2</td>
<td>7-50.2</td>
<td>3</td>
<td>8-50</td>
<td>3</td>
</tr>
<tr>
<td>6-68</td>
<td>3</td>
<td>7-51</td>
<td>2</td>
<td>8-51</td>
<td>2</td>
</tr>
<tr>
<td>6-69 - 6-72</td>
<td>0</td>
<td>7-52</td>
<td>3</td>
<td>8-52</td>
<td>3</td>
</tr>
<tr>
<td>7-1</td>
<td>2</td>
<td>7-53</td>
<td>0</td>
<td>8-53</td>
<td>2</td>
</tr>
<tr>
<td>7-2</td>
<td>3</td>
<td>7-54</td>
<td>3</td>
<td>8-54</td>
<td>3</td>
</tr>
<tr>
<td>7-3</td>
<td>0</td>
<td>7-55</td>
<td>0</td>
<td>8-55 - 8-57</td>
<td>0</td>
</tr>
<tr>
<td>7-4</td>
<td>3</td>
<td>7-56 - 7-60</td>
<td>3</td>
<td>8-58</td>
<td>3</td>
</tr>
<tr>
<td>7-5</td>
<td>2</td>
<td>7-61</td>
<td>2</td>
<td>8-59</td>
<td>0</td>
</tr>
<tr>
<td>7-6</td>
<td>3</td>
<td>7-62</td>
<td>3</td>
<td>8-60</td>
<td>3</td>
</tr>
<tr>
<td>7-7 - 7-9</td>
<td>0</td>
<td>7-63</td>
<td>2</td>
<td>8-61</td>
<td>0</td>
</tr>
<tr>
<td>7-10</td>
<td>3</td>
<td>7-64</td>
<td>3</td>
<td>8-62</td>
<td>3</td>
</tr>
<tr>
<td>7-11</td>
<td>0</td>
<td>7-65</td>
<td>0</td>
<td>8-63</td>
<td>0</td>
</tr>
<tr>
<td>7-12</td>
<td>3</td>
<td>7-66 Blank</td>
<td>0</td>
<td>8-64</td>
<td>3</td>
</tr>
<tr>
<td>7-13</td>
<td>0</td>
<td>8-1</td>
<td>2</td>
<td>8-65 - 8-67</td>
<td>0</td>
</tr>
<tr>
<td>7-14</td>
<td>3</td>
<td>8-2 - 8-3</td>
<td>0</td>
<td>8-68</td>
<td>3</td>
</tr>
<tr>
<td>7-15</td>
<td>0</td>
<td>8-4</td>
<td>2</td>
<td>8-69</td>
<td>2</td>
</tr>
<tr>
<td>7-16 - 7-17</td>
<td>3</td>
<td>8-5 - 8-7</td>
<td>0</td>
<td>8-70</td>
<td>3</td>
</tr>
<tr>
<td>7-18</td>
<td>2</td>
<td>8-8 - 8-9</td>
<td>3</td>
<td>8-71</td>
<td>0</td>
</tr>
<tr>
<td>7-18.1</td>
<td>2</td>
<td>8-10 - 8-13</td>
<td>2</td>
<td>8-72</td>
<td>3</td>
</tr>
<tr>
<td>7-18.2</td>
<td>3</td>
<td>8-14</td>
<td>3</td>
<td>8-73</td>
<td>2</td>
</tr>
<tr>
<td>7-18.3</td>
<td>2</td>
<td>8-14.1</td>
<td>0</td>
<td>8-74</td>
<td>3</td>
</tr>
<tr>
<td>7-18.4</td>
<td>1</td>
<td>8-14.2 - 8-14.4</td>
<td>3</td>
<td>8-74.1</td>
<td>2</td>
</tr>
<tr>
<td>7-18.5</td>
<td>2</td>
<td>8-14.5</td>
<td>2</td>
<td>8-74.2</td>
<td>3</td>
</tr>
<tr>
<td>7-18.6 Blank</td>
<td>2</td>
<td>8-14.6</td>
<td>3</td>
<td>8-74.3 - 8-74.6 Added</td>
<td>3</td>
</tr>
<tr>
<td>7-19 - 7-23</td>
<td>0</td>
<td>8-14.7</td>
<td>2</td>
<td>8-75 - 8-76</td>
<td>3</td>
</tr>
<tr>
<td>7-24 - 7-25</td>
<td>2</td>
<td>8-14.8 - 8-14.10</td>
<td>3</td>
<td>8-77</td>
<td>2</td>
</tr>
<tr>
<td>7-26 - 7-28</td>
<td>3</td>
<td>8-15 - 8-17</td>
<td>3</td>
<td>8-78 - 8-81</td>
<td>0</td>
</tr>
<tr>
<td>7-29</td>
<td>0</td>
<td>8-18 - 8-21</td>
<td>2</td>
<td>8-82</td>
<td>3</td>
</tr>
<tr>
<td>7-30</td>
<td>3</td>
<td>8-22 - 8-23</td>
<td>3</td>
<td>8-83</td>
<td>0</td>
</tr>
<tr>
<td>7-31</td>
<td>0</td>
<td>8-24</td>
<td>2</td>
<td>8-84</td>
<td>3</td>
</tr>
<tr>
<td>7-32</td>
<td>3</td>
<td>8-24.1</td>
<td>2</td>
<td>8-85</td>
<td>0</td>
</tr>
<tr>
<td>7-32.1 - 7-32.2</td>
<td>2</td>
<td>8-24.2 - 8-24.3</td>
<td>3</td>
<td>8-86</td>
<td>2</td>
</tr>
<tr>
<td>7-33 - 7-34</td>
<td>2</td>
<td>8-24.4 - 8-24.7</td>
<td>2</td>
<td>8-87</td>
<td>3</td>
</tr>
<tr>
<td>7-34.1 - 7-34.2</td>
<td>2</td>
<td>8-24.8 - 8-24.9</td>
<td>3</td>
<td>8-88</td>
<td>2</td>
</tr>
<tr>
<td>7-35 - 7-39</td>
<td>2</td>
<td>8-24.10</td>
<td>2</td>
<td>9-1 - 9-4</td>
<td>3</td>
</tr>
<tr>
<td>7-40</td>
<td>3</td>
<td>8-25 - 8-26</td>
<td>3</td>
<td>9-5</td>
<td>0</td>
</tr>
<tr>
<td>7-41</td>
<td>0</td>
<td>8-27 - 8-29</td>
<td>0</td>
<td>9-6</td>
<td>3</td>
</tr>
<tr>
<td>7-42</td>
<td>3</td>
<td>8-30</td>
<td>3</td>
<td>9-7</td>
<td>0</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9-8 - 9-14</td>
<td>3</td>
<td>10-35 - 10-36</td>
<td>0</td>
<td>10-103 - 10-110</td>
<td>0</td>
</tr>
<tr>
<td>9-14.1</td>
<td>3</td>
<td>10-37 - 10-38</td>
<td>1</td>
<td>10-111</td>
<td>2</td>
</tr>
<tr>
<td>9-14.2 Blank</td>
<td>2</td>
<td>10-39 - 10-43</td>
<td>0</td>
<td>10-112</td>
<td>1</td>
</tr>
<tr>
<td>9-15</td>
<td>3</td>
<td>10-44 - 10-47</td>
<td>2</td>
<td>10-113 - 10-114</td>
<td>0</td>
</tr>
<tr>
<td>9-16 - 9-19</td>
<td>0</td>
<td>10-48 - 10-50</td>
<td>2</td>
<td>10-114.1</td>
<td>2</td>
</tr>
<tr>
<td>9-20 - 9-23</td>
<td>3</td>
<td>10-51 - 10-52</td>
<td>2</td>
<td>10-114.2 Blank</td>
<td>1</td>
</tr>
<tr>
<td>9-24 Added</td>
<td>3</td>
<td>10-53</td>
<td>0</td>
<td>10-115</td>
<td>1</td>
</tr>
<tr>
<td>Index-1</td>
<td>3</td>
<td>10-54</td>
<td>2</td>
<td>10-116 - 10-118</td>
<td>2</td>
</tr>
<tr>
<td>Index-2 - Index-6</td>
<td>2</td>
<td>10-55</td>
<td>0</td>
<td>10-119</td>
<td>0</td>
</tr>
<tr>
<td>Index-7</td>
<td>3</td>
<td>10-56</td>
<td>2</td>
<td>10-120</td>
<td>2</td>
</tr>
<tr>
<td>Index-8 - Index-9</td>
<td>2</td>
<td>10-56.1</td>
<td>1</td>
<td>10-121 - 10-123</td>
<td>0</td>
</tr>
<tr>
<td>Index-10</td>
<td>3</td>
<td>10-56.2</td>
<td>2</td>
<td>10-124 - 10-125</td>
<td>2</td>
</tr>
<tr>
<td>Index-11 - Index 15</td>
<td>2</td>
<td>10-57</td>
<td>1</td>
<td>10-126</td>
<td>1</td>
</tr>
<tr>
<td>Index-16 - Index 26</td>
<td>3</td>
<td>10-58</td>
<td>2</td>
<td>10-127</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-59</td>
<td>0</td>
<td>10-128</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-60 - 10-61</td>
<td>2</td>
<td>10-129</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-62</td>
<td>0</td>
<td>10-130 - 10-133</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-63</td>
<td>2</td>
<td>10-134 - 10-143</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-64</td>
<td>0</td>
<td>10-144</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-65 - 10-66</td>
<td>2</td>
<td>10-145</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-66</td>
<td>0</td>
<td>10-146</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-67</td>
<td>2</td>
<td>10-147 - 10-149</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-68</td>
<td>0</td>
<td>10-150</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-69</td>
<td>0</td>
<td>10-151</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-70</td>
<td>2</td>
<td>10-152</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-71</td>
<td>0</td>
<td>10-153</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-72</td>
<td>2</td>
<td>10-154</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-73 - 10-80</td>
<td>0</td>
<td>10-154.1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-80.1 - 10-80.2</td>
<td>1</td>
<td>10-154.2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-81</td>
<td>1</td>
<td>10-155 - 10-156</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-82</td>
<td>0</td>
<td>10-157 - 10-159</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-82.1 - 10-82.2</td>
<td>1</td>
<td>10-160</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-83</td>
<td>1</td>
<td>10-161</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-84</td>
<td>2</td>
<td>10-162 Blank</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-85 - 10-86</td>
<td>0</td>
<td>10-163 - 10-164</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-87 - 10-88</td>
<td>2</td>
<td>10-164.1 - 10-164.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-89</td>
<td>0</td>
<td>10-165</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-90</td>
<td>2</td>
<td>10-166</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-91</td>
<td>0</td>
<td>10-166.1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-92 - 10-93</td>
<td>2</td>
<td>10-166.2 Blank</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-94</td>
<td>0</td>
<td>10-167 - 10-170</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-95 - 10-96</td>
<td>2</td>
<td>10-171</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-97</td>
<td>0</td>
<td>10-172</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-98</td>
<td>2</td>
<td>10-172.1 - 10-172.4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-99</td>
<td>0</td>
<td>10-173</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-100</td>
<td>2</td>
<td>10-174</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-101</td>
<td>2</td>
<td>10-175</td>
<td>2</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10-176</td>
<td>1</td>
<td>11-67</td>
<td>2</td>
<td>11-160</td>
<td>2</td>
</tr>
<tr>
<td>10-176.1</td>
<td>2</td>
<td>11-68</td>
<td>0</td>
<td>11-160.1</td>
<td>2</td>
</tr>
<tr>
<td>10-176.2</td>
<td>1</td>
<td>11-69</td>
<td>2</td>
<td>11-161</td>
<td>0</td>
</tr>
<tr>
<td>10-177</td>
<td>2</td>
<td>11-71</td>
<td>0</td>
<td>11-162</td>
<td>2</td>
</tr>
<tr>
<td>10-178</td>
<td>0</td>
<td>11-72</td>
<td>2</td>
<td>11-166</td>
<td>2</td>
</tr>
<tr>
<td>10-179.1</td>
<td>2</td>
<td>11-73</td>
<td>0</td>
<td>11-167</td>
<td>0</td>
</tr>
<tr>
<td>10-179.3</td>
<td>2</td>
<td>11-74</td>
<td>2</td>
<td>11-168</td>
<td>2</td>
</tr>
<tr>
<td>10-186.1</td>
<td>2</td>
<td>11-75</td>
<td>0</td>
<td>11-170</td>
<td>2</td>
</tr>
<tr>
<td>10-186.5</td>
<td>2</td>
<td>11-76</td>
<td>0</td>
<td>11-171</td>
<td>0</td>
</tr>
<tr>
<td>10-187</td>
<td>2</td>
<td>11-77</td>
<td>0</td>
<td>11-172</td>
<td>0</td>
</tr>
<tr>
<td>10-190</td>
<td>2</td>
<td>11-78</td>
<td>0</td>
<td>11-173</td>
<td>1</td>
</tr>
<tr>
<td>10-190.2</td>
<td>2</td>
<td>11-79</td>
<td>0</td>
<td>11-175</td>
<td>0</td>
</tr>
<tr>
<td>10-195</td>
<td>2</td>
<td>11-80</td>
<td>0</td>
<td>11-176</td>
<td>2</td>
</tr>
<tr>
<td>10-204</td>
<td>2</td>
<td>11-81</td>
<td>0</td>
<td>11-177</td>
<td>0</td>
</tr>
<tr>
<td>11-1</td>
<td>0</td>
<td>11-82</td>
<td>2</td>
<td>11-178</td>
<td>2</td>
</tr>
<tr>
<td>11-2</td>
<td>1</td>
<td>11-83</td>
<td>0</td>
<td>11-179</td>
<td>0</td>
</tr>
<tr>
<td>11-3</td>
<td>2</td>
<td>11-84</td>
<td>0</td>
<td>11-180</td>
<td>2</td>
</tr>
<tr>
<td>11-4</td>
<td>0</td>
<td>11-85</td>
<td>0</td>
<td>11-181</td>
<td>0</td>
</tr>
<tr>
<td>11-5</td>
<td>2</td>
<td>11-86</td>
<td>2</td>
<td>11-182</td>
<td>2</td>
</tr>
<tr>
<td>11-6</td>
<td>0</td>
<td>11-87</td>
<td>0</td>
<td>11-183</td>
<td>0</td>
</tr>
<tr>
<td>11-8</td>
<td>2</td>
<td>11-88</td>
<td>2</td>
<td>11-184</td>
<td>0</td>
</tr>
<tr>
<td>11-9</td>
<td>0</td>
<td>11-89</td>
<td>0</td>
<td>11-185</td>
<td>2</td>
</tr>
<tr>
<td>11-10</td>
<td>2</td>
<td>11-90</td>
<td>2</td>
<td>11-186</td>
<td>2</td>
</tr>
<tr>
<td>11-11</td>
<td>0</td>
<td>11-91</td>
<td>2</td>
<td>11-187</td>
<td>2</td>
</tr>
<tr>
<td>11-12</td>
<td>2</td>
<td>11-92</td>
<td>0</td>
<td>11-188</td>
<td>2</td>
</tr>
<tr>
<td>11-13</td>
<td>2</td>
<td>11-93</td>
<td>0</td>
<td>11-189</td>
<td>2</td>
</tr>
<tr>
<td>11-14</td>
<td>2</td>
<td>11-94</td>
<td>2</td>
<td>11-190</td>
<td>2</td>
</tr>
<tr>
<td>11-15</td>
<td>0</td>
<td>11-95</td>
<td>0</td>
<td>11-191</td>
<td>0</td>
</tr>
<tr>
<td>11-16</td>
<td>2</td>
<td>11-96</td>
<td>2</td>
<td>11-192</td>
<td>2</td>
</tr>
<tr>
<td>11-17</td>
<td>0</td>
<td>11-97</td>
<td>0</td>
<td>11-193</td>
<td>2</td>
</tr>
<tr>
<td>11-18</td>
<td>2</td>
<td>11-98</td>
<td>0</td>
<td>11-194</td>
<td>0</td>
</tr>
<tr>
<td>11-20</td>
<td>2</td>
<td>11-99</td>
<td>2</td>
<td>11-195</td>
<td>0</td>
</tr>
<tr>
<td>11-21</td>
<td>0</td>
<td>11-100</td>
<td>2</td>
<td>11-196</td>
<td>2</td>
</tr>
<tr>
<td>11-22</td>
<td>2</td>
<td>11-101</td>
<td>0</td>
<td>11-197</td>
<td>0</td>
</tr>
<tr>
<td>11-23</td>
<td>0</td>
<td>11-102</td>
<td>2</td>
<td>11-198</td>
<td>2</td>
</tr>
<tr>
<td>11-24</td>
<td>0</td>
<td>11-103</td>
<td>2</td>
<td>11-199</td>
<td>0</td>
</tr>
<tr>
<td>11-25</td>
<td>0</td>
<td>11-104</td>
<td>2</td>
<td>11-200</td>
<td>2</td>
</tr>
<tr>
<td>11-26</td>
<td>0</td>
<td>11-105</td>
<td>2</td>
<td>11-201</td>
<td>0</td>
</tr>
<tr>
<td>11-27</td>
<td>0</td>
<td>11-106</td>
<td>2</td>
<td>11-202</td>
<td>2</td>
</tr>
<tr>
<td>11-28</td>
<td>0</td>
<td>11-107</td>
<td>2</td>
<td>11-203</td>
<td>2</td>
</tr>
<tr>
<td>11-29</td>
<td>0</td>
<td>11-108</td>
<td>2</td>
<td>11-204</td>
<td>2</td>
</tr>
<tr>
<td>11-30</td>
<td>0</td>
<td>11-109</td>
<td>2</td>
<td>11-205</td>
<td>2</td>
</tr>
<tr>
<td>11-31</td>
<td>0</td>
<td>11-110</td>
<td>2</td>
<td>11-206</td>
<td>2</td>
</tr>
<tr>
<td>11-32</td>
<td>0</td>
<td>11-111</td>
<td>2</td>
<td>11-207</td>
<td>2</td>
</tr>
<tr>
<td>11-33</td>
<td>0</td>
<td>11-112</td>
<td>2</td>
<td>11-208</td>
<td>2</td>
</tr>
<tr>
<td>11-34</td>
<td>0</td>
<td>11-113</td>
<td>2</td>
<td>11-209</td>
<td>2</td>
</tr>
<tr>
<td>11-35</td>
<td>0</td>
<td>11-114</td>
<td>2</td>
<td>11-210</td>
<td>2</td>
</tr>
<tr>
<td>11-36</td>
<td>0</td>
<td>11-115</td>
<td>2</td>
<td>11-211</td>
<td>2</td>
</tr>
<tr>
<td>11-37</td>
<td>0</td>
<td>11-116</td>
<td>2</td>
<td>11-212</td>
<td>2</td>
</tr>
<tr>
<td>11-38</td>
<td>0</td>
<td>11-117</td>
<td>2</td>
<td>11-212.1</td>
<td>2</td>
</tr>
<tr>
<td>11-39</td>
<td>0</td>
<td>11-118</td>
<td>2</td>
<td>11-212.2</td>
<td>1</td>
</tr>
<tr>
<td>11-40</td>
<td>0</td>
<td>11-119</td>
<td>2</td>
<td>11-213</td>
<td>1</td>
</tr>
<tr>
<td>11-41</td>
<td>0</td>
<td>11-120</td>
<td>2</td>
<td>11-214</td>
<td>2</td>
</tr>
<tr>
<td>11-42</td>
<td>0</td>
<td>11-121</td>
<td>2</td>
<td>11-217</td>
<td>2</td>
</tr>
<tr>
<td>11-43</td>
<td>0</td>
<td>11-122</td>
<td>2</td>
<td>11-218</td>
<td>2</td>
</tr>
<tr>
<td>11-50</td>
<td>0</td>
<td>11-123</td>
<td>2</td>
<td>11-219</td>
<td>2</td>
</tr>
<tr>
<td>11-51</td>
<td>0</td>
<td>11-124</td>
<td>2</td>
<td>11-220</td>
<td>2</td>
</tr>
<tr>
<td>11-52</td>
<td>0</td>
<td>11-125</td>
<td>2</td>
<td>11-221</td>
<td>2</td>
</tr>
<tr>
<td>11-53</td>
<td>0</td>
<td>11-126</td>
<td>2</td>
<td>11-222</td>
<td>2</td>
</tr>
<tr>
<td>11-54</td>
<td>0</td>
<td>11-127</td>
<td>2</td>
<td>11-223</td>
<td>2</td>
</tr>
<tr>
<td>11-55</td>
<td>0</td>
<td>11-128</td>
<td>2</td>
<td>11-224</td>
<td>2</td>
</tr>
<tr>
<td>11-56</td>
<td>0</td>
<td>11-129</td>
<td>2</td>
<td>11-225</td>
<td>2</td>
</tr>
<tr>
<td>11-57</td>
<td>0</td>
<td>11-130</td>
<td>2</td>
<td>11-226</td>
<td>2</td>
</tr>
<tr>
<td>11-58</td>
<td>0</td>
<td>11-131</td>
<td>2</td>
<td>11-227</td>
<td>2</td>
</tr>
<tr>
<td>11-59</td>
<td>0</td>
<td>11-132</td>
<td>2</td>
<td>11-228</td>
<td>2</td>
</tr>
<tr>
<td>11-60</td>
<td>0</td>
<td>11-133</td>
<td>2</td>
<td>11-229</td>
<td>2</td>
</tr>
<tr>
<td>11-61</td>
<td>0</td>
<td>11-134</td>
<td>2</td>
<td>11-230</td>
<td>2</td>
</tr>
<tr>
<td>11-62</td>
<td>0</td>
<td>11-135</td>
<td>2</td>
<td>11-231</td>
<td>0</td>
</tr>
<tr>
<td>11-63</td>
<td>0</td>
<td>11-136</td>
<td>2</td>
<td>11-232</td>
<td>2</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.

H Change 2
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11-233</td>
<td>0</td>
<td>11-326 Blank</td>
<td>0</td>
<td>12-70.4</td>
<td>2</td>
</tr>
<tr>
<td>11-234 - 11-236</td>
<td>2</td>
<td>12-1</td>
<td>1</td>
<td>12-71</td>
<td>1</td>
</tr>
<tr>
<td>11-237</td>
<td>0</td>
<td>12-2</td>
<td>2</td>
<td>12-72</td>
<td>2</td>
</tr>
<tr>
<td>11-238 - 11-241</td>
<td>2</td>
<td>12-3</td>
<td>0</td>
<td>12-72.1</td>
<td>1</td>
</tr>
<tr>
<td>11-242 - 11-245</td>
<td>2</td>
<td>12-4</td>
<td>2</td>
<td>12-72.2 Blank</td>
<td>1</td>
</tr>
<tr>
<td>11-246</td>
<td>2</td>
<td>12-5 - 12-16</td>
<td>0</td>
<td>12-73 - 12-74</td>
<td>0</td>
</tr>
<tr>
<td>11-247</td>
<td>0</td>
<td>12-7 - 12-8</td>
<td>1</td>
<td>12-75</td>
<td>2</td>
</tr>
<tr>
<td>11-248</td>
<td>2</td>
<td>12-9 - 12-11</td>
<td>2</td>
<td>12-76 - 12-84</td>
<td>0</td>
</tr>
<tr>
<td>11-249 - 11-251</td>
<td>0</td>
<td>12-12</td>
<td>0</td>
<td>12-85</td>
<td>2</td>
</tr>
<tr>
<td>11-252 - 11-254</td>
<td>2</td>
<td>12-13 - 12-15</td>
<td>2</td>
<td>12-86 - 12-87</td>
<td>0</td>
</tr>
<tr>
<td>11-255 - 11-256</td>
<td>0</td>
<td>12-16</td>
<td>0</td>
<td>12-88 - 12-90</td>
<td>2</td>
</tr>
<tr>
<td>11-257 - 11-261</td>
<td>2</td>
<td>12-17 - 12-20</td>
<td>2</td>
<td>12-91 - 12-92</td>
<td>0</td>
</tr>
<tr>
<td>11-262</td>
<td>0</td>
<td>12-21</td>
<td>0</td>
<td>12-93</td>
<td>2</td>
</tr>
<tr>
<td>11-262.1</td>
<td>2</td>
<td>12-22</td>
<td>2</td>
<td>12-94</td>
<td>0</td>
</tr>
<tr>
<td>11-262.2 Blank</td>
<td>1</td>
<td>12-23</td>
<td>1</td>
<td>12-95</td>
<td>2</td>
</tr>
<tr>
<td>11-263 - 11-264</td>
<td>2</td>
<td>12-24</td>
<td>2</td>
<td>12-96</td>
<td>0</td>
</tr>
<tr>
<td>11-265</td>
<td>2</td>
<td>12-25</td>
<td>0</td>
<td>12-97 - 12-103</td>
<td>2</td>
</tr>
<tr>
<td>11-266</td>
<td>2</td>
<td>12-26</td>
<td>1</td>
<td>12-104 - 12-106</td>
<td>0</td>
</tr>
<tr>
<td>11-267</td>
<td>0</td>
<td>12-27</td>
<td>0</td>
<td>12-107 - 12-110</td>
<td>2</td>
</tr>
<tr>
<td>11-268 - 11-273</td>
<td>2</td>
<td>12-28</td>
<td>2</td>
<td>12-111</td>
<td>1</td>
</tr>
<tr>
<td>11-274 - 11-277</td>
<td>2</td>
<td>12-28.1</td>
<td>1</td>
<td>12-112 - 12-115</td>
<td>0</td>
</tr>
<tr>
<td>11-278</td>
<td>2</td>
<td>12-28.2</td>
<td>2</td>
<td>12-116</td>
<td>2</td>
</tr>
<tr>
<td>11-279</td>
<td>0</td>
<td>12-29 - 12-30</td>
<td>2</td>
<td>12-117 - 12-118</td>
<td>2</td>
</tr>
<tr>
<td>11-280 - 11-281</td>
<td>2</td>
<td>12-31</td>
<td>0</td>
<td>12-119</td>
<td>2</td>
</tr>
<tr>
<td>11-282 - 11-285</td>
<td>2</td>
<td>12-32</td>
<td>2</td>
<td>12-120 - 12-134</td>
<td>0</td>
</tr>
<tr>
<td>11-286</td>
<td>2</td>
<td>12-33 - 12-34</td>
<td>1</td>
<td>12-135 - 12-138</td>
<td>2</td>
</tr>
<tr>
<td>11-287 - 11-291</td>
<td>0</td>
<td>12-34.1</td>
<td>1</td>
<td>12-139 - 12-140</td>
<td>0</td>
</tr>
<tr>
<td>11-292 - 11-293</td>
<td>2</td>
<td>12-34.2</td>
<td>2</td>
<td>12-141 - 12-142</td>
<td>2</td>
</tr>
<tr>
<td>11-294 - 11-295</td>
<td>0</td>
<td>12-34.3 - 12-34.8</td>
<td>1</td>
<td>12-143</td>
<td>0</td>
</tr>
<tr>
<td>11-296</td>
<td>2</td>
<td>12-35 - 12-36</td>
<td>1</td>
<td>12-144</td>
<td>2</td>
</tr>
<tr>
<td>11-297</td>
<td>0</td>
<td>12-37</td>
<td>0</td>
<td>12-145</td>
<td>0</td>
</tr>
<tr>
<td>11-298</td>
<td>2</td>
<td>12-38</td>
<td>2</td>
<td>12-146</td>
<td>2</td>
</tr>
<tr>
<td>11-299 - 11-301</td>
<td>0</td>
<td>12-39</td>
<td>1</td>
<td>12-147 - 12-149</td>
<td>0</td>
</tr>
<tr>
<td>11-302</td>
<td>2</td>
<td>12-40 - 12-56</td>
<td>0</td>
<td>12-150</td>
<td>2</td>
</tr>
<tr>
<td>11-303</td>
<td>2</td>
<td>12-57 - 12-59</td>
<td>2</td>
<td>12-151 - 12-152</td>
<td>0</td>
</tr>
<tr>
<td>11-304</td>
<td>2</td>
<td>12-60</td>
<td>0</td>
<td>12-153</td>
<td>2</td>
</tr>
<tr>
<td>11-305 - 11-306</td>
<td>0</td>
<td>12-61 - 12-62</td>
<td>2</td>
<td>12-154 - 12-157</td>
<td>0</td>
</tr>
<tr>
<td>11-307</td>
<td>1</td>
<td>12-62.1</td>
<td>1</td>
<td>12-158</td>
<td>2</td>
</tr>
<tr>
<td>11-308 - 11-312</td>
<td>0</td>
<td>12-62.2</td>
<td>2</td>
<td>12-159 - 12-161</td>
<td>0</td>
</tr>
<tr>
<td>11-313 - 11-314</td>
<td>2</td>
<td>12-63</td>
<td>1</td>
<td>12-162</td>
<td>2</td>
</tr>
<tr>
<td>11-315</td>
<td>0</td>
<td>12-64 - 12-65</td>
<td>0</td>
<td>12-163 - 12-164</td>
<td>0</td>
</tr>
<tr>
<td>11-316</td>
<td>2</td>
<td>12-66</td>
<td>2</td>
<td>12-165 - 12-168</td>
<td>2</td>
</tr>
<tr>
<td>11-317</td>
<td>0</td>
<td>12-67</td>
<td>0</td>
<td>12-169</td>
<td>0</td>
</tr>
<tr>
<td>11-318 - 11-319</td>
<td>2</td>
<td>12-68 - 12-70</td>
<td>2</td>
<td>12-170</td>
<td>2</td>
</tr>
<tr>
<td>11-320</td>
<td>0</td>
<td>12-70.1</td>
<td>1</td>
<td>12-171</td>
<td>0</td>
</tr>
<tr>
<td>11-321 - 11-323</td>
<td>2</td>
<td>12-70.2</td>
<td>2</td>
<td>12-172</td>
<td>2</td>
</tr>
<tr>
<td>11-324 - 11-325</td>
<td>0</td>
<td>12-70.3</td>
<td>1</td>
<td>12-173 - 12-175</td>
<td>0</td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12-176</td>
<td>2</td>
<td>12-267</td>
<td>0</td>
<td>E-1 - E-4</td>
<td>0</td>
</tr>
<tr>
<td>12-177 - 12-179</td>
<td>0</td>
<td>12-268</td>
<td>2</td>
<td>F-1</td>
<td>1</td>
</tr>
<tr>
<td>12-180</td>
<td>2</td>
<td>12-269</td>
<td>0</td>
<td>F-2 - F-12</td>
<td>0</td>
</tr>
<tr>
<td>12-181</td>
<td>2</td>
<td>12-270 - 12-274</td>
<td>2</td>
<td>G-1</td>
<td>0</td>
</tr>
<tr>
<td>12-182</td>
<td>2</td>
<td>12-275 - 12-276</td>
<td>0</td>
<td>G-2 - G-9</td>
<td>2</td>
</tr>
<tr>
<td>12-183</td>
<td>2</td>
<td>12-277 - 12-278</td>
<td>2</td>
<td>G-10 - G-12 Added</td>
<td>2</td>
</tr>
<tr>
<td>12-184</td>
<td>2</td>
<td>12-279 - 12-281</td>
<td>0</td>
<td>Index-1 - Index-7</td>
<td>1</td>
</tr>
<tr>
<td>12-185</td>
<td>2</td>
<td>12-282</td>
<td>2</td>
<td>Index-8 - Index-35</td>
<td>2</td>
</tr>
<tr>
<td>12-186</td>
<td>2</td>
<td>12-283 - 12-294</td>
<td>0</td>
<td>Index-36 Blank</td>
<td>1</td>
</tr>
<tr>
<td>12-187 - 12-189</td>
<td>0</td>
<td>12-295</td>
<td>1</td>
<td>FP-1</td>
<td>0</td>
</tr>
<tr>
<td>12-190</td>
<td>2</td>
<td>12-296</td>
<td>2</td>
<td>FP-2 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-191 - 12-193</td>
<td>0</td>
<td>12-297</td>
<td>1</td>
<td>FP-3</td>
<td>0</td>
</tr>
<tr>
<td>12-194 - 12-197</td>
<td>2</td>
<td>12-298</td>
<td>2</td>
<td>FP-4 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-198 - 12-200</td>
<td>0</td>
<td>12-299 - 12-301</td>
<td>1</td>
<td>FP-5</td>
<td>0</td>
</tr>
<tr>
<td>12-201 - 12-202</td>
<td>1</td>
<td>12-302</td>
<td>2</td>
<td>FP-6 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-202.1</td>
<td>2</td>
<td>12-303 - 12-305</td>
<td>1</td>
<td>FP-7</td>
<td>0</td>
</tr>
<tr>
<td>12-202.2</td>
<td>1</td>
<td>12-306</td>
<td>2</td>
<td>FP-8 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-203</td>
<td>1</td>
<td>12-307 - 12-309</td>
<td>1</td>
<td>FP-9</td>
<td>0</td>
</tr>
<tr>
<td>12-204</td>
<td>2</td>
<td>12-310 - 12-312</td>
<td>2</td>
<td>FP-10 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-204.1</td>
<td>1</td>
<td>12-313 - 12-317</td>
<td>1</td>
<td>FP-11</td>
<td>0</td>
</tr>
<tr>
<td>12-204.2</td>
<td>2</td>
<td>12-318 Blank</td>
<td>1</td>
<td>FP-12 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-204.3 - 12-204.4</td>
<td>1</td>
<td>13-1 - 13-3</td>
<td>0</td>
<td>FP-13</td>
<td>0</td>
</tr>
<tr>
<td>12-205</td>
<td>1</td>
<td>13-4 Blank</td>
<td>0</td>
<td>FP-14 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-206 - 12-214</td>
<td>2</td>
<td>A-1 - A-2</td>
<td>2</td>
<td>FP-15</td>
<td>0</td>
</tr>
<tr>
<td>12-215</td>
<td>0</td>
<td>B-1 - B-3</td>
<td>0</td>
<td>FP-16 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-216 - 12-222</td>
<td>2</td>
<td>B-4 - B-27</td>
<td>2</td>
<td>FP-17</td>
<td>0</td>
</tr>
<tr>
<td>12-222.1</td>
<td>1</td>
<td>B-28 - B-29 Added</td>
<td>2</td>
<td>FP-18 Blank</td>
<td>0</td>
</tr>
<tr>
<td>12-222.2 Blank</td>
<td>1</td>
<td>B-30 Blank Added</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-223 - 12-225</td>
<td>2</td>
<td>C-1</td>
<td>0</td>
<td>12-225.2 Blank</td>
<td>2</td>
</tr>
<tr>
<td>12-226 - 12-227</td>
<td>0</td>
<td>C-2 - C-7</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-228</td>
<td>2</td>
<td>C-8 Blank</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-229</td>
<td>0</td>
<td>D-1 - D-2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-230</td>
<td>2</td>
<td>D-3 - D-9</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-231</td>
<td>0</td>
<td>D-10</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-232</td>
<td>2</td>
<td>D-11 - D-22</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-233 - 12-235</td>
<td>0</td>
<td>D-23</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-236</td>
<td>2</td>
<td>D-24</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-237 - 12-239</td>
<td>0</td>
<td>D-25</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-240</td>
<td>2</td>
<td>D-26 - D-46</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-241</td>
<td>0</td>
<td>D-46.1 - D-46.2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-242</td>
<td>2</td>
<td>D-47 - D-48</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-243 - 12-246</td>
<td>0</td>
<td>D-49 - D-64</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-247 - 12-250</td>
<td>2</td>
<td>D-65 - D-66</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-251</td>
<td>0</td>
<td>D-67 - D-69</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-252</td>
<td>2</td>
<td>D-70 - D-71</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-253 - 12-254</td>
<td>0</td>
<td>D-72 - D-77</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-255 - 12-266</td>
<td>2</td>
<td>D-78 - D-116</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Zero in this column indicates original page.
TECHNICAL ORDER
NO. 36A12-1A-2092-1-1

TECHNICAL MANUAL
VOLUME 1 OF 3
UNIT MAINTENANCE

TRUCK, UTILITY: CARGO/TROOP CARRIER, 1-1/4 TON, 4X4, M998 (2320-01-107-7155) [EIC: BBD];
M998A1 (2320-01-371-9577) [EIC: BBN];
TRUCK, UTILITY: CARGO/TROOP CARRIER, 1-1/4 TON, 4X4, W/WINCH, M1038 (2320-01-107-7156) [EIC: BBE];
M1038A1 (2320-01-371-9578) [EIC: BBP];
TRUCK, UTILITY: HEAVY VARIANT, 4X4, M1097 (2320-01-346-9317) [EIC: BBM]; M1097A1 (2320-01-371-9583) [EIC: BBU];
M1097A2 (2320-01-380-8664) [EIC: BB6]; M1123 (2320-01-455-9593) [EIC: BBG];
TRUCK, UTILITY: TOW CARRIER, ARMORED, 1-1/4 TON, 4X4, M966 (2320-01-107-7153) [EIC: BBC];
M966A1 (2320-01-372-3932) [EIC: BBX]; M1121 (2320-01-456-1282) [EIC: BBH];
TRUCK, UTILITY: TOW CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, M1045 (2320-01-146-7191);
M1045A1 (2320-01-371-9580) [EIC: BB]; M1045A2 (2320-01-380-8229) [EIC: BB5];
TRUCK, UTILITY: TOW CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, W/WINCH, M1046 (2320-01-146-7188);
M1046A1 (2320-01-371-9582) [EIC: BB];
TRUCK, UTILITY: ARMAMENT CARRIER, ARMORED, 1-1/4 TON, 4X4, M1025 (2320-01-128-9551) [EIC: BBF];
M1025A1 (2320-01-371-9584) [EIC: BBV]; M1025A2 (2320-01-380-8233) [EIC: BB3];
TRUCK, UTILITY: ARMAMENT CARRIER, ARMORED, 1-1/4 TON, 4X4, W/WINCH, M1026 (2320-01-128-9552) [EIC: BBG];
M1026A1 (2320-01-371-9579) [EIC: BBQ];
TRUCK, UTILITY: ARMAMENT CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, M1043 (2320-01-146-7190);
M1043A1 (2320-01-372-3933) [EIC: BB]; M1043A2 (2320-01-380-8213) [EIC: BB4];
TRUCK, UTILITY: ARMAMENT CARRIER, W/SUPPLEMENTAL ARMOR, 1-1/4 TON, 4X4, W/WINCH, M1044 (2320-01-146-7189);
M1044A1 (2320-01-371-9581) [EIC: BB];
TRUCK, UTILITY: S250 SHELTER CARRIER, 4X4, M1037 (2320-01-146-7193) [EIC: BBK];
TRUCK, UTILITY: S250 SHELTER CARRIER, 4X4, W/WINCH, M1042 (2320-01-146-7187);
TRUCK, AMBULANCE, 2-LITTER, ARMORED, 4X4, M996 (2310-01-111-2275) [EIC: BB]; M996A1 (2310-01-372-3935) [EIC: BB2];
TRUCK, AMBULANCE, 4-LITTER, ARMORED, 4X4, M997 (2310-01-111-2274) [EIC: BB]; M997A1 (2310-01-372-3934) [EIC: BB2]; M997A2 (2310-01-380-8225) [EIC: BB2];
TRUCK, AMBULANCE, 2-LITTER, SOFT TOP, 4X4, M1035 (2310-01-146-7194);
M1035A1 (2310-01-371-9585) [EIC: BB]; M1035A2 (2310-01-380-8290) [EIC: BB9].

Approved for public release; distribution is unlimited.

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS
You can help improve this publication. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Submit your DA Form 2028 (Recommended Changes to Publications and Blank Forms), through the Internet, on the Army Electronic Product Support (AEPS) website. The Internet address is http://aeps.ria.army.mil. If you need a password, scroll down and click on “ACCESS REQUEST FORM.” The DA Form 2028 is located in the ONLINE FORMS PROCESSING section of the AEPS. Fill out the form and click on SUBMIT. Using this form on the AEPS will enable us to respond quicker to your comments and better manage the DA Form 2028 program. You may also mail, fax or E-mail your letter or DA Form 2028 direct to: AMSTA-LC-CI Tech Pubs, TACOM-R1, 1 Rock Island Arsenal, Rock Island, IL 61299-7630. The E-mail address is TACOM-TECH-PUBS@ria.army.mil. The fax number is DSN 793-0726 or Commercial (309) 782-0726. (Marine Corps) Submit NAVMC 10722 to Commander Code 835-2, Marine Corps Logistic Base, 814 Radford Boulevard, Albany, GA 31704-1128.

This manual is published in three parts. TM 9-2320-280-20-1 contains chapters 1 and 2, TM 9-2320-280-20-2 contains chapters 3 through 9, and TM 9-2320-280-20-3 contains chapters 10 through 13 and appendices A through G.

This manual contains a table of contents for all three volumes 1, 2, and 3 and alphabetical index for chapters 1 and 2.

*This publication supersedes TM 9-2320-280-20-1 dated 19 January 1990 and all changes.
<table>
<thead>
<tr>
<th>CHAPTER 5</th>
<th>TRANSMISSION AND TRANSFER CASE MAINTENANCE ...........................................</th>
<th>5-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section I.</td>
<td>Transmission Maintenance .............................................................................</td>
<td>5-1</td>
</tr>
<tr>
<td>II.</td>
<td>Transfer Case Maintenance ........................................................................</td>
<td>5-47</td>
</tr>
<tr>
<td>CHAPTER 6</td>
<td>PROPELLER SHAFTS, AXLES, AND SUSPENSION MAINTENANCE ................................</td>
<td>6-1</td>
</tr>
<tr>
<td>Section I.</td>
<td>Propeller Shafts Maintenance ....................................................................</td>
<td>6-1</td>
</tr>
<tr>
<td>II.</td>
<td>Front and Rear Axles Maintenance ..........................................................</td>
<td>6-16</td>
</tr>
<tr>
<td>III.</td>
<td>Suspension Maintenance ...............................................................................</td>
<td>6-54</td>
</tr>
<tr>
<td>CHAPTER 7</td>
<td>BRAKE SYSTEM MAINTENANCE .......................................................................</td>
<td>7-1</td>
</tr>
<tr>
<td>Section I.</td>
<td>Parking Brake System Maintenance ............................................................</td>
<td>7-1</td>
</tr>
<tr>
<td>II.</td>
<td>Service Brake System Maintenance ............................................................</td>
<td>7-19</td>
</tr>
<tr>
<td>III.</td>
<td>Rear Dual Service/Parking Brake System Maintenance ..................................</td>
<td>7-45</td>
</tr>
<tr>
<td>CHAPTER 8</td>
<td>WHEELS AND STEERING MAINTENANCE ............................................................</td>
<td>8-1</td>
</tr>
<tr>
<td>Section I.</td>
<td>Wheel and Runflat System Maintenance .....................................................</td>
<td>8-1</td>
</tr>
<tr>
<td>II.</td>
<td>Steering Components Maintenance ................................................................</td>
<td>8-43</td>
</tr>
<tr>
<td>CHAPTER 9</td>
<td>FRAME MAINTENANCE ....................................................................................</td>
<td>9-1</td>
</tr>
</tbody>
</table>

VOLUME 3 OF 3

| CHAPTER 10 | BODY AND ACCESSORIES MAINTENANCE ......................................................... | 10-1 |
| Section I. | Body Maintenance ....................................................................................... | 10-1 |
| II.        | Body Accessories Maintenance .................................................................... | 10-115|
| III.       | Winch Maintenance .................................................................................... | 10-179|
| CHAPTER 11 | SPECIAL PURPOSE BODIES MAINTENANCE ....................................................... | 11-1 |
| Section I. | Weapon Carrier Body Maintenance ............................................................. | 11-1 |
| II.        | S250 Shelter Carrier Body Maintenance .................................................. | 11-161|
| III.       | Ambulance Body Maintenance ...................................................................... | 11-173|
# CHAPTER 12
## SPECIAL PURPOSE KITS MAINTENANCE

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Deep Water Fording Kit Maintenance</td>
<td>12-1</td>
</tr>
<tr>
<td>II</td>
<td>Troop Seat Kit Maintenance</td>
<td>12-19</td>
</tr>
<tr>
<td>III</td>
<td>100 Ampere Alternator Kit Maintenance</td>
<td>12-23</td>
</tr>
<tr>
<td>IV</td>
<td>Arctic Winterization Kits Maintenance</td>
<td>12-36</td>
</tr>
<tr>
<td>V</td>
<td>Arctic Winterization Crew Top Kits Maintenance</td>
<td>12-104</td>
</tr>
<tr>
<td>VI</td>
<td>Troop/Cargo Winterization Kit Maintenance</td>
<td>12-114</td>
</tr>
<tr>
<td>VII</td>
<td>Communications Kits Maintenance</td>
<td>12-201</td>
</tr>
<tr>
<td>VIII</td>
<td>81 MM Mortar Kit Maintenance</td>
<td>12-235</td>
</tr>
<tr>
<td>IX</td>
<td>Traversing Bar Kit Maintenance</td>
<td>12-251</td>
</tr>
<tr>
<td>X</td>
<td>M1097, M1097A1, and M1097A2 Special Purpose Kits Maintenance</td>
<td>12-254</td>
</tr>
<tr>
<td>XI</td>
<td>Accessory Kits Installation</td>
<td>12-282</td>
</tr>
<tr>
<td>XII</td>
<td>Cargo Barrier and Net Kit Maintenance</td>
<td>12-314</td>
</tr>
</tbody>
</table>

# CHAPTER 13
## PREPARATION FOR STORAGE OR SHIPMENT

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>General Instructions</td>
<td>13-1</td>
</tr>
<tr>
<td>II</td>
<td>Preparation for Storage and Shipment</td>
<td>13-2</td>
</tr>
</tbody>
</table>

## APPENDIXES
- A: REFERENCES - A-1
- B: MAINTENANCE ALLOCATION CHART - B-1
- C: EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST - C-1
- D: ILLUSTRATED LIST OF MANUFACTURED ITEMS - D-1
- E: TORQUE LIMITS - E-1
- F: WIRING DIAGRAMS AND SCHEMATIC - F-1
- G: MANDATORY REPLACEMENT PARTS - G-1

## INDEX - Index 1
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 Maintenance authorized by the Maintenance Allocation Chart (appendix B) and Source, Maintenance, and Recovery (SMR) codes (TM 9-2320-280-24P).

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

- Safety summary (warning page 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)
- Electrical/Mechanical Systems Troubleshooting (chapter 2, section IV)
- Detailed maintenance procedures (chapters 3-12)
- General maintenance instructions (chapter 2, section II and III)
- Maintenance Allocation Chart - MAC (appendix B)
- Expendable/durable supplies and materials list (appendix C)
- Manufactured items (appendix D)
- Torque limits (appendix E)
- Wiring Diagrams and Schematic (appendix F)
- Mandatory replacement parts (appendix G)

A typical example of how to use this manual is provided on the following pages.
a. **TASK:** The operator of an M998 series vehicle has complained that his TOW 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 four sections:
   - Section I - Repair Parts, Special Tools, TMDE, and Support Equipment
   - Section II - Service Upon Receipt
   - Section III - PMCS
   - Section IV - Electrical/Mechanical Systems Troubleshooting
6. Turn to section IV, "ELECTRICAL/MECHANICAL SYSTEMS TROUBLESHOOTING" (page 2-30). This troubleshooting section is system-oriented and is broken down into five top level tests and twenty-one system level tests.

7. One of the first pages of this section is the "ELECTRICAL/MECHANICAL SYSTEM TROUBLESHOOTING" (turn to page 2-31)

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

9. Turn to the test indicated.
10. On page 2-188, 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 appears normal and you move on to Test 2.

12. In Test 2, you begin a methodical 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 9-2320-280-24P, Unit Maintenance Repair Parts and Special Tools List for M998 Series Vehicles, 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 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 and Transmission Oil Cooler Assembly Maintenance". Turn to page 3-12.
3. On page 3-12 you find paragraph 3-8, 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.

1. Before beginning the maintenance task, look through the procedure. You must familiarize yourself with the entire maintenance procedure of para. 3-8: "Engine and Transmission Oil Cooler Assembly Maintenance". The task includes "a. Removal" "b. Installation" and "c. Cleaning and Inspection".

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 9-2320-280-24P, 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 unserviceable parts, refer to TM 9-2320-280-24P 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 TM's 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. 10-17, 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.

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, oil cooler assembly replacement - a. Removal, step 1 is "Disconnect engine oil cooler supply and return lines (7) from engine oil cooler ports (9)". Note that the numbers in parenthesis 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, 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 oil cooler assembly replacement are:

- Fill oil to proper level ([TM 9-2320-280-10]).
- Install left-hand splash shield (para. 10-17).
- Start engine ([TM 9-2320-280-10]) and check for leaks.

5. Refer to the example pages for para. 3-8, Engine and Transmission 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 that 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 for M998 series vehicles.
CHAPTER 1
INTRODUCTION

Section I. GENERAL INFORMATION

1-1. SCOPE

a. This technical manual contains instructions for organizational maintenance of the 1-1/4 ton, 4X4, M998 series vehicles.

b. Models included are:

   (1) M998 and M998A1, Cargo/Troop Carrier
   (2) M1038 and M1038A1, Cargo/Troop Carrier, W/Winch
   (3) M1097, M1097A1, M1097A2, and M1123 Heavy Variant
   (4) M966, M966A1, and M1121 TOW Carrier, Armored
   (5) M1036, TOW Carrier, Armored, W/Winch
   (6) M1045, M1045A1, and M1045A2 TOW Carrier, W/Supplemental Armor
   (7) M1046 and M1046A1, TOW Carrier, W/Supplemental Armor, W/Winch
   (8) M1025, M1025A1, and M1025A2 Armament Carrier, Armored
   (9) M1026 and M1026A1, Armament Carrier, Armored, W/Winch
   (11) M1044 and M1044A1, Armament Carrier, W/Supplemental Armor, W/Winch
   (12) M1037, S250 Shelter Carrier
   (13) M1042, S250 Shelter Carrier, W/Winch
   (14) M996 and M996A1 2-Litter Ambulance, Armored
   (15) M997, M997A1, and M997A2 4-Litter Ambulance, Armored
   (16) M1035, M1035A1, and M1035A2 2-Litter Ambulance, Soft Top

1-2. MAINTENANCE FORMS, RECORDS, AND REPORTS

(Army) Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA Pam 738-750, The Army Maintenance Management System (TAMMS). (Marine Corps) Refer to TM 4700-15/1–.

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

(Army) Refer to TM 746-10, Marking, Packaging and Shipment of Supplies and Equipment: General Packaging Instructions for Field Use. (Marine Corps) Refer to MCO 4450-7.

1-5. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR)

(Army) 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: http://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 Armaments Command, ATTN: AMSTA-TR-E/PQDR MS 267, 6501 E. 11 Mile Road, Warren, MI 48397-500. We'll send you a reply. (Marine Corps) Submit QDR's in accordance with MCO 4855-10.
1-6. EQUIPMENT IMPROVEMENT REPORT AND MAINTENANCE DIGEST (EIR MD)

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. (Marine Corps) Submit QDR’s in accordance with MCO 4855-10. For those with access to the World Wide Web (WWW), the EIR MD can be viewed through the Army Electronic Product Support. The site is http://aeps.ria.army.mil.

1-7. METRIC SYSTEM

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.

1-8. MANDATORY REPLACEMENT PARTS

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.

1-9. BREAK-IN PROCEDURE

Upon receipt of vehicles, or after engine replacement, break-in procedures must be observed during the first 500 miles (804 kilometers) of operation. For break-in procedure, refer to TM 9-2320-280-10.

Section II. EQUIPMENT DESCRIPTION AND DATA

1-10. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES

The 1-1/4 ton, 4x4, M998 series of 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, diesel engine. Four-wheel hydraulic service brakes and a mechanical parking brake are common to all models in the M998 series. All vehicles are equipped with a pintle hook for towing. Tiedown and lifting eyes are provided for air, rail, or sea shipment.
CARGO/TROOP CARRIERS: M998, M998A1, M1038, AND M1038A1

PURPOSE: These models are used to transport cargo and troops. The M1038 and M1038A1 models, which have a winch, can be used for recovery operations. Both models utilize a troop seat kit for troop transport operations.
HEAVY VARIANT CARGO/TROOP CARRIERS: M1097, M1097A1, M1097A2, AND M1123

PURPOSE: This model is used for transporting equipment, materials, and/or personnel (including crew) of 4,400 pounds (1,998 kilograms). The only difference between the M998 and M998A1 cargo/troop carriers and the M1097, M1097A1, M1097A2, and M1123 heavy variant cargo/troop carriers is that the M1097, M1097A1, M1097A2, and M1123 are specifically designed to accommodate a higher payload capacity. This difference affects vehicle length, width, and shipping dimensions, but does not affect the basic purpose and performance of the vehicle. The increased payload capabilities accomodate 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
M1097/M1097A1/M1097A2/M1123
(WITH 2-MAN SOFT TOP INSTALLED)

M1097A2

M1123
M1097/M1097A1/M1097A2/M1123
(WITH L119 KIT INSTALLED)
(WITHOUT WINCH, TOWED VULCAN SYSTEMS (TVS) MOVER)

M1097/M1097A1/M1097A2/M1123
(WITH S250 SHELTER INSTALLED)
TOW CARRIERS: M966, M966A1, M1036, AND M1121

PURPOSE: These models are used to transport, mount, and operate the TOW missile launcher system with armor protection for crew, TOW system components, and ammunition. The M1036 model, which has a winch, can be used for recovery operations.
TOW CARRIERS, W/ SUPPLEMENTAL ARMOR M1045, M1045A1, M1045A2, M1046, AND M1046A1

a. PURPOSE: These models are used to transport, mount, and operate the TOW missile launcher system with added ballistic protection for crew, TOW system components, and ammunition. The M1046 and M1046A1 models, which have a winch, can be used for recovery operations.

b. SPECIAL LIMITATIONS: Weapon station azimuth is limited to 300° left and right of vehicle centerline when Vehicle Power Conditioner (VPC) cables are connected. With launcher installed, elevation is limited to 20° and depression is limited to 10°.
ARMAMENT CARRIERS, W/ SUPPLEMENTAL ARMOR: M1025, M1025A1, M1025A2, M1026, AND M1026A1

a. PURPOSE: These models are used to transport, mount, and operate the M2 and M60 machine guns and MK19 automatic grenade launcher with armor protection for crew, weapons components, and ammunition. The M1026 and M1026A1 models, which have a winch, can be used for recovery operations.

b. SPECIAL LIMITATIONS: Weapon station azimuth is limited to 300° left and right of vehicle centerline when Vehicle Power Condition (VPC) cables are connected. With launcher installed, elevation is limited to 20° and depression is limited to 10°.
PURPOSE: These models are used to transport, mount, and operate the M2 and M60 machine guns and MK19 automatic grenade launcher with added ballistic protection for crew, weapons components, and ammunition. The M1044 and M1044A1 models, which have a winch, can be used for recovery operations.
S250 SHELTER CARRIERS M1037 AND M1042

PURPOSE: These models are used for securing and transporting the S250 electrical equipment shelter. The M1042 model, which has a winch, can be used for recovery operations.
PURPOSE: These models are used to transport patients with armor protection for crew and patients. The M996 and M996A1 are reducible in height for CH47 helicopter transport. The M997, M997A1, and M997A2 have air conditioning for patient comfort. For operation in an NBC environment, the M997, M997A1, and M997A2 is equipped with a Gas-Particulate Filter Unit (GPFU) with heaters capable of supporting up to seven personnel equipped with either M25 series protective masks or M13 series patient protective masks.
SOFT TOP AMBULANCES: M1035, M1035A1, AND M1035A2

PURPOSE: These models are used to transport a maximum of 2 litter and 2 ambulatory patients and are transportable by a CH47 helicopter.
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 \textit{TM 9-2320-280-10} or \textit{Table 1-1}, differences between models, of this manual.

\begin{itemize}
\item[A] **AIR CLEANER** – Filters air before it enters intake manifold.
\item[B] **ENGINE** – Provides power for the vehicle.
\item[C] **TRANSMISSION** – Transmits engine power to transfer case at varying speeds.
\item[D] **FUEL TANK** – Stores fuel.
\item[E] **GEARED HUB** – Transfers turning action of half shafts to wheels for vehicle motion.
\item[F] **PINTLE HOOK** – Permits towing of vehicles or equipment.
\item[G] **REAR PROPELLER SHAFT** – Transmits power from the transfer case to the rear differential.
\item[H] **TRANSFER CASE** – Provides full-time four-wheel drive with three drive ranges.
\item[I] **FRONT PROPELLER SHAFT** – Transmits power from the transfer case to the front differential.
\item[J] **MASTER CYLINDER AND HYDRO-BOOST** – Provides hydraulic pressure and power assist for vehicle stopping power.
\item[K] **DIFFERENTIAL** – Transfers turning action of the propeller shaft to the geared hubs through the half shafts.
\item[L] **WINCH** – 6000 lb (M1026, M1026A1, M1036, M1038, M1038A1, M1042, M1044, M1044A1, M1046, and M1046A1 only), electrically powered to provide recovery capability.
\item[M] **WINCH** – 9000 lb, can be used on “A2” models M1025A2, M1043A2, M1045A2, and M1097A2 and M1123.
\end{itemize}
1-11. LOCATION AND DESCRIPTION OF MAJOR EXTERIOR COMPONENTS (Cont'd)

- **AIR CLEANER**
- **ENGINE**
- **TRANSMISSION**
- **FUEL TANK**
- **GEARED HUB**
- **PINTLE HOOK**
- **REAR PROPELLER SHAFT**
- **TRANSFER CASE**
- **FRONT PROPELLER SHAFT**
- **MASTER CYLINDER AND HYDRO-BOOST**
- **DIFFERENTIAL**
- **WINCH (6000 lb)**
- **WINCH (9000 lb)**
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 9-2320-280-10 or the applicable maintenance chapters of this manual.

A  AIR RESTRICTION GAUGE - Indicates restrictions in the air cleaner.
B  DIRECTIONAL SIGNAL CONTROL - Activates turn signal lights.
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.
1-12. LOCATION AND DESCRIPTION OF MAJOR INTERIOR COMPONENTS (Cont’d)

1. "R" (Reverse)
2. "N" (Neutral)
3. "D" (Manual Third)
4. "2" (Manual Second)
5. "1" (Manual First)
6. "P" (Park)
7. "R" (Reverse)
8. "N" (Neutral)
9. "D" (Overdrive)
10. "D" (Manual Third)
11. "2" (Manual Second)
12. "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 per model.
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

R.H. HEATER OUTLET
ROTATE CLOCKWISE TO CLOSE

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

TO ADJUST SEAT
Grasp top and front rails of seat firmly at center and lift into desired position.
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

**MAX. VEHICLE OPERATING SPEEDS**

<table>
<thead>
<tr>
<th>TRANSMISSION</th>
<th>&quot;L&quot;</th>
<th>&quot;H&quot;</th>
<th>&quot;H/L&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANGE SELECTION</td>
<td>Low</td>
<td>High</td>
<td>High Lock</td>
</tr>
<tr>
<td>&quot;R&quot; Reverse</td>
<td>11 MPH</td>
<td>29 MPH</td>
<td>11 MPH</td>
</tr>
<tr>
<td>&quot;D&quot; Drive</td>
<td>27 MPH</td>
<td>55 MPH</td>
<td>55 MPH</td>
</tr>
<tr>
<td>&quot;2&quot; Second</td>
<td>19 MPH</td>
<td>48 MPH</td>
<td>48 MPH</td>
</tr>
<tr>
<td>&quot;1&quot; First</td>
<td>11 MPH</td>
<td>29 MPH</td>
<td>29 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:**
- DO NOT EXCEED A SPEED OF 55 MPH (88 KPH)
- DO NOT DRIVE FOR LONG PERIODS OF TIME AT CONSTANT SPEED
- AVOID RAPID ACCELERATION OR DECELERATION
- DRIVE AT MODERATE SPEED UNTIL THE ENGINE IS FULLY WARMED UP
- NO TRAILER TOWING
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES

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

**WARNING**
PRIOR TO STARTING, ENGAGE PARK BRAKE AND SHIFT TRANSMISSION TO NEUTRAL
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**

SEAT BELT HAS NON-LOCKING RETRACTORS. FOR PROPER USE, WEBBING MUST FIRST BE COMPETELY EXTENDED FROM THE NON-LOCKING RETRACTOR DEVICE. ALL EXCESS WEBBING MUST THEN BE ADJUSTED AT THE BUCKLE.

STEERING WHEEL LOCKING DEVICE LOCATED UNDER INSTRUMENT PANEL.
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

SLAVE RECEPTACLE INSIDE

CONNECTING BATTERY CABLES

CAUTION

CONTINUED RELIABILITY OF ELECTRICAL SYSTEM REQUIRES THAT ROUTINE MAINTENANCE BE PERFORMED TO ASSURE GOOD ELECTRICAL CONNECTIONS AND SAFE CABLE POSITIONS

1. BATTERY AND CABLES MUST BE INSTALLED AS SHOWN
2. CABLES MUST LAY DOWN FLAT ON TOP OF BATTERIES
3. LEAD 08 IS 12 VOLT POWER
4. KEEP TERMINALS AND CONNECTIONS CLEAN AND TIGHT APPLY A HEAVY COAT OF GREASE TO BATTERY TERMINALS
HEATER OPERATING INSTRUCTIONS

TO START HEATER:
1. WITH HEATER "HI-LO" SWITCH IN "LO" POSITION, HOLD HEATER SWITCH IN "START" POSITION.
2. WHEN HEATER INDICATOR LIGHT COMES ON, MOVE HEATER SWITCH TO "RUN" POSITION.

TO SELECT TEMPERATURE:
1. SNAP "HI-LO" SWITCH TO DESIRED LEVEL.

TO DEFROST (IF APPLICABLE):
1. CLOSE DAMPER.

IF HEATER FAILS TO START:
1. CHECK "PRESS TO TEST" INDICATOR LIGHT.
2. IF LIGHT WORKS AND HEATER STILL FAILS TO START IN APPROXIMATELY 3 MINUTES, SERVICE IS REQUIRED. SEE SERVICE MANUAL.

NOTE: CLEAN FUEL FILTER FREQUENTLY TO PREVENT ICE FORMATION.
1-13. LOCATION AND CONTENTS OF WARNING, CAUTION, AND DATA PLATES (Cont'd)

**WARNING**

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.

RESTRICT MOVEMENT OF CANNON AMMUNITION IN FIBER CONTAINERS (INNER PACK) IN THE AMMUNITION RACK OF THE HMMWV TO OTHER THAN PUBLIC HIGHWAYS.

**CAUTION**

HIGH INTENSITY NOISE HEARING PROTECTION REQUIRED
### Table 1-1. Differences Between Models

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel/Cargo Operations</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOW Launcher Mounting</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armament Mounting</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S250 Shelter Configuration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambulance:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Litter Patients</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four Litter Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eight Ambulatory Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six Ambulatory Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Litter and Four Ambulatory Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One Litter and Three Ambulatory Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Winch</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Communications:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AN/GRC-160</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>AN/VRC-12 Series</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collective NBC Protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Armor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Supplemental Armor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Howitzer Prime Mover</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Vehicle performance data for the M998 series vehicles is listed in Table 1-2. This information includes only that data applicable to unit maintenance. Information not covered can be found in TM-9-2320-280-10.

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

**STANDARD** | **METRIC**

1. **PAYLOAD**
   - M998, M998A1, M1038, and M1038A1: 2,500 lb | 1,135 kg
   - M1097, M1123, “A1” and “A2” Series: 4,400 lb | 1,998 kg

2. **CAPACITIES**
   - Cooling System: 26 qt | 24.6 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 (3L80): Drain and Refill: 6 qt | 5.7 L
   - W/Dry Converter: 11 qt | 13.2 L
   - Transmission (4L80-E): Drain and Refill: 7.7 qt | 7.3 L
   - W/Dry Converter: 13.5 qt | 12.8 L
   - Transfer Case (model 218): 3.5 qt | 3.3 L
   - Transfer Case (model 242): 3.35 qt | 3.17 L
   - Geared Hub: 1 pt | 0.47 L
   - Steering Hydraulic System: 1 qt | 0.95 L
   - Steering Hydraulic System with Steering Cooler: 1.25 qt | 1.18 L
   - Brake Hydraulic System (All except M1097, M1123, “A1” and “A2” series): 1.2 pt | 0.57 L
   - Brake Hydraulic System (M1097, M1123, “A1” and “A2” series): 1.63 pt | 0.77 L
   - Brake Master Cylinder (All except M1097, M1123, “A1” and “A2” series): 0.69 pt | 0.33 L
   - Brake Master Cylinder (M1097, M1123, “A1” and “A2” series): 1.12 pt | 0.53 L
   - Windshield Washer Reservoir: 1 qt | 0.95 L

*ALL HYDRAULIC SYSTEMS AND ALL FUEL CAPACITIES ARE CALCULATED APPROXIMATIONS
3. ENGINE

<table>
<thead>
<tr>
<th></th>
<th>STANDARD</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>DDA 6.2 L</td>
<td>111.9 kW @ 3,600 rpm</td>
</tr>
<tr>
<td>Type</td>
<td>Diesel, Naturally Aspirated Liquid-Cooled, V8</td>
<td></td>
</tr>
<tr>
<td>Brake Horsepower</td>
<td>150 hp @ 3,600 rpm</td>
<td>119.4 kW @ 3,400 rpm</td>
</tr>
<tr>
<td>Idle Speed</td>
<td>650 ± 25 rpm</td>
<td>69 kPa</td>
</tr>
<tr>
<td>Operating Speed</td>
<td>1,500-2,300 rpm</td>
<td></td>
</tr>
<tr>
<td>Oil Pressure:</td>
<td>10 psi</td>
<td>276-345 kPa</td>
</tr>
<tr>
<td></td>
<td>40-50 psi</td>
<td></td>
</tr>
</tbody>
</table>

4. ENGINE

<table>
<thead>
<tr>
<th></th>
<th>STANDARD</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>DDA 6.5 L and 6.5 L Detuned</td>
<td>119.4 kW @ 3,400 rpm</td>
</tr>
<tr>
<td>Type</td>
<td>Diesel, Naturally Aspirated, Liquid-Cooled, V8</td>
<td></td>
</tr>
<tr>
<td>Brake Horsepower</td>
<td>160 hp @ 3,400 rpm</td>
<td>119.4 kW @ 3,400 rpm</td>
</tr>
<tr>
<td>Idle Speed</td>
<td>700 ± 25 rpm</td>
<td>69 kPa</td>
</tr>
<tr>
<td>Operating Speed</td>
<td>1,500-2,300 rpm</td>
<td></td>
</tr>
<tr>
<td>Oil Pressure:</td>
<td>10 psi</td>
<td>276-345 kPa</td>
</tr>
<tr>
<td></td>
<td>40-50 psi</td>
<td></td>
</tr>
</tbody>
</table>

5. FUEL SYSTEM

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Pump (Mechanical):</td>
<td>Cam-Driven Diaphragm</td>
</tr>
<tr>
<td>Fuel Filter</td>
<td>Fuel/Water Separator</td>
</tr>
<tr>
<td>Air Cleaner:</td>
<td>Dry Element</td>
</tr>
<tr>
<td>Glowplug:</td>
<td>Fast Start</td>
</tr>
</tbody>
</table>

6. COOLING SYSTEM

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surge Tank Cap Pressure</td>
<td>15 psi</td>
</tr>
<tr>
<td>Thermostat:</td>
<td></td>
</tr>
<tr>
<td>Starts to Open</td>
<td>190°F</td>
</tr>
<tr>
<td>Fully Open</td>
<td>212°F</td>
</tr>
<tr>
<td>Radiator:</td>
<td>Downflow</td>
</tr>
<tr>
<td>Fan:</td>
<td>Ten Blade</td>
</tr>
<tr>
<td>Diameter</td>
<td>19 in.</td>
</tr>
</tbody>
</table>

7. ELECTRICAL SYSTEM

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternator:</td>
<td></td>
</tr>
<tr>
<td>60 Ampere</td>
<td>60 A @ 28 V</td>
</tr>
<tr>
<td>100 Ampere</td>
<td>100 A @ 28 V</td>
</tr>
<tr>
<td>200 Ampere</td>
<td>200 A @ 28 V</td>
</tr>
<tr>
<td>400 Ampere</td>
<td>400 A @ 28 V</td>
</tr>
<tr>
<td>Starter:</td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>14 V</td>
</tr>
<tr>
<td>Batteries (2):</td>
<td>Voltage</td>
</tr>
<tr>
<td></td>
<td>12 V</td>
</tr>
</tbody>
</table>
Table 1-2. Tabulated Data (Cont’d)

<table>
<thead>
<tr>
<th>STANDAD</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. TRANSMISSION</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>3L80</td>
</tr>
<tr>
<td>Type</td>
<td>3-Speed, Automatic</td>
</tr>
<tr>
<td>Oil Type</td>
<td>Dexron® II</td>
</tr>
<tr>
<td>Oil Pressure</td>
<td>55-160 psi</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>9. TRANSMISSION</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>4L80-E</td>
</tr>
<tr>
<td>Type</td>
<td>4-speed, Automatic Torque Converter Stall Ratio and Direct Drive w/Lock Up Clutch</td>
</tr>
<tr>
<td>Gear Ratios</td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>2.48:1</td>
</tr>
<tr>
<td>Second</td>
<td>1.45:1</td>
</tr>
<tr>
<td>Third</td>
<td>1.00:1</td>
</tr>
<tr>
<td>Fourth</td>
<td>0.75:1</td>
</tr>
<tr>
<td>Reverse</td>
<td>2.08:1</td>
</tr>
<tr>
<td>Oil Type</td>
<td>Dexron® III</td>
</tr>
<tr>
<td>Oil Pressure</td>
<td>35-324 psi</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>10. TRANSFER CASE</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>NPG 218 w/Cooler</td>
</tr>
<tr>
<td></td>
<td>NPG 242 w/Cooler</td>
</tr>
<tr>
<td>Type</td>
<td>2-speed</td>
</tr>
<tr>
<td>Oil Type</td>
<td>Dexron® II</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>11. SERVICE BRAKE CALIPER (FRONT)</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Kelsey-Hayes</td>
</tr>
<tr>
<td>Piston Diameter</td>
<td>2.6 in. 66 mm</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>12. SERVICE/PARKING BRAKE CALIPER (REAR)</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Kelsey-Hayes</td>
</tr>
<tr>
<td>Piston diameter</td>
<td>2.6 in. 66 mm</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>13. SERVICE BRAKE ROTOR (FRONT)</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Kelsey-Hayes</td>
</tr>
<tr>
<td>A2 Manufacturer</td>
<td>Kelsey-Hayes</td>
</tr>
<tr>
<td>Diameter</td>
<td>10.5 in.</td>
</tr>
<tr>
<td>A2 Diameter</td>
<td>12 in.</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.87 in.</td>
</tr>
<tr>
<td>A2 Thickness</td>
<td>1.02 in.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>14. SERVICE/PARKING BRAKE ROTOR (REAR)</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Kelsey-Hayes</td>
</tr>
<tr>
<td>A2 Manufacturer</td>
<td>Kelsey-Hayes</td>
</tr>
<tr>
<td>Diameter</td>
<td>10.5 in.</td>
</tr>
<tr>
<td>A2 Diameter</td>
<td>12 in.</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.87 in.</td>
</tr>
<tr>
<td>A2 Thickness</td>
<td>1.02 in.</td>
</tr>
</tbody>
</table>
## Table 1-2. Tabulated Data (Cont’d)

### 15. PARKING BRAKE (VEHICLES SERIAL NUMBERS 1 THROUGH 44824)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Rod and Cable Actuated, Caliper</td>
</tr>
<tr>
<td>Rotor Diameter</td>
<td>8 in. 203 mm</td>
</tr>
<tr>
<td>Brake Pad:</td>
<td>Bonded</td>
</tr>
<tr>
<td>Minimum thickness</td>
<td>0.125 in. 3.2 mm</td>
</tr>
<tr>
<td>Lever Type</td>
<td>Over-Center</td>
</tr>
</tbody>
</table>

### 16. WHEELS AND TIRES

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tire size (Bias ply)</td>
<td>36 in. x 12.5 in. x 16.5 in. 91.4 cm x 31.75 cm x 41.9 cm</td>
</tr>
<tr>
<td>Tire size (Radial)</td>
<td>37 in. x 12.5 in. x 16.5 in. 93.98 cm x 31.75 cm x 41.9 cm</td>
</tr>
<tr>
<td>Wheels:</td>
<td>Offset Disc</td>
</tr>
<tr>
<td>Runflat Insert:</td>
<td>2-Piece Magnesium</td>
</tr>
</tbody>
</table>

### 17. STEERING SYSTEM

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steering Gear: Manufacturer</td>
<td>Saginaw</td>
</tr>
<tr>
<td>Type</td>
<td>Variable Ratio</td>
</tr>
<tr>
<td>Ratio</td>
<td>13/16:1</td>
</tr>
<tr>
<td>Power Steering Pump:</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>Saginaw 125</td>
</tr>
<tr>
<td>Output Pressure (max)</td>
<td>1,450 psi 9,998 kPa</td>
</tr>
<tr>
<td>Flow Rate (max)</td>
<td>3.5 gpm 13.2 l/m</td>
</tr>
<tr>
<td>Tow-In (Front/Rear @ curb weight):</td>
<td></td>
</tr>
<tr>
<td>M998, M998A1, M1025, M1025A1, M1025A2, M1026, M1026A1, M1035, M1035A1, M1035A2, M1038, M1038A1, M1043, M1043A1, M1043A2, M1044, M1044A1, M1097, M1097A1, M1097A2, and M1123</td>
<td>0.438 in. ± 0.125 in. 11 mm ± 3.2 mm</td>
</tr>
<tr>
<td>M966, M966A1, M996, M996A1, M997, M997A1, M997A2, M1036, M1037, M1042, M1045, M1045A1, M1045A2, M1046, M1121, and M1046A1</td>
<td>0.312 in. ± 0.125 in. 8 mm ± 3.2 mm</td>
</tr>
</tbody>
</table>

### 18. WINCH

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>W6000D25</td>
</tr>
<tr>
<td>Type</td>
<td>Electric Drive, Thermal Cutoff Switch</td>
</tr>
<tr>
<td>Capacity</td>
<td>6,000 lb 2,724 kg</td>
</tr>
</tbody>
</table>

### 19. WINCH

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>MIL-9000</td>
</tr>
<tr>
<td>Type</td>
<td>Electric Drive, Thermal Cutoff Switch</td>
</tr>
<tr>
<td>Capacity</td>
<td>9,000 lb 4,086 kg</td>
</tr>
</tbody>
</table>

### 19.1. WINCH

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>983-75-50050</td>
</tr>
<tr>
<td>Type</td>
<td>Hydraulic</td>
</tr>
<tr>
<td>Capacity</td>
<td>10,500 lb 4,767 kg</td>
</tr>
</tbody>
</table>

### 20. AIR-CONDITIONING COMPRESSOR

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Sanden</td>
</tr>
<tr>
<td>Model</td>
<td>510</td>
</tr>
<tr>
<td>Field Coil</td>
<td>24V</td>
</tr>
</tbody>
</table>

1-34 Change 1
This section explains how components of the M998 series vehicles work together. The systems (functional groups) covered are listed in the Principles of Operation Reference Index. [paragraph 1-17]

### Section III. PRINCIPLES OF OPERATION

#### 1-16. GENERAL

This section explains how components of the M998 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>
<thead>
<tr>
<th>REF. PARA.</th>
<th>SYSTEM</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-18</td>
<td>Drivetrain Operation</td>
<td>1-36</td>
</tr>
<tr>
<td>1-19</td>
<td>Fuel System Operation</td>
<td>1-37</td>
</tr>
<tr>
<td>1-20</td>
<td>Cooling System Operation</td>
<td>1-38</td>
</tr>
<tr>
<td>1-21</td>
<td>Starting System Operation</td>
<td>1-40</td>
</tr>
<tr>
<td>1-22</td>
<td>Generating System Operation</td>
<td>1-41</td>
</tr>
<tr>
<td>1-23</td>
<td>Generating System Operation (200 Ampere Alternator)</td>
<td>1-42</td>
</tr>
<tr>
<td>1-23.1</td>
<td>Generating System Operation (100 Ampere Dual Voltage Alternator)</td>
<td>1-42.1</td>
</tr>
<tr>
<td>1-23.2</td>
<td>Generating System Operation (200 Ampere Dual Voltage Alternator)</td>
<td>1-42.2</td>
</tr>
<tr>
<td>1-23.3</td>
<td>Generating System Operation (400 Ampere Dual Voltage Alternator)</td>
<td>1-42.3</td>
</tr>
<tr>
<td>1-24</td>
<td>Battery System Operation</td>
<td>1-43</td>
</tr>
<tr>
<td>1-25</td>
<td>Windshield Wiper/Washer System Operation</td>
<td>1-44</td>
</tr>
<tr>
<td>1-26</td>
<td>Parking Brake System Operation</td>
<td>1-45</td>
</tr>
<tr>
<td>1-27</td>
<td>Service/Parking Brake System Operation</td>
<td>1-46</td>
</tr>
<tr>
<td>1-28</td>
<td>Service Brake System Operation</td>
<td>1-47</td>
</tr>
<tr>
<td>1-29</td>
<td>Steering Control System Operation</td>
<td>1-49</td>
</tr>
<tr>
<td>1-30</td>
<td>Suspension System Operation</td>
<td>1-51</td>
</tr>
<tr>
<td>1-31</td>
<td>Ambulance Patient Compartment Fuel Burning Heater System Operation</td>
<td>1-53</td>
</tr>
<tr>
<td>1-33</td>
<td>Stowage Racks and Tiedown Straps</td>
<td>1-55</td>
</tr>
<tr>
<td>1-34</td>
<td>200 Ampere Umbilical Power Cable</td>
<td>1-58</td>
</tr>
</tbody>
</table>
The drivetrain is identical for all models covered in this manual. It converts horsepower into mechanical force to move the vehicle. Major components of the drivetrain are:

**A** **ENGINE** - The water-cooled 6.2 liter, V-8, Diesel engine provides up to 150 horsepower at 3600 rpm to power the vehicle. The 6.5 liter V-8 engine develops approximately 160 horsepower at 3400 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 sealed dipstick, dipstick tube, and vented CDR valve. These differences do not affect engine performance.

**B** **TRANSMISSION (3L80)** - Adapts engine power to meet different driving conditions. The automatic transmission has three forward speeds, a reverse and a neutral. A neutral safety switch prevents the vehicle from being started with the transmission in any selector lever position except neutral. **TRANSMISSION (4L80E)** - 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 9-2320-280-10].

**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** - Transmits 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 all models covered in this manual. It stores, 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** - Directs unused fuel from the injection pump back to the fuel tank.

C. **FUEL SUPPLY LINE** - Directs fuel from fuel tank to the system.

D. **FUEL TANK** - Stores 25 gallons 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 sprays fuel into the combustion chamber.

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

The cooling system removes excess heat from the engine, engine oil, transfer oil, and transmission oil. This system is identical on all models covered in this manual. 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 215°F (102°C) and deactivate 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) 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.
FAN - Pulls outside air through radiator to remove heat from coolant.

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

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

FAN CLUTCH SOLENOID - Actuates hydraulic control valve as required by coolant temperature.

WATER PUMP - Driven by V-belts provides circulation of coolant through cooling system.

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

DRAINCOCK - Draining point for radiator and cooling system.

RADIATOR SHROUD - Permits a greater concentration of air to be pulled through the radiator.
1-21. STARTING SYSTEM OPERATION

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

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

B. **NEUTRAL STARTER SWITCH** - When transmission shift lever is in "N" (neutral) position, this switch closes a relay in the protective control box through circuit 14 allowing battery power to reach the starter solenoid.

C. **PROTECTIVE CONTROL BOX** - Locks out the starter circuit, which prevents starter from reengaging while engine is running.

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 (60/100 AMPERE ALTERNATOR)

The 60 ampere generating system is identical for all vehicles except the M997, M997A1, M997A2 4-litter and M996, M996A1 2-litter ambulances.

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

B ALTERNATOR (100 ampere) – Rated at 28 volts, 100 amperes, with external regulator. The alternator assists and recharges the batteries during operation.

C ALTERNATOR (60 ampere) – Rated at 28 volts, 60 amperes, with internal regulator. The alternator assists and recharges the batteries during operation.

D CIRCUIT 3 – Provides a ground circuit to alternator.

E CIRCUIT 5 – Conducts alternator output to charge the batteries and maintain vehicle voltage.

F CIRCUIT 568 – Senses vehicle voltage activating the field current in the alternator to generate current.
1-23. GENERATING SYSTEM OPERATION (200 AMPERE ALTERNATOR)

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

- **BATTERY GAUGE**: Indicates electrical system voltage. It is connected to the electrical system through circuit 567.
- **ALTERNATOR (200 AMPERE)**: Is rated at 28 volts, 200 amperes, with external regulator. The alternator assists and recharges the vehicle batteries during operation.
- **CIRCUIT 568/CIRCUIT 5 (ALTERNATOR A0013036AA ONLY)**: Senses vehicle voltage, and activates the field current in the alternator to generate current.
- **PROTECTIVE CONTROL BOX**: Protects the vehicle electrical system in the event battery polarity is reversed.
- **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.
- **BATTERIES**: Two 12-volt batteries are connected in a series to provide 24 volts to start vehicle and assist alternator during operation.
- **POSITIVE CABLE**: Transmits alternator output to maintain battery charge. A fuse at the alternator power stud will prevent damage to alternator if battery polarity is reversed.
- **CIRCUIT 3**: Connects to negative stud on alternator with engine ground strap to provide a ground circuit to alternator.
1-23.1. GENERATING SYSTEM OPERATION (100 AMPERE DUAL VOLTAGE ALTERNATOR)

The 100-ampere dual voltage generating system maintains battery charge and provides electrical power to operate vehicle circuits. Major components of the generating system are:

- **BATTERY GAUGE** – Indicates electrical system voltage. It is connected to the electrical system through circuit 567.
- **ALTERNATOR (100 AMPERE)** – Is rated at 28 volts at 100 amperes and 14 volts at 50 amperes with external regulator. The alternator assists and recharges the vehicle batteries during operation.
- **CIRCUIT 568** – Senses vehicle voltage, and activates the field current in the alternator circuit to alternator.
- **PROTECTIVE CONTROL BOX / DISTRIBUTION BOX** – Protects the vehicle electric system in the event battery polarity is reversed. Provides load dump, glow plug operation, and interfacing of engine and body harnesses.
- **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.
- **BATTERIES** – Two 12-volt batteries are connected in a series to provide 24 volts to start vehicle and assist alternator during operation.
- **POSITIVE CABLE 6** – Provides 28-volt alternator output to maintain charge across two batteries.
- **POSITIVE CABLE 68A** – Provides 16-volt alternator output to maintain charge across the lower battery.
- **CIRCUIT 3** – Connects to negative stud on alternator with engine ground strap to provide a ground circuit to alternator.

*Distribution box provides same function as protective control box except distribution box does not protect against reversal of battery polarity.*
1-23.2. GENERATING SYSTEM OPERATION (200 AMPERE DUAL VOLTAGE ALTERNATOR)

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

- **BATTERY GAUGE** – Indicates electrical system voltage. It is connected to the electrical system through circuit 567.
- **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.
- **CIRCUIT 568** – Senses vehicle voltage, and activates the field current in the alternator circuit to alternator.
- **PROTECTIVE CONTROL BOX / DISTRIBUTION BOX** – Protects the vehicle electric system in the event battery polarity is reversed. Provides load dump, glow plug operation, and interfacing of engine and body harnesses.
- **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.
- **BATTERIES** – Two 12-volt batteries are connected in a series to provide 24 volts to start vehicle and assist alternator during operation.
- **POSITIVE CABLE 6** – Provides 28-volt alternator output to maintain charge across two batteries.
- **POSITIVE CABLE 68A** – Provides 16-volt alternator output to maintain charge across the lower battery.
- **CIRCUIT 3** – Connects to negative stud on alternator with engine ground strap to provide a ground circuit to alternator.

* Distribution box provides same function as protective control box except distribution box does not protect against reversal of battery polarity.
1-23.3. GENERATING SYSTEM OPERATION (400 AMPERE DUAL VOLTAGE ALTERNATOR)

The 400-ampere dual voltage generating system maintains battery charge and provides electrical power to operate vehicle circuits. Major components of the generating system are:

- **BATTERY GAUGE** – Indicates electrical system voltage. It is connected to the electrical system through circuit 567.
- **ALTERNATOR (400 AMPERE)** – Is rated at 28 volts at 400 amperes and 14 volts at 50 amperes with external regulator. The alternator assists and recharges the vehicle batteries during operation.
- **CIRCUIT 568** – Senses vehicle voltage, and activates the field current in the alternator circuit to alternator.
- **PROTECTIVE CONTROL BOX / DISTRIBUTION 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.
- **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.
- **BATTERIES** – Two 12-volt batteries are connected in a series to provide 24 volts to start vehicle and assist alternator during operation.
- **POSITIVE CABLE 6** – Provides 28-volt alternator output to maintain charge across two batteries.
- **POSITIVE CABLE 68A** – Provides 16-volt alternator output to maintain charge across the lower battery.
- **CIRCUIT 3** – Connects to negative stud on alternator with engine ground strap to provide a ground circuit to alternator.

* Distribution box provides same function as protective control box except distribution box does not protect against reversal of battery polarity.
The battery system is identical for all vehicles covered in this manual and consists of the following circuits and components.

A. CIRCUIT 6A - Connects the batteries to the starter and to the protective control box through circuit 74A.

B. BATTERIES - Two 6TN batteries are connected to provide 24 volts D.C. for the electrical starting system.

C. 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.

D. SHUNT - Used when measuring current draw from batteries utilizing STE/ICE-R.

E. PROTECTIVE CONTROL BOX - Protects the vehicle electrical system in the event the battery system polarity is reversed.

F. ROTARY SWITCH - When in "START" position actuates starter solenoid through circuit 11A and 74A. When in "RUN" position closes circuit 29A to activate instrument cluster gauges through circuit 27.

G. CIRCUIT 7A - Connects the battery system to the starter negative terminal and chassis ground.

H. STARTER SOLENOID - Actuates starter motor gear to crank vehicle engine.
1-25. 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.
The parking brake system for vehicles with serial numbers 1 through 44824 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 service brake system failure. Major components of the parking brake system are:

- **PARKING BRAKE ROTOR** - Attached to pinion flange on rear differential, rotor prevents pinion flange from turning when parking brake is applied.
- **BRAKE PADS** - Apply friction to rotor when hand lever is applied.
- **PARKING BRAKE CALIPER** - Forces brake pads against rotor when hand lever is applied.
- **PARKING BRAKE CABLE** - Connects brake caliper to parking brake rod at bracket on left frame rail.
- **PARKING BRAKE ROD** - Connects parking brake hand lever to parking brake cable by means of an adjustable clevis.
- **PARKING BRAKE HAND LEVER** - Permits operator to engage the parking brake.
- **PARKING BRAKE HAND LEVER ADJUSTING CAP** - Permits operator to make minor tension adjustment of parking brake.
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:

- **PARKING BRAKE ROTORS** - Attached to output flanges on rear differential, rotors prevent output flanges from turning when parking brake is applied.
- **BRAKE PADS** - Apply friction to rotors when hand lever is applied.
- **PARKING BRAKE CALIPERS** - Forces brake pads against rotors when hand lever is applied.
- **PARKING BRAKE CABLES** - Connects parking brake hand lever to equalizer bar.
- **EQUALIZER BAR** - Evenly distributes braking pressure to the rear brake rotors.
- **PARKING BRAKE ROD** - Connects parking brake hand lever to equalizer bar.
- **PARKING BRAKE HAND LEVER** - Permits operator to engage the parking brake.
- **PARKING BRAKE HAND LEVER ADJUSTING CAP** - Permits operator to make minor tension adjustment of parking brake.
1-28. SERVICE BRAKE SYSTEM OPERATION

The service brake system is identical for all 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 HYDRO-BOOST - Converts hydraulic power from the steering pump to mechanical power to the master cylinder, providing power assist during braking.

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

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

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

E BRAKE PEDAL - Provides operator control for stopping vehicle.

F BRAKE LINKAGE - Directs brake pedal pressure to hydro-boost.
1-28. SERVICE BRAKE SYSTEM OPERATION (Cont'd)

A HYDRAULIC BRAKE LINES - Directs brakes 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.
1-29. STEERING CONTROL SYSTEM OPERATION

The steering system is identical for all 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 supplied by power steering pump.

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

C ACCESSORY DRIVE PULLEY BELTS – Transmits mechanical driving power from crankshaft drive pulley to steering pump pulley which drives the steering pump.

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 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.
1-29. STEERING CONTROL SYSTEM OPERATION (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.
1-30. **SUSPENSION SYSTEM OPERATION**

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

- **BALL JOINTS** – Connects geared hub to control arms, and allows change of angle between geared hub and control arms during suspension movement.
- **UPPER CONTROL ARM** – Connects geared hub to frame rail.
- **STABILIZER BAR (FRONT ONLY)** – Prevents vehicle sway when cornering.
- **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.
- **LOWER CONTROL ARM** – Connects geared hub to frame rail.
- **SHOCK ABSORBER** – Dampens suspension movement and limits amount of suspension travel.
- **COIL SPRING** – Supports weight of vehicle and allows suspension travel to vary depending on terrain and vehicle loading.
1-30. SUSPENSION SYSTEM OPERATION (Cont’d)

A  RADIUS ROD (REAR ONLY) - Connects geared hub to frame, to maintain rear end alignment.
The ambulance patient compartment fuel burning heater in the M996, M996A1, M997, M997A1, and M997A2 vehicles are similar in that they are multi-fuel burning and heat filtered fresh air. Major components of the fuel burning heater system are:

A  **FRESH AIR INTAKE GRILLE** — The entry point of fresh air for the heater and ventilation system. The grille stops large debris from entering the system.

B  **FRESH AIR FILTER** — Filters out dust and dirt which could foul the system.

C  **FUEL BURNING HEATER** — A self-contained heater/blower unit which heats filtered fresh air with a heat exchanger and forces it out to heat vents in the patient compartment.

D  **HEATER EXHAUST PIPE** — Outlet for exhaust gases from fuel burning heater.

E  **HEATING/VENTILATION AND AIR-CONDITIONING SYSTEM (HVAC) CONTROL BOX** — The central point of operation for fuel burning heater.

F  **ELECTRICAL SYSTEM FUSE BOX** — Provides electrical overload protection for the HVAC system.

G  **MANUAL SHUTOFF VALVE** — Stops fuel flow to heater in an emergency or when performing maintenance on the heater.

H  **FUEL FILTER** — Filters contaminants out of the fuel for efficient burning.

I  **FUEL PUMP** — Pumps fuel out of the fuel tank and provides fuel pressure to the rest of the system. Pump will not draw fuel if tank is below 1/4 tank.

J  **FUEL TANK** — The supply point of fuel for fuel burning heater.

K  **FUEL LINES** — Supply fuel to the fuel burning heater.
The air-conditioning system covered in this manual applies only to the M997, M997A1, and M997A2 vehicles and 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 condenser.

C. **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.

D. **Liquid Line** - High pressure liquid refrigerant is carried back to the evaporator by the liquid line to repeat the evaporation/condensation cycle.

E. **Expansion Valve** - High pressure liquid refrigerant enters a non-adjustable expansion valve where the refrigerant is formed into a liquid spray.

F. **Evaporator** - Refrigerant enters evaporator as a liquid spray. It absorbs heat from the air in the patient compartment and vaporizes into a low pressure gas.

G. **Suction Line** - Refrigerant in low pressure gas form is drawn from the evaporator by the suction action of the compressor.
1-33. STOWAGE RACKS AND TIEDOWN STRAPS

The stowage racks and tiedown straps covered in this manual apply to the M1097, M1097A1, M1097A2, and M1123 vehicles and consist of the following major components:

A  AMMO STOWAGE RACK AND AMMO STRAP ASSEMBLY — Provides stowage for twenty-two ammunition rounds during transportation and allows quick access to rounds during reload operations.

B  M60 MACHINE GUN STRAPS (two each) — Secure M60 machine gun on top of ammo rack.

C  JACK STRUT SPRING CLIPS (two each) — Secure jack strut on top of ammo rack.

D  PARALLELOSCOPE SPIKE CLIPS (four each) — Secure two aiming stacks on top of ammo rack.

E  SIGHT BOX #1 STRAPS (two each) — Secure sight box #1 to cargo floor in front of ammo rack.

F  SIGHT BOX #2 STRAP — Secure sight box #2 to cargo floor in front of ammo rack.

G  SPADE STRAPS (two each) — Secure spade on cargo floor and against cargo bulkhead.

H  SECTION CHEST STRAPS (two each) — Secure section box on cargo floor.
1-33. STOWAGE RACKS AND TIEDOWN STRAPS (Cont'd)

A FUEL CAN STRAP - Secures fuel cans to cargo bulkhead in front of right footwell.

B REMOTE STRAP - Secures remote to right fixed door behind companion seat.

C TRIPOD STRAPS (two each) - Secure tripod to bottom of troop seat.

D TELEPHONE STRAP - Secures telephone to right fixed door in front of wheelhouse.

E PARALLELOSCOPE AIMING POST STRAPS (three each) - Secure paralleloscope and aiming posts to cargo floor and right wheelhouse.

F CABLE REEL STRAPS (two each) - Secure cable reels to right footwell in front of wheelhouse.
1-33. STOWAGE RACKS AND TIEDOWN STRAPS (Cont'd)

G  **G.D.U. BATTERY STRAP** - Secures G.D.U. battery to left fixed door in front of wheelhouse.

H  **WATER CAN STRAP** - Secures water cans to cargo bulkhead in front of left footwell.


J  **CAMOUFLAGE STOWAGE RACK AND STRAPS (three)** - Provide stowage for camouflage screen and support system during transportation.
1-34. **200 AMPERE UMBILICAL POWER CABLE**

The 200 ampere umbilical power cable covered in this manual applies to the M1097A2 and M1123 vehicles 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 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, Diagnostic Equipment (TMDE), and Support Equipment used to maintain the vehicles covered in this manual can be found in TM 9-2320-280-24P.

2-3. REPAIR PARTS
Repair parts are listed and illustrated in TM 9-2320-280-24P.

Section II. SERVICE UPON RECEIPT

2-4. 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 be sure they are in proper working order.
   (2) Secure, clean, lubricate, or adjust as needed.
   (3) Check all Basic Issue Items [TM 9-2320-280-10] to be sure every item is present, in good condition, and properly mounted, or stowed.
   (4) Follow general procedures for all services and inspections given in [TM 9-2320-280-10].

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

c. See [TM 9-2320-280-10] when checking equipment for proper operation.

d. Refer to [TM 9-2320-280-10] for information concerning brake-in procedures.

2-5. GENERAL INSPECTION AND SERVICING INSTRUCTIONS
The following steps should be taken while performing general inspection and services:

NOTE
Cooler fin and engine protective covers can be used to prevent damage to the vehicle components during maintenance. Refer to Appendix D for fabrication instructions.

(1) Use [TM 9-2320-280-10] 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 18).
(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.

**WARNING**

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

**NOTE**

Use compressed air to dry electrical components. Use sealing compound (Appendix C, Item 40) before reconnecting plugs.

(4) Inspect electrical connectors for corrosion and/or damage (i.e., bent pins). Clean and repair damage. Clean electrical components with clean cloth dampened with drycleaning solvent. Care must be taken not to damage protective insulation.

(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.

### 2-6. SPECIFIC INSPECTION AND SERVICING INSTRUCTIONS

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

1. Do the Semiannual (S) 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 514 (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, 9-3, or 9-4).
7. Remove front lifting shackles from stowed position under passenger seat and install on towing brackets (para. 9-13).

### Section III. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

#### 2-7. GENERAL

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 your 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).

#### 2-8. INTERVALS

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

1. **Semiannually (S)**. Every 6 months or 3,000 miles (4,800 km), whichever comes first.
2. **Annually (A)**. Every 12 months or 6,000 miles (9,654 km), whichever comes first.
3. **Biennially (B)**. Every 24 months or 12,000 miles (19,308 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 (S) 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 (S) Preventive Maintenance Service.

(2) **Army Oil Analysis Program (AOAP).** HMMWV engines and transmissions are enrolled in the Army Oil Analysis Program (AOAP). The sampling interval for the engine is every six months or 3,000 miles, or 100 hours (if hour meter is installed) of operation. For the transmission, the sampling interval is every 12 months or 6,000 miles, or 300 hours (if hour meter is installed) of operation.

(3) **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 (S) inspections in addition to (A) inspections at the time of the annual inspection. Perform all (A) and (S) inspections in addition to (B) inspections at the time of the biennial inspection.

### 2-9. REPORTING REPAIRS

All vehicle shortcomings will be reported on DA Form 2404 Equipment Inspection and Maintenance Worksheet or DA Form 5988-E (automated) (DA Pam 738-750) immediately after the PMCS, and before taking corrective action. All vehicle deficiencies will be reported in the equipment record.

### 2-10. GENERAL SERVICE AND INSPECTION PROCEDURES

a. While performing specific PMCS procedures, make sure 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, or wrench, 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 9-2320-280-10](#) 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 18) 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 9-2320-280-10](#) for general vehicle cleaning instructions.
2-11. 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) **Intervals.** 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 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>Semi-Annual</td>
<td>Pre-Service Checks</td>
<td><strong>PRIOR TO ROAD TEST</strong>&lt;br&gt;Ensure Operator/Crew has performed PMCS listed in TM 9-2320-280-10.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td><strong>ROAD TEST</strong>&lt;br&gt;Maintenance personnel will be with vehicle operator to assist in performing PMCS checks and verify pre-service checks.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>a.</strong> Notice if starter engages smoothly and turns the engine at normal cranking speed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>b.</strong> 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></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>c.</strong> 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></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>NOTE</strong>&lt;br&gt;If desired range cannot be selected, turn engine off, select range, and re-start engine.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>d.</strong> 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></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>e.</strong> Test for response to accelerator feed. Observe for sticking pedal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>f.</strong> With vehicle speed 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></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>g.</strong> 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></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>a.</strong> Starter inoperative or makes excessive grinding sound.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>b.</strong> Engine knocks, rattles, or smokes excessively.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>c.</strong> Transmission shifts improperly, does not shift, or makes excessive noises.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>d.</strong> Lever inoperable or does not engage in all ranges with engine not running.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>e.</strong> Pedal sticking or binding.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>f.</strong> Steering binds, grabs, wanders, or has excessive freeplay.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>g.</strong> Brakes chatter, pull to one side, or inoperative. Brakes will not release.</td>
<td></td>
</tr>
</tbody>
</table>

**TM 9-2320-280-20-1**

Change 1  2-5
### Table 2-1. Unit Level Preventive Maintenance Checks and Semites 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>
| 1        | Semi-Annual    | Pre-Service Checks (Cont’d)| **h.** Bring vehicle to full stop. Engage parking brake while transmission is still in “D” (drive) or “D” (overdrive) for A2 series vehicles. Vehicle should remain stationary.  
 **i.** Observe vehicle response to road shock. Side sway or continuous bouncing indicates a malfunction. | **h.** Parking brake doesn't hold vehicle stationary. |
| 2        | Semi-Annual    | Body                       | **AFTER ROAD TEST**  
 **a.** Make sure the vehicle has been cleaned of mud, gravel, etc., from the underbody, outside, and crew compartment area.  
 **b.** Thoroughly wash all underbody sheet metal panels and corners.  
 **NOTE**  
 Lubricate vehicle in accordance with Lubrication Table.  
 **c.** Inspect for loose rivets, cracks, loose or missing bolts and general body damage. | **c.** Any body damage that would hinder vehicle operation. |
| 3        | Semi-Annual    | 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.  
 **FUEL/WATER SEPARATOR** | **a.** Any class III fuel leak.  
 **b.** Any class III leak. Any nozzle loose or damaged.  
 **c.** Rubber cap missing or damaged. |
<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-Annual | Fuel System (Cont’d) | d. Inspect all fuel lines for loose connections, splits, cracks, and bends that could leak.  
        |          |                      | e. Disconnect leads from each glow plug (paragraph 3-38) and check for resistance between glow plug terminal and ground. Continuity should be present.  
        |          |                      | f. Check each glow plug for looseness and damage. Tighten each plug to 8-12 lb-ft (11-16 N-m).  
        |          |                      | g. Check locknut on body mounts. Proper torque 90 lb-ft (122 N-m).  
        |          |                      | h. Check the 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). |
| 4       | Semi-Annual | Engine Accessory Drive and Serpentine Belt | a. Check for missing, broken, cracked, and frayed drivebelts. Ensure serpentine drivebelt has not moved out of place on pulley.  
        |          |                      | b. (All models except M1123 and “A2” vehicles). Check all drivebelts tension using belt tension gauge. Belt tension should be 70 lbs (311 N) minimum. If belt tension is not at least 70 lbs (311 N), adjust drivebelts (paragraph 3-82). Tension should not be greater than 110 lbs (489 N) for new belts; old belts 95 lbs (422 N). |
| 5       | Semi-Annual | Protective Control Box | a. Inspect four nuts for security of mounting.  
        |          |                      | b. Ensure cannon plugs are securely connected to box. |

**NOT FULLY MISSION CAPABLE IF:**

- d. Any class III leak.
- e. Continuity is not present.
- f. Glow plugs are loose or damaged.
- g. Body mounts loose.
- h. Any class III fuel leak or tank strap improperly installed or loose.
- a. Any drivebelt is missing, broken, frayed, or dry-rotted. 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. (51 mm) long. Serpentine belt has moved out of place on pulleys.
- b. Tension below 70 lbs (311 N), or greater than 110 lbs (489 N) new belt and 95 lbs (422 N) old belts.
- a. Mounting not secure, four nuts loose.
<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>
| 6       | Semi-Annual | 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.  

**NOTE**  
Ž Coolant level is correct when coolant recovery tank is full (TM 9-2320-280-10).  
Ž Use MIL-A-46153 in temperatures above 0°F (-18°C) and MIL-A-11755 in temperature below 0°F (-18°C).  

**a.** Check coolant condition. Test coolant to see if draining is necessary (TB 750-651).  

**b.** 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.  

|          |          |          |            | a. Coolant condition/testing shows draining is required.  
|          |          |          |            | b. Any class III water leak. Hoses cracked or dry rotted. |
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>
| 7       | Semi-Annual  | Air-Intake System     | **WARNING**
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.

a. Inspect and clean air cleaner element and housing (para. 3-13).

b. 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. Correct CDR function is determined by checking vacuum with a water manometer. (para. 3-9a).

**CAUTION**
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.

c. Remove and wipe off the CDR valve and hoses with a rag.

b. CDR fails water manometer vacuum test.
<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>
| 8       | Semi-Annual  | 60, 100, and 200 Amp Alternators      | a. Inspect alternator and voltage regulator (200 amp only) for condition, proper installation, and security of mounting.  
          |              |                                       | b. Inspect electrical wiring for broken strands, frayed, cracked or worn insulation, and loose connections.                   | a. Mounting bolts missing or alternator damaged. |
|         |              |                                       | c. Deleted                                                                   | b. Wiring frayed, broken, or loose connections.                              | d. Any alternator mounting bolt is loose. |
|         |              |                                       | d. Check alternator mounting bolts for security of mounting. Tighten bolts to 40 lb-ft (54 N•m).                              |                                |
| 9       | Semi-Annual  | Accelerator Linkage                   | Inspect for bends, excessive play, cracks, and damage that could cause failure.                                              | Linkage damaged, bent, or cracked.                                           |
| 10      | Semi-Annual  | Suspension and Steering System        | **NOTE**                                                                    |                                |
|         |              |                                       | If access to locknut is a problem, remove geared hub from control arm (para. 8-3). Check front and rear lower ball joint mounting. For M996, M997, M1042, M1037, M1097, M1123, and “A1” and “A2” series vehicles, tighten rear lower ball joint to lower control arm locknuts to 60 lb-ft (81 N•m) and front to 35 lb-ft (48 N•m). All other models, tighten front and rear lower ball joint to lower control arm locknuts to 35 lb-ft (48 N•m) and ensure cotter pin is present. Tighten ball joint slotted nut to 73 lb-ft (99 N•m) and ensure cotter pin is present.                                |
|         |              |                                       | a. Remove wheel and tire assembly (para. 8-3). Check front and rear lower ball joint mounting. For M996, M997, M1042, M1037, M1097, M1123, and “A1” and “A2” series vehicles, tighten rear lower ball joint to lower control arm locknuts to 60 lb-ft (81 N•m) and front to 35 lb-ft (48 N•m). All other models, tighten front and rear lower ball joint to lower control arm locknuts to 35 lb-ft (48 N•m) and ensure cotter pin is present. Tighten ball joint slotted nut to 73 lb-ft (99 N•m) and ensure cotter pin is present.                                |
|         |              |                                       | b. Check front and rear upper ball joint mounting. Tighten upper ball joint to upper control arm locknuts to 21 lb-ft 29 (N•m). Tighten upper control arm to control arm bracket locknuts to 260 lb-ft (353 N•m). Tighten ball joint slotted nut to 65 lb-ft (88 N•m) and ensure cotter pin is present.  
<pre><code>      |              |                                       | **NOTE**                                                                    | b. Capscrews or locknuts are finger or hand turnable.                         |
</code></pre>
<p>|         |              |                                       | Do not over lubricate ball joints, one or two shots is adequate.              |                                |
|         |              |                                       | c. Lubricate front and rear upper ball joints with GAA.                      |                                |</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>
<tbody>
<tr>
<td>10</td>
<td>Semi-Annual</td>
<td>Suspension and Steering System (Cont'd)</td>
<td><strong>NOTE</strong>&lt;br&gt;Do not lubricate shock absorber bushings, radius rod bushings, stabilizer bar bushing, or suspension arm pivot bushing.</td>
<td><strong>d.</strong> Control arm bent, bushing worn or obvious damage that would hinder operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>d.</strong> 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><strong>e.</strong> Inspect steering column U-joints, tie rods or radius rods, pitman arm, center link, and idler arm for breaks, cracks, and wear.</td>
<td><strong>e.</strong> U-joints, tie rods, pitman arm or idler arm are worn or cracked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>e.1.</strong> Inspect steering column for security of mounting hardware.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>f.</strong> Inspect steering gear for mounting security. Tighten mounting bolts to 60 lb-ft (81 N·m).</td>
<td><strong>f.</strong> Any mounting bolt missing or unserviceable.</td>
</tr>
</tbody>
</table>

**CONTROL ARM BUSHINGS**

- Control arm bushings
- Shock absorber bushing
- Stabilizer bar bushing
- Suspension arm pivot bushing

**CONTROL ARM BRACKET**

- Control arm bracket
- Springs

**CONTROL ARMS**

- Control arms

**UPPER BALL JOINT**

- Upper ball joint

**BRACKET**

- Bracket

**PITMAN ARM**

- Pitman arm

**CENTER LINK**

- Center link

**IDLER ARM**

- Idler arm

**TIE RODS**

- Tie rods
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-Annual</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-Annual</td>
<td>Brake System</td>
<td>a. Inspect master cylinder, hydro-boost, 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, Silicone Brake Fluid (BFS), for filling master brake cylinder. Failure to use BFS will cause damage to brake cylinder.
- Thoroughly clean exterior of master cylinder cover before removing cover (Table 2-11). Dirt, water, or grease will contaminate brake fluid causing brake system damage.
- Do not use screwdriver to remove cover. Damage to bail wire will result.
- 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.

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

b. Level below 1/8 inch (3.2 mm) from top of master cylinder reservoir.
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-Annual</td>
<td>Brake System (Cont'd)</td>
<td>c. Inspect service brake pads and rotor disks for wear (para. 7-11).</td>
<td>c. Service brake pads less than 1/8 inch (3.2 mm).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d. Inspect parking brake pads and rotor disk for wear (para. 7-3).</td>
<td>d. Parking brake pads less than 1/8 inch (3.2 mm).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d.1. Inspect brake calipers and mounting hardware for damage or loose hardware.</td>
<td>d.1. Brake calipers are damaged or mounting bolts are loose.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>e. Inspect dual service/park brake pads and rotor for wear (para. 7-21).</td>
<td>e. Brake pads less than 1/8 inch (3.2 mm).</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>11</td>
<td>Semi-Annual</td>
<td>Brake System (Cont’d)</td>
<td><strong>f.</strong> Inspect parking brake cable, cable clip, lever, spring, and pushrod/guide pin for binding and loose components.</td>
<td><strong>f.</strong> Parking brake binding or cable frayed or broken. Spring or cable clip missing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>g.</strong> On vehicles equipped with a single parking brake assembly mounted between the rear prop shaft and rear differential, lubricate parking brake lever, parking brake cam, parking brake push pins, and parking brake guide pins with WTR. On vehicles equipped with a left and right parking/service brake assembly mounted between the rear axle half-shafts and rear differential, lubricate the parking brake lever with WTR. The parking/service brake assembly needs no lubrication.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>h.</strong> Inspect rear parking brake cables for damage and/or chaffing in the area of the control arm. If cables are damaged, replace cables (paragraph 7-23 or 7-24).</td>
<td><strong>h.</strong> Parking brake binding or cable frayed or broken.</td>
</tr>
<tr>
<td>12</td>
<td>Semi-Annual</td>
<td>Engine and Transmission Mounts</td>
<td><strong>a.</strong> Inspect engine mounts and insulators for loose, worn, and damaged condition.</td>
<td><strong>a.</strong> Engine mounts or insulators cracked, damaged, loose, or worn.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>b.</strong> Check for loose or missing engine mount capscrews and locknuts. If engine mount capscrews or locknuts are loose or missing, notify DS maintenance.</td>
<td><strong>b.</strong> Capscrews or locknuts, loose or missing.</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>12</td>
<td>Semi- Annual</td>
<td>Engine and Transmission Mount (Cont’d)</td>
<td>c. Using 3/4 inch torque adapter (refer to Appendix B, Item 145), tighten two capscrews securing transmission mount to adapter to 65 lb-ft (88 N(\cdot)m). Tighten two locknuts securing transmission mount to crossmember to 28 lb-ft (38 N(\cdot)m).</td>
<td>c. Transmission mount loose, cracked, or damaged.</td>
</tr>
<tr>
<td>13</td>
<td>Semi- Annual</td>
<td>Starter</td>
<td>a. Inspect starter for mounting security. Tighten mounting bolts to 40 lb-ft (54 N(\cdot)m).</td>
<td>a. Mounting bolt missing or will not torque.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Inspect cables and studs for loose nuts and damage.</td>
<td>b. Stud nut loose.</td>
</tr>
<tr>
<td>13.1</td>
<td>Semi- Annual</td>
<td>Neutral Start Safety Switch</td>
<td><strong>WARNING</strong> Ensure vehicle parking brake is set, wheels are chocked, and rotary switch is in the ENG STOP position. Failure to comply may result in injury to personnel and/or damage to equipment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Disconnect wires 14A and 14B from wires 14 at neutral start safety switch.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Check for continuity of neutral start safety switch.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>(1)</em> With transmission shift lever in N (neutral), or P (park) (for M1123, A2 series, and up-armor models only), continuity should be present between wires 14 at neutral start safety switch.</td>
<td></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>13.1</td>
<td>Semi-Annual</td>
<td>Neutral Start Safety Switch (Cont'd)</td>
<td>(2) Place transmission shift lever in D (drive). There should be no continuity present between wires 14. If continuity is present, replace neutral start safety switch (para. 5-6).</td>
<td>a. Vent line cracked, plugged, or missing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Connect wires 14A and 14B to wires 14 at neutral start safety switch.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Semi-Annual</td>
<td>Transmission</td>
<td>a. Inspect vent lines and connectors for security, cracks, and deterioration.</td>
<td>b. Shift linkage is unserviceable.</td>
</tr>
<tr>
<td>15</td>
<td>Semi-Annual</td>
<td>Transfer</td>
<td>a. Inspect transfer case vent lines and connectors for security, cracks, and deterioration.</td>
<td>a. Vent line cracked, plugged or missing. Shift linkage is unserviceable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Inspect transfer case shift linkage for bends, excessive play, cracks, and damage that could cause failure.</td>
<td></td>
</tr>
</tbody>
</table>

**CAUTION**

Use Dexron® II for filling transfer case. Failure to use Dexron® II will cause damage to transfer case.

c. Check transfer case fluid level every 3,000 (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).
### 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>15</td>
<td>Semi-Annual</td>
<td>Transfer (Cont’d)</td>
<td><strong>NOTE</strong></td>
<td>d. Any class III oil leak or damage to spiral wrap.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>CAUTION</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Change geared hub and differential lubricants when required by maintenance repair action, contaminated by water or foreign material, or if lubricant appears by smell, feel, or visual indication to be overheated.</td>
</tr>
</tbody>
</table>

**NOTE**
- Do not overtorque retaining nuts.
- d. Inspect oil cooler lines for leaks or damage. Check for loose oil cooler line nuts and damage to the spiral wrap on the cooler line. If oil cooler line nuts are loose, hold end of oil cooler stationary, and tighten line nuts to 194-212 lb-in. (22-24 N·m)

<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-Annual</td>
<td>Driveline Components</td>
<td>a. Inspect geared hub vent lines and connectors for security, cracks, and deterioration.</td>
<td>a. Hub vent lines cracked, plugged, or missing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Inspect geared hub for leaking seals and damage.</td>
<td>b. Class III leaks or damage.</td>
</tr>
</tbody>
</table>

**CAUTION**
- Change geared hub and differential lubricants when required by maintenance repair action, contaminated by water or foreign material, or if lubricant appears by smell, feel, or visual indication to be overheated.

**NOTE**
- Fill each axle differential with 2 quarts (1.9 L) of GO.
- Fill each geared hub with 1 pint (0.5 L) of GO.
- c. Adjust spindle bearing (paragraph 6-14).
- d. Inspect differential vent lines and connectors for security, cracks, and deterioration.
- e. Inspect differentials for leaking seals and cracks.
<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-Annual</td>
<td>Driveline Components (Cont’d)</td>
<td>f. M998, M998A1, and M1121 series vehicles – Check differential lubricant level semiannually or every (3,000 miles) (4,830 km). M998A2 and M1123 series vehicles – Change differential lubricant semiannually or every 3,000 miles (4,830 km). Differential level should be within 1/4 inch (6.4 mm) of fill plug opening when lubricant is cold or to plug level when hot. g. U-joint is damaged, unserviceable, or missing lubrication fitting. h. Loose, missing, or broken capscrews. i. Rubber block or center support bearing is worn or propeller shaft wobbles.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

![Diagram of driveline components]
<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-Annual</td>
<td>Driveline Components (Cont'd)</td>
<td>j. Tighten halfshaft mounting bolts to 48 lb-ft (65 N•m).</td>
<td>j. Loose, missing, or broken bolts.</td>
</tr>
<tr>
<td>17</td>
<td>Semi-Annual</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>18</td>
<td>Semi-Annual</td>
<td>Frame and Cross-members</td>
<td>a. Inspect frame side rails for cracks, breaks, bends, wear, deterioration, and missing or loose fasteners. b. Inspect crossmembers for cracks, breaks, bends, deterioration, and loose or missing fasteners. c. Inspect for missing, broken, bent, or loose bumper supports before towing a trailer.</td>
<td>a. Any loose or missing fasteners, cracks, bends, or breaks in frame. b. Any loose or missing fasteners. Cracks, bends (bends are defined as a condition that would affect vehicle operation) or breaks in cross-members. c. Any missing, broken, bent, or loose bumper supports.</td>
</tr>
<tr>
<td>19</td>
<td>Semi-Annual</td>
<td>Tires</td>
<td>Warning: 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 in serious injury or death and damage to equipment. Radial and bias ply tires should not be mixed on the same vehicle. Injury to personnel and damage to equipment may result.</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE**

Vehicle must be up on jack stands for the following checks.

a. Check tread depth of tires with tire gauge. If tread depth is less than 1/16 in. (1.59 mm), replace tire in approximately 400 miles (644 km), bias tires will wear 1/32 in. (0.79 mm), radial tires will take approximately 1,300 miles (2092 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). a. Tread depth is less than 1/16 in. (1.59 mm).
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>
</table>
| 19       | Semi-Annual| Tires (Cont'd)        | **b.** Inspect tires for uneven wear and balance (paragraph 8-9). For normal wear, rotate tires as shown in rotation diagram. The vehicle's wheel alignment is optimumly 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 rim (para. 8-4).

  **c.** Rotate tires as diagram shows.

**ROTATION DIAGRAM**

**d.** Tighten wheel lug nuts to 90-110 lb-ft (122-149 N·m) in tightening sequence shown.

**TIGHTENING SEQUENCE**

<table>
<thead>
<tr>
<th>NOT FULLY MISSION CAPABLE IF:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>b.</strong> Tires exhibit excessive or uneven wear or balance.</td>
<td></td>
</tr>
<tr>
<td><strong>d.</strong> Any broken studs, loose or missing lug nuts.</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>19</td>
<td>Semi-Annual</td>
<td>Tires (Cont’d)</td>
<td>e. Check for loose, missing, or broken wheel studs and nuts.</td>
<td>e. Any broken studs, or loose or missing wheel nuts.</td>
</tr>
</tbody>
</table>

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

1. Release air pressure from tire (para. 8-4 or 8-5).

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

2. Wheel configurations:

   (a) 12-bolt configuration –
       Tighten locknuts to 85 lb-ft (115 N·m) in sequence shown; repeat torque sequence at 125 lb-ft (170 N·m).

   **12-BOLT TIGHTENING SEQUENCE**

   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10
   - 11
   - 12

   (b) 8-bolt configuration –
       Tighten locknuts to 55 lb-ft (75 N·m) in sequence shown; repeat torque sequence at 65 lb-ft (88 N·m).

   **8-BOLT TIGHTENING SEQUENCE**

   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8

3. Inflate tire to recommended tire pressure (TM 9-2320-280-10).
### 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-Annual</td>
<td>Tires (Cont'd)</td>
<td><strong>NOTE</strong> If vehicle is new and has been driven less than 3,000 miles (4,800 km), it is not necessary to align wheels unless abnormal handling is reported.</td>
<td>f. Front or rear wheels are out of alignment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>f. Check alignment of front and rear wheels (paras. 8-10 and 8-11).</td>
<td>a. Class III leaks. Damage evident that would cause engine failure.</td>
</tr>
<tr>
<td>20</td>
<td>Semi-Annual</td>
<td>Engine</td>
<td>a. Inspect engine for leaks or damage that could cause engine failure.</td>
<td>b. Perform AOAP sample. If AOAP is not available, change oil and oil filter at 3,000 miles (4,800 km), or 100 hours (if hour meter is installed), or every six months.</td>
</tr>
</tbody>
</table>

**NOTE**

Oil and oil filter will be changed when they are known to be contaminated, clogged, or when service is recommended by AOAP laboratory.

*Diagram:*

![Diagram of Oil Filter and Crankcase Drain](image-url)
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</td>
<td>Semi-Annual</td>
<td>Batteries</td>
<td><strong>WARNING</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 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.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 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.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>NOTE</strong> Refer to TM 9-6140-200-14 for more specific details on battery maintenance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Inspect battery box and battery tray bolts for corrosion and debris. If any corrosion is evident, wipe bolts and/or washers clean. If corrosion cannot be removed or the surface of bolts are pitted, replace bolts and/or washers (para. 4-80).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Check and record specific gravity of each cell.</td>
<td>b. Terminals corroded.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d. Inspect battery cables for frays, splits, or looseness.</td>
<td>c. If cell is below 1.225 specific gravity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>SPECIAL PURPOSE KITS</strong></td>
<td>d. Cables frayed, split, or loose.</td>
</tr>
<tr>
<td>22</td>
<td>Semi-Annual</td>
<td>Cargo Shell Door</td>
<td>Check adjustment of cargo shell door (paragraph 11-13).</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Semi-Annual</td>
<td>Rear Cargo Door</td>
<td>Check rear cargo door for proper operation. Rotate gas springs (para. 11-21) 180 degrees every six months and move left spring to right side and right spring to left side.</td>
<td></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>24</td>
<td>Semi-Annual</td>
<td>Ambulance (M996, M996A1, M997, M997A1, and M997A2)</td>
<td><strong>a.</strong> Check DC outlets for proper operation. Using multimeter, check for voltage at DC receptacles. If engine is running, voltage should be 27-28 volts. If engine is not running, voltage should be 24.2-25.2 volts. Refer to para. 2-39 electrical troubleshooting, if voltage is not within the specified range. <strong>b.</strong> Inspect and tighten two mounting capscrews securing ambulance body to cargo floor to 90 lb-ft (122 N·m). Tighten seven capscrews securing ambulance body to “D” beam to 90 lb-ft (122 N·m).</td>
<td><strong>a.</strong> No DC voltage at outlet, or not within range. <strong>b.</strong> Body not securely mounted to floor.</td>
</tr>
<tr>
<td>25</td>
<td>Semi-Annual</td>
<td>DeepWater Fording Kit</td>
<td><strong>a.</strong> Inspect vent tubes for bends, cracks, breaks, deterioration, and restrictions. <strong>b.</strong> Inspect vent tube mounting hardware for proper installation. <strong>c.</strong> Inspect intake and exhaust extensions for proper installation and leaks.</td>
<td><strong>c.</strong> Any class III leak. <strong>e.</strong> Any exhaust extension leaks.</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>26</td>
<td>Semi-Annual</td>
<td>Arctic Winterization Kit and/or Troop/Cargo Winterization Kit</td>
<td>Inspect all fuel lines for loose connections, splits, cracks, and bends that could cause leaks. Tighten loose connections and replace damaged parts.</td>
<td>Any class III leak.</td>
</tr>
<tr>
<td>27</td>
<td>Semi-Annual</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>28</td>
<td>Annually</td>
<td>Fuel System</td>
<td>Replace filter element every 6,000 miles (9,600 km) or annually, whichever occurs first. Replace water separator element if unserviceable (para. 3-33).</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Annually</td>
<td>Air-Intake System</td>
<td>Test CDR valve (para. 3-9).</td>
<td></td>
</tr>
<tr>
<td>29.1</td>
<td>Annually</td>
<td>Dust Unloader</td>
<td>Visually inspect dust unloader for presence and for cuts, tears, obstructions, worn areas, enlarged gap, or if center opening exceeds 1/8 in. (3.175 mm).</td>
<td>Dust unloader missing or has cuts, tears, obstructions, worn areas, enlarged gap, or if center opening exceeds 1/8 in. (3.175 mm).</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>30</td>
<td>Annually</td>
<td>Electrical Wiring</td>
<td>Inspect all wiring and wiring harness for frays, splits, missing insulation, or poor connections. Repair any worn wiring (para. 4-85). If wiring cannot be repaired, notify DS maintenance.</td>
<td>Broken, frayed, split wires or harness.</td>
</tr>
<tr>
<td>30.1</td>
<td>Annually</td>
<td>Engine Running Test</td>
<td>Observe engine and vehicle operation for rough idle, rough running, lack of power, and unusual noise or vibration [para. 2-15].</td>
<td>Vehicle fails to operate properly.</td>
</tr>
<tr>
<td>30.2</td>
<td>Annually</td>
<td>Transmission</td>
<td>Perform AOAP sample.</td>
<td></td>
</tr>
</tbody>
</table>

**NOT FULLY MISSION CAPABLE IF:**

**CAUTION**

Use Dexron® II or Dexron® III for 3L80 transmission. Use only Dexron® III for 4L80-E transmission. Failure to use only Dexron® III for 4L80E transmission will cause damage to transmission.

**NOTE**

- Oil and oil filter will be changed when they are known to be contaminated, clogged, or when service is recommended by AOAP laboratory.
- Replace transmission oil filter each time transmission is drained. Fill 3L80 transmission with 6 quarts (5.7 L) of Dexron® II or Dexron® III. Fill 4L80-E transmission with 7.7 quarts (7.3 L) of only Dexron® III. In arctic conditions, use OEA in both model transmissions.

<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>31</td>
<td>Biennially</td>
<td>Transmission</td>
<td>Use Dexron® II or Dexron® III for 3L80 transmission. Use only Dexron® III for 4L80-E transmission. Failure to use only Dexron® III for 4L80E transmission will cause damage to transmission.</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE**

- Change fluid every 12,000 miles (19,300 km) or biennially, whichever occurs first (para. 5-2a). Inspect either 3L80 or 4L80-E transmission drainplug for metal particles.
- Replace transmission oil filter each time transmission is drained. Fill 3L80 transmission with 6 quarts (5.7 L) of Dexron® II or Dexron® III. Fill 4L80-E transmission with 7.7 quarts (7.3 L) of only Dexron® III. In arctic conditions, use OEA in both model transmissions.
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>31</td>
<td>Biennially</td>
<td>Transmission (Cont’d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Biennially</td>
<td>Transfer Case</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CAUTION**
- If water or metal particles are detected during transfer case draining, notify Direct Support Maintenance personnel before refilling transfer case.
- Use Dexron® II for filling transfer case. Failure to use Dexron® II will cause damage to transfer case.

**NOTE**
- Fill transfer case (model 218) with 3.5 quarts (3.3 L) of Dexron® II.
- Fill transfer case (model 242) with 3.35 quarts (3.17 L) of Dexron® II.

Change fluid every 12,000 miles

Metal particles are...
### 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>5305-00-061-4650</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>5593033</td>
<td>5310-00-252-2999</td>
<td>Nut and Lockwasher Assembly</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>MS21245-L10</td>
<td>5310-00-449-2381</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>MS35756-8</td>
<td>5315-00-616-5526</td>
<td>Woodruff Key</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>MS24665-355</td>
<td>5315-00-012-0123</td>
<td>Cotter Pin</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>MS51943-43</td>
<td>5310-00-061-4651</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>MS51943-35</td>
<td>5310-00-935-9021</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>MS51943-39</td>
<td>5310-00-488-3889</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>MS51967-18</td>
<td>5310-00-763-8919</td>
<td>Locknut</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>MS35338-45</td>
<td>5310-00-407-9566</td>
<td>Lockwasher</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>PH13</td>
<td>2940-00-082-6034</td>
<td>Filter, Fluid, Engine Oil</td>
<td>1</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>5305-00-061-4650</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>5593033</td>
<td>5310-00-252-2999</td>
<td>Nut and Lockwasher Assembly</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>MS21245-L10</td>
<td>5310-00-449-2381</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>MS35756-8</td>
<td>5315-00-616-5526</td>
<td>Woodruff Key</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>MS24665-355</td>
<td>5315-00-012-0123</td>
<td>Cotter Pin</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>MS51943-43</td>
<td>5310-00-061-4651</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>MS51943-35</td>
<td>5310-00-935-9021</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>MS51943-39</td>
<td>5310-00-488-3889</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>MS51967-18</td>
<td>5310-00-763-8919</td>
<td>Locknut</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>MS35338-45</td>
<td>5310-00-407-9566</td>
<td>Lockwasher</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>PH13</td>
<td>2940-00-082-6034</td>
<td>Filter, Fluid, Engine Oil</td>
<td>1</td>
</tr>
<tr>
<td>12.</td>
<td>5589121</td>
<td>4330-01-190-3579</td>
<td>Filter Element Kit, Fuel</td>
<td>1</td>
</tr>
</tbody>
</table>
**BIENNIAILLY (12,000 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>5305-00-061-4650</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>271172</td>
<td>5310-00-152-0598</td>
<td>Assembled Locknut</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>MS21245-L10</td>
<td>5310-00-449-2381</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>MS35756-8</td>
<td>5315-00-616-5526</td>
<td>Woodruff Key</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>MS24665-355</td>
<td>5315-00-012-0123</td>
<td>Cotter Pin</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>MS51943-43</td>
<td>5310-00-061-4651</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>MS51943-35</td>
<td>5310-00-935-9021</td>
<td>Locknut</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>MS51943-39</td>
<td>5310-00-488-3889</td>
<td>Locknut</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>MS51967-18</td>
<td>5310-00-763-8919</td>
<td>Locknut</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>MS5338-45</td>
<td>5310-00-407-9566</td>
<td>Lockwasher</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>PH13</td>
<td>2940-00-082-6034</td>
<td>Filter, Fluid, Engine Oil</td>
<td>1</td>
</tr>
<tr>
<td>12.</td>
<td>12337210</td>
<td>4330-01-121-6350</td>
<td>Parts Kit, Fluid, Transmission (3L80)</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>8655625</td>
<td>5330-01-148-7492</td>
<td>Gasket (3L80)</td>
<td>1</td>
</tr>
<tr>
<td>14.</td>
<td>8684221</td>
<td>2520-01-398-4589</td>
<td>Parts Kit, Fluid, Transmission (4L80-E)</td>
<td>1</td>
</tr>
<tr>
<td>15.</td>
<td>8677743</td>
<td>5330-01-360-5271</td>
<td>Gasket (4L80-E)</td>
<td>1</td>
</tr>
<tr>
<td>16.</td>
<td>12354864</td>
<td>4330-01-438-3813</td>
<td>Parts Kit, Fluid, Transmission (4L80-E)</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</td>
<td>OE/HDO 30</td>
<td>Crankcase: 7 qt (6.6 L) w/o filter</td>
<td>Above +15°F (-9°C)</td>
</tr>
<tr>
<td></td>
<td>OE/HDO 10</td>
<td>w/filter 8 qt (7.6 L) Dry System</td>
<td>40°F to -15°F (4°C to -26°C)</td>
</tr>
<tr>
<td></td>
<td>OEA</td>
<td>10 qt (9.5 L) (INC. oil cooler)</td>
<td>40°F to -65°F (4°C to -54°C)</td>
</tr>
<tr>
<td>Engine Coolant</td>
<td>Ethylene Glycol and Water</td>
<td>Radiator: 5 qt (4.7 L) Complete</td>
<td>15°F (-9°C) and above</td>
</tr>
<tr>
<td></td>
<td></td>
<td>System: 26 qt (24.6 L)</td>
<td>40°F to -15°F (4°C to -26°C)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40°F to -65°F (4°C to -54°C)</td>
</tr>
<tr>
<td>Brake System</td>
<td>Fluid Silicone BFS</td>
<td>Master Cylinder: 0.69 pt (0.33 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>(All except M1097)</td>
<td></td>
<td>Complete System: 1.2 pt (0.56 L)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(M1097, “A1”, “A2”</td>
<td>Master Cylinder: 1.12 pt (0.53 L)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>series and M1123)</td>
<td>Complete System: 1.63 pt (0.78 L)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(M1097, “A1”, “A2”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>series and M1123)</td>
<td></td>
<td></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 lubricant is required to meet the temperature ranges prescribed in the table, then the OEA 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 miles (1,600 kilometers).
LUBRICATION TABLE (Cont’d)

<table>
<thead>
<tr>
<th>USAGE</th>
<th>FLUID/LUBRICANT</th>
<th>CAPACITIES</th>
<th>EXPECTED TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission (3L80)</td>
<td>Dexron® II or Dexron® III</td>
<td>Dry: 11 qt (10.4 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td></td>
<td>or Dexron® III only</td>
<td>Drain &amp; Refill: 6 qt (5.7 L)</td>
<td>Except Arctic</td>
</tr>
<tr>
<td></td>
<td>(Do not use Dexron® II)</td>
<td>Dry: 13.5 qt (12.8L)</td>
<td>Arctic Temperatures</td>
</tr>
<tr>
<td></td>
<td>OEA</td>
<td>Drain &amp; Refill 7.7 qt (7.3 L)</td>
<td></td>
</tr>
<tr>
<td>Transfer (218)</td>
<td>Dexron® II or Dexron® III</td>
<td>3.5 qt (3.3 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td>Case (242)</td>
<td></td>
<td>3.35 qt (3.17 L)</td>
<td></td>
</tr>
<tr>
<td>Steering System</td>
<td>Dexron® II or Dexron® III</td>
<td>1 qt (0.95 L)</td>
<td>All Temperatures</td>
</tr>
<tr>
<td></td>
<td>w/Cooler</td>
<td>1.25 qt (1.18 L)</td>
<td></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>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, 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>

Section IV. ELECTRICAL/MECHANICAL SYSTEMS TROUBLESHOOTING

2-12. 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 1. 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 you determine the cause of the problem.

(2) Never over look 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.

(4) Use test instruments or gauges to help you 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.

e. 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 M998 series vehicles is 21 (14 is the temporary VIN). On page 2-753, 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 2-763 you will find STE/ICE-R setup and internal checks. These must be performed prior to performing tests.
## ELECTRICAL/MECHANICAL TROUBLESHOOTING

<table>
<thead>
<tr>
<th>PARA NO.</th>
<th>PAGE NO.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-14</td>
<td>2-32</td>
<td>How to use this troubleshooting guide</td>
</tr>
<tr>
<td>2-15</td>
<td>2-38</td>
<td>Glossary of abbreviations and commonly used terms</td>
</tr>
<tr>
<td>2-16</td>
<td>2-39</td>
<td>Electrical circuit description</td>
</tr>
<tr>
<td>2-17</td>
<td>2-41</td>
<td>Startability tests</td>
</tr>
<tr>
<td>2-18</td>
<td>2-47</td>
<td>Engine running tests</td>
</tr>
<tr>
<td>2-19</td>
<td>2-57</td>
<td>Cooling system tests</td>
</tr>
<tr>
<td>2-20</td>
<td>2-65</td>
<td>Lubrication system tests</td>
</tr>
<tr>
<td>2-21</td>
<td>2-71</td>
<td>Electrical tests</td>
</tr>
<tr>
<td>2-22</td>
<td>2-95</td>
<td>Fuel system tests</td>
</tr>
<tr>
<td>2-23</td>
<td>2-137</td>
<td>Air intake/exhaust tests</td>
</tr>
<tr>
<td>2-24</td>
<td>2-143</td>
<td>Compression/mechanical tests</td>
</tr>
<tr>
<td>2-25</td>
<td>2-155</td>
<td>Engine cooling tests</td>
</tr>
<tr>
<td>2-26</td>
<td>2-187</td>
<td>Engine lubrication tests</td>
</tr>
<tr>
<td>2-27</td>
<td>2-194</td>
<td>Alternator tests</td>
</tr>
<tr>
<td>2-28</td>
<td>2-227</td>
<td>Protective control box/distribution box tests</td>
</tr>
<tr>
<td>2-29</td>
<td>2-251</td>
<td>Battery circuit test</td>
</tr>
<tr>
<td>2-30</td>
<td>2-261</td>
<td>Starter circuit tests</td>
</tr>
<tr>
<td>2-31</td>
<td>2-303</td>
<td>Glowplugs circuit tests (protective control box)</td>
</tr>
<tr>
<td>2-31.1</td>
<td>2-318.1</td>
<td>Glowplugs circuit tests (distribution box)</td>
</tr>
<tr>
<td>2-32</td>
<td>2-319</td>
<td>Instrument tests</td>
</tr>
<tr>
<td>2-33</td>
<td>2-389</td>
<td>Light tests</td>
</tr>
<tr>
<td>2-34</td>
<td>2-399</td>
<td>Transmission system tests (3L80)</td>
</tr>
<tr>
<td>2-35</td>
<td>2-411</td>
<td>Transmission system tests (4L80-E)</td>
</tr>
<tr>
<td>2-36</td>
<td>2-445</td>
<td>Brake system tests</td>
</tr>
<tr>
<td>2-37</td>
<td>2-459</td>
<td>Steering system tests</td>
</tr>
<tr>
<td>2-38</td>
<td>2-479</td>
<td>Drivetrain tests</td>
</tr>
<tr>
<td>2-39</td>
<td>2-497</td>
<td>Ambulance electrical system tests</td>
</tr>
<tr>
<td>2-40</td>
<td>2-693</td>
<td>Ambulance mechanical system tests</td>
</tr>
<tr>
<td>2-41</td>
<td>2-715</td>
<td>Winch system tests</td>
</tr>
<tr>
<td>2-42</td>
<td>2-723</td>
<td>DCA troubleshooting</td>
</tr>
<tr>
<td>2-43</td>
<td>2-733</td>
<td>STE/ICE-R test procedures</td>
</tr>
<tr>
<td>2-44</td>
<td>2-761</td>
<td>Vehicle testing</td>
</tr>
</tbody>
</table>
### 2-14. HOW TO USE THIS TROUBLESHOOTING GUIDE

**NOTE TO THE RECIPIENT OF THIS MANUAL**

There are 16 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. That way, the foldout will be with diagnostics for that system. Use the cross-reference information listed below to guide you in the placement of the foldouts.

<table>
<thead>
<tr>
<th>SYSTEM LEVEL TESTS</th>
<th>PARAGRAPH</th>
<th>FOLDOUT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUEL</td>
<td>2-22</td>
<td>FO-1</td>
</tr>
<tr>
<td>AIR INTAKE/EXHAUST</td>
<td>2-23</td>
<td>FO-2</td>
</tr>
<tr>
<td>COMPRESSION/MECHANICAL</td>
<td>2-24</td>
<td>FO-3</td>
</tr>
<tr>
<td>ENGINE COOLING</td>
<td>2-25</td>
<td>FO-4</td>
</tr>
<tr>
<td>ENGINE LUBRICATION</td>
<td>2-26</td>
<td>FO-5</td>
</tr>
<tr>
<td>ALTERNATOR</td>
<td>2-27</td>
<td>FO-6</td>
</tr>
<tr>
<td>PROTECTIVE CONTROL BOX/ DISTRIBUTION BOX</td>
<td>2-28</td>
<td>FO-7</td>
</tr>
<tr>
<td>BATTERY CIRCUIT</td>
<td>2-29</td>
<td>FO-8</td>
</tr>
<tr>
<td>STARTER CIRCUIT</td>
<td>2-30</td>
<td>FO-9</td>
</tr>
<tr>
<td>GLOWPLUGS (PROTECTIVE CONTROL BOX)</td>
<td>2-31</td>
<td>FO-10</td>
</tr>
<tr>
<td>GLOWPLUGS (DISTRIBUTION BOX)</td>
<td>2-31.1</td>
<td>FO-11</td>
</tr>
<tr>
<td>INSTRUMENTS</td>
<td>2-32</td>
<td>FO-12</td>
</tr>
<tr>
<td>LIGHTS</td>
<td>2-33</td>
<td>FO-13</td>
</tr>
<tr>
<td>TRANSMISSION (3L80)</td>
<td>2-34</td>
<td>FO-14</td>
</tr>
<tr>
<td>TRANSMISSION (4L80-E)</td>
<td>2-35</td>
<td>FO-15</td>
</tr>
<tr>
<td>BRAKES</td>
<td>2-36</td>
<td>FO-16</td>
</tr>
<tr>
<td>STEERING</td>
<td>2-37</td>
<td></td>
</tr>
<tr>
<td>DRIVETRAIN</td>
<td>2-38</td>
<td></td>
</tr>
<tr>
<td>AMBULANCE ELECTRICAL SYSTEM</td>
<td>2-39</td>
<td></td>
</tr>
<tr>
<td>AMBULANCE MECHANICAL SYSTEM</td>
<td>2-40</td>
<td></td>
</tr>
<tr>
<td>WINCH SYSTEM</td>
<td>2-41</td>
<td></td>
</tr>
<tr>
<td>DCA TROUBLESHOOTING</td>
<td>2-42</td>
<td></td>
</tr>
</tbody>
</table>
2-14. 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 21 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.

**TOP LEVEL TESTS**

<table>
<thead>
<tr>
<th>Test</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGINE STARTING</td>
<td>2-41</td>
</tr>
<tr>
<td>ENGINE RUNNING</td>
<td>2-47</td>
</tr>
<tr>
<td>COOLING</td>
<td>2-57</td>
</tr>
<tr>
<td>LUBRICATION</td>
<td>2-65</td>
</tr>
<tr>
<td>ELECTRICAL</td>
<td>2-71</td>
</tr>
</tbody>
</table>

**SYSTEM LEVEL TESTS**

<table>
<thead>
<tr>
<th>Test</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUEL</td>
<td>2-95</td>
</tr>
<tr>
<td>AIR INTAKE/EXHAUST</td>
<td>2-137</td>
</tr>
<tr>
<td>COMPRESSION/MECHANICAL</td>
<td>2-143</td>
</tr>
<tr>
<td>ENGINE COOLING</td>
<td>2-155</td>
</tr>
<tr>
<td>ENGINE LUBRICATION</td>
<td>2-187</td>
</tr>
<tr>
<td>ALTERNATOR</td>
<td>2-194</td>
</tr>
<tr>
<td>PROTECTIVE CONTROL BOX/ DISTRIBUTION BOX</td>
<td>2-227</td>
</tr>
<tr>
<td>BATTERY CIRCUIT</td>
<td>2-251</td>
</tr>
<tr>
<td>STARTER CIRCUIT</td>
<td>2-261</td>
</tr>
<tr>
<td>GLOWPLUGS (PCB)</td>
<td>2-303</td>
</tr>
<tr>
<td>GLOWPLUGS (DISTRIBUTION BOX)</td>
<td>2-318.1</td>
</tr>
<tr>
<td>INSTRUMENTS</td>
<td>2-319</td>
</tr>
<tr>
<td>LIGHTS</td>
<td>2-389</td>
</tr>
<tr>
<td>TRANSMISSION (3L80)</td>
<td>2-399</td>
</tr>
<tr>
<td>TRANSMISSION (4L80-E)</td>
<td>2-11</td>
</tr>
<tr>
<td>BRAKES</td>
<td>2-445</td>
</tr>
<tr>
<td>STEERING</td>
<td>2-459</td>
</tr>
<tr>
<td>DRIVETRAIN</td>
<td>2-79</td>
</tr>
<tr>
<td>AMBULANCE ELECTRICAL</td>
<td>2-497</td>
</tr>
<tr>
<td>AMBULANCE MECHANICAL</td>
<td>2-693</td>
</tr>
<tr>
<td>WINCH</td>
<td>2-715</td>
</tr>
<tr>
<td>DCA TROUBLESHOOTING</td>
<td>2-723</td>
</tr>
</tbody>
</table>
2-14. 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.

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.

Known info and possible problems with the system.

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.
2-14. HOW TO USE THIS TROUBLESHOOTING GUIDE (CONTD)

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.
### 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.
2-14. 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 BOLD FACE 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 assume a basic working knowledge of the equipment to be used, but references are included for the less experienced operator.

<table>
<thead>
<tr>
<th>TYPE OF MEASUREMENT</th>
<th>TYPE OF EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure for performing the measurement using the type of equipment listed above.</td>
<td></td>
</tr>
</tbody>
</table>

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.
2-15. GLOSSARY OF ABBREVIATIONS AND COMMONLY USED TERMS

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.
2-15. 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.

2-16. 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 1000 amps of current that flow through it there is a drop of .1 volts from one side of it 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.
2-17. STARTABILITY TESTS

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.

<table>
<thead>
<tr>
<th>PARAGRAPH</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BATTERY CIRCUIT</td>
<td>2-251</td>
</tr>
<tr>
<td>GLOWPLUGS CIRCUIT</td>
<td>2-303</td>
</tr>
<tr>
<td>STARTER CIRCUIT</td>
<td>2-261</td>
</tr>
<tr>
<td>FUEL SYSTEM</td>
<td>2-95</td>
</tr>
<tr>
<td>INTAKE AIR/EXHAUST</td>
<td>2-137</td>
</tr>
<tr>
<td>COMPRESSION/MECHANICAL</td>
<td>2-143</td>
</tr>
</tbody>
</table>
STARTABILITY

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

TEST OPTIONS
1. LISTEN
2. STE/ICE TEST 10 (Page 2-734) (FOR RPM)

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

TEST OPTIONS
FUEL SYSTEM TESTS, (Page 2-35)

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

TEST OPTIONS
INTAKE AIR/EXHAUST TESTS, (Page 2-137)

REASON FOR TESTS
The intake air/exhaust system tests are easy to run and can cause starting problems.

GO TO 4, (Page 2-44)
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.

ENGINE RPM
STEACE-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.
STARTABILITY

KNOWN INFO
ENGINE NOT LOCKED
BATTERIES OK
STARTING SYSTEM OK
FUEL SYSTEM OK
INTAKE AIR/EXHAUST OK

POSSIBLE PROBLEMS
GLOWPLUGS
COMPRESSION

FROM 3,
PAGE 2-42

TEST OPTIONS
1. GLOWPLUGS TESTS

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

TEST OPTIONS
STE/ICE-R TEST 14
(PAGE 2-737)

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.
REFERENCE INFORMATION

WARNING

A HOT ENGINE MAY CAUSE SERIOUS BURNS. Always use caution when approaching a hot engine.

NOTE

When using the vehicle's temperature gage to determine engine temperature, don't forget to turn the rotary switch to "RUN". The gages don't work when power is off.

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

If the vehicle passes the STEACE-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.

COMPRESSION UNBALANCE STEACE-R TEST 14

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

CAUTION

THE GLOWPLUGS CONTROLLER AND THE CONTROL VALVE ELECTRICAL CONNECTOR MUST BE DISCONNECTED PRIOR TO RUNNING THIS TEST.

2. Disconnect wire 54A at injection pump to prevent starting.
3. Disconnect glowplugs 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.
2-18. 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>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUEL SYSTEM</td>
<td>2-95</td>
</tr>
<tr>
<td>INTAKE AIR/EXHAUST</td>
<td>2-137</td>
</tr>
<tr>
<td>COMPRESSION/MECHANICAL</td>
<td>2-143</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?

NO

GO TO FUEL SYSTEM, Page 2-96

YES

TEST OPTIONS

OBSERVE THE ENGINE AND VEHICLE OPERATION.

REASON FOR QUESTION

To detect and fix minor problems before looking for major problems.

GO TO 3, Page 2-50
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
- INTAKE/EXHAUST OK

POSSIBLE PROBLEMS
- MECHANICAL
- ELECTRICAL
- GLOWPLUGS
- COOLING
- LUBRICATION

3

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

FROM 2, Page 2-48

TEST OPTIONS
- OBSERVE THE ENGINE WHILE RUNNING THE VEHICLE AT VARIOUS SPEEDS.

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

YES

NO

GO TO 4, Page 2-52

RUN THE FUEL SYSTEM TESTS, Page 2-95
- IF NO FAULTS FOUND, GO TO COMPRESSION/MECHANICAL, Page 2-143
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

FROM 3, Page 2-50

TEST OPTIONS
1. STE/ICE-R TESTS 13, 12 (Page 2-736 & 2-735)
2. ACCELERATE ON A LEVEL SURFACE.

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

DOES THE ENGINE PRODUCE RATED POWER?

NO

GO TO FUEL SYSTEM, Page 2-95

YES

KNOWN INFO

ENGINE STARTS AND STAYS RUNNING WITH NO ABNORMAL SOUNDS OR VIBRATIONS.

POSSIBLE PROBLEMS
MECHANICAL FUEL SYSTEM

IS THE EXHAUST COLORLESS?

NO

GO TO FUEL SYSTEM, Page 2-95

YES

KNOWN INFO

ENGINE STARTS AND STAYS RUNNING WITH NO ABNORMAL SOUNDS OR VIBRATIONS.

POSSIBLE PROBLEMS
MECHANICAL FUEL SYSTEM

DOES THE ENGINE PASS COMPRESSION UNBALANCE? (6.2L ONLY)

NO

NOTIFY DS MAINTENANCE

YES

GO TO 7, Page 2-54

TEST OPTIONS
1. STE/ICE-R TEST 14 (Page 2-737)

REASON FOR QUESTION
Bad compression can make other systems look bad. The lower the compression unbalance number, the better the engine.
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 6700 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
   per cent 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's 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 GLOWPLUG 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 glowplug 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.
**DIAGNOSTIC FLOWCHART**

**ENGINE RUNNING**

**TEST OPTIONS**
1. CHECK TEMPERATURE GAUGE
2. RUN COOLING SYSTEM TESTS, Page 2-155

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

**KNOWN INFO**
- ENGINE RUNS
- NO ABNORMAL NOISES OR VIBRATIONS
- EXHAUST OK
- COMPRESSION OK

**POSSIBLE PROBLEMS**
- FUEL SYSTEM
- COOLING SYSTEM
- ELECTRICAL SYSTEM

---

7

**DOES THE ENGINE OPERATE AT NORMAL TEMPERATURE?**

**TEST OPTIONS**

**REASON FOR QUESTION**

---

8

**DOES THE ENGINE STOP WHEN THE ROTARY SWITCH IS TURNED TO "STOP"?**

**TEST OPTIONS**
- LISTEN

**REASON FOR QUESTION**
If the engine stops then the fuel and electrical systems are ok.

---

9

**IF YOU STILL HAVE AN ENGINE RUNNING PROBLEM, TRY RERUNNING THIS CHAIN OF TESTS. IF EVERYTHING CHECKS OUT OK, GO TO PARAGRAPH 2-38**

**TEST OPTIONS**
1. RE-RUN THIS CHAIN
2. DRIVETRAIN, Page 2-479

**REASON FOR QUESTION**
We've checked just about everything that could cause an engine running problem.
Because the Cooling System 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 watercooling system or the oil cooling system. Just follow the path, answering 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.
COOLING SYSTEM

DIAGNOSTIC FLOWCHART

1. IS THE ENGINE TEMPERATURE GAUGE BELOW FULL SCALE AT ALL TIMES?
   - KNOWN INFO
     - NONE
   - POSSIBLE PROBLEMS
     - TEMPERATURE GAUGE
     - TEMPERATURE SENDER
     - ENGINE COOLING SYSTEM
     - OIL COOLING SYSTEMS
     - FAN BELTS
     - CONTROL VALVE
   - TEST OPTIONS
     - LOOK.
     - REASON FOR QUESTION
       - The engine should not reach temperatures over 240°F.
   - NO → GO TO A, Page 2-62
   - YES

2. DOES THE TEMPERATURE GAUGE READ BELOW 120°F WHEN THE ENGINE IS COLD AND THEN INDICATE HIGHER TEMPERATURES AS THE ENGINE WARMS?
   - KNOWN INFO
     - TEMPERATURE GAUGE IS BELOW 240°F AT ALL TIMES.
   - POSSIBLE PROBLEMS
     - TEMPERATURE GAUGE
     - TEMPERATURE SENDER
     - ENGINE COOLING SYSTEM
     - OIL COOLING SYSTEMS
     - FAN BELTS
     - CONTROL VALVE
   - TEST OPTIONS
     - VISUAL INSPECTION.
     - REASON FOR QUESTION
       - You want to know if the gauge is working properly.
   - NO → INSTRUMENTS, Page 3-319
   - YES

3. DOES THE ENGINE APPEAR TO BE PROPERLY COOLED? THAT IS, IS THERE NO EVIDENCE OF OVERHEATING?
   - KNOWN INFO
     - TEMPERATURE GAUGE SEEMS TO WORK OK
   - POSSIBLE PROBLEMS
     - TEMPERATURE GAUGE
     - TEMPERATURE SENDER
     - ENGINE COOLING SYSTEM
     - OIL COOLING SYSTEMS
     - FAN BELTS
     - CONTROL VALVE
   - TEST OPTIONS
     - LOOK.
     - REASON FOR QUESTION
       - If the engine is overheating with the temperature gauge below full scale, both the temperature sending system and the engine cooling are faulty.
   - NO → ENGINE COOLING, Page 2-185 AND THEN INSTRUMENTS, Page 2-319
   - YES

4. GO TO 4, Page 2-60
The question describes how the gauge should work. If you aren't sure if its 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

FROM 3, Page 2-58

DOES THE FAN TURN ON WHEN THE ENGINE TEMPERATURE GAUGE READS ABOVE 220°F?

TEST OPTIONS
LOOK.

REASON FOR QUESTION
The fan clutch should turn the fan on when the temperature is above 220°F.

GO TO ENGINE COOLING, Page 2-155

KNOWN INFO
TEMPERATURE GAUGE OK
TEMPERATURE SENDER OK

POSSIBLE PROBLEMS
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS
FAN BELTS
FAN CLUTCH/TIMER

YES

NO

KNOWN INFO
FAN BELTS OK
FAN CLUTCH/TIMER OK
GAUGE AND SENDER OK

POSSIBLE PROBLEMS
ENGINE COOLING SYSTEM
OIL COOLING SYSTEMS

YES

SEE NOTE AT RIGHT

NO FAULTS

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

TEST OPTIONS
LOOK.

REASON FOR QUESTION
The vehicle should not leak fluids.
220°F is the approximate temperature at which the fan should turn itself on.

The fan will turn on and off as the engine temperature varies.

NOTE

If the leaking fluid is red, go to the transmission, Paragraph 2-34, Page 2-399 or Paragraph 2-35, Page 2-411.

If the leaking fluid is yellow/green, go to engine cooling, Paragraph 2-25, Page 2-155.

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, Paragraph 2-26, Page 2-68.
COOLING SYSTEM

KNOWN INFO
TEMPERATURE GAUGE WENT ABOVE 240° F (115° C).

POSSIBLE PROBLEMS
ENGINE COOLING SYSTEM
TEMPERATURE GAUGE TEMPERATURE SENDER

DIAGNOSTIC FLOWCHART

A FROM 1,
Page 2-58

IS THE COOLANT BOILING OR THE ENGINE OVERHEATING?

TEST OPTIONS
LOOK.

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

GO TO INSTRUMENTS,
Page 2-319

NO

YES

GO TO ENGINE COOLING,
Page 2-155
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, answering 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 paragraphs as required.

NOTE
Bold lines represent ventilation system.
LUBRICATION SYSTEM

START

1

TEST OPTIONS

SEE PARAGRAPH 2-26
PAGE 2-187

REASON FOR QUESTION
The tests in Paragraph 2-26 are easy to run and will test out the engine lubrication system.

NOTIFY DS MAINTENANCE

RUN THE ENGINE LUBRICATION TESTS IN PARAGRAPH 2-26. WERE YOU ABLE TO CORRECT ALL OF THE FAULTS?

NO

POSSIBLE PROBLEMS
ENGINE LUBRICATION
TRANSMISSION
LUBRICATION
CHASSIS LUBRICATION
VENTING SYSTEM

YES

KNOWN INFO
NONE

2

TEST OPTIONS

VISUAL - SEE NOTE AT RIGHT. IF YOU SUSPECT PROBLEMS WITH THE TRANSMISSION YOU CAN RUN THE TESTS IN PARAGRAPH 2-34, PAGE 2-399 OR PARAGRAPH 2-35, PAGE 2-411

REASON FOR QUESTION
Transmission fluid level and appearance give a good indication of the system's condition.

SEE NOTE AT RIGHT

CHECK THE TRANSMISSION FLUID. IS IT O.K.?

NO

POSSIBLE PROBLEMS
TRANSMISSION
LUBRICATION.
CHASSIS LUBRICATION
VENTING SYSTEM

YES

KNOWN INFO
ENGINE LUBRICATION OK
TRANSMISSION LUBRICATION OK

3

TEST OPTIONS

SEE TM 9-2320-220-10 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.

LUBRICATE OR REPAIR AS NEEDED.

NO

POSSIBLE PROBLEMS
CHASSIS LUBRICATION
VENTING SYSTEM

YES

KNOWN INFO
ENGINE LUBRICATION OK
TRANSMISSION LUBRICATION OK

GO TO 4, PAGE 2-65
The tests in para. 2-26 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.
• Bubbles indicate an overfilled system or air leaks in the system. Drain the fluid and refill to proper level. Refer to (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. Refer to (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. Refer to (para. 5-2).
• Transmission fluid coming out of dipstick filler tube indicates a restriction in the ventilation system. Check for clogged, melted, or crushed lines and/or fittings between transmission and atmosphere vent on air cleaner canister. Replace where needed. Refer to (para. 5-16).

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

FROM 3,
Page 2-66

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

NO

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.

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

POSSIBLE PROBLEMS
VENT SYSTEM
FORDING VALVE

TEST OPTIONS

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.

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

POSSIBLE PROBLEMS
VENT FILTER
FORDING VALVE

REPLACE FILTER

YES

CHECK THE VENT FILTER. IS IT OK?

NO

YES

CHECK THE FORDING VALVE FOR PROPER OPERATION (IF YOUR VEHICLE HAS ONE). IS IT OK?

NO

REPAIR AS NEEDED

YES

TEST OPTIONS
VISUAL INSPECTION - TEST OPERATION IN BOTH POSITIONS.

REASON FOR QUESTION
The fording control valve regulates the venting of vapors to the atmosphere.

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

POSSIBLE PROBLEMS
FORDING VALVE

NO FAULTS

2-68
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.

Replace the fording valve. Refer to para 12-9.
2-21. 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 flowchart 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 are 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 Paragraph 2-16, page 2-39.

All electrical systems require a connection to ground (called grounding), which is the completion of the circuit to the battery negative. Pages 2-66, 2-67 and 2-68 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. **START**

### Known Info
- **Nothing**

### Possible Problems
- **Shorts**
- **Opens**

**With the rotary switch turned to "Stop", are all circuits except the lights unpowered?**

**Test Options**
1. **Look**
2. **Test 90 TE/ICE-R**
   - **Page 2-751**

**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.

**Go to A, Page 2-78**

---

2. **DO ANY OF THE LIGHTS WORK WITH THE ROTARY SWITCH IN THE "STOP" POSITION?**

**Test Options**
- **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.

**Go to C, Page 2-82**

---

3. **DO ALL OF THE LIGHTS WORK WITH THE ROTARY SWITCH IN ANY POSITION?**

**Test Options**
- **Turn lights on and look**

**Reason for Question**
There may be problems which only affect one light, rather than all of them.

**Go to lights, Page 2-380**

---

**Go to 4, Page 2-74**
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 think that this is just an offset in the sensor.

The lights should work with the rotary switch in any position.

| 0-1500 AMPS DC |
| STE/ICE-R TEST 90 |
| 1. Connect probe. |
| 2. Start Test 90, DC amps. |
| 3. Displayed reading is in amps. |
DIAGNOSTIC FLOWCHART

4

WITH THE ROTARY SWITCH IN THE "RUN" POSITION, IS THE INSTRUMENT CLUSTER VOLTOMETER IN THE YELLOW OR GREEN ZONE?

4-72

GO TO D,
Page 2-84

YES

NO

5

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

5-84

GO TO INSTRUMENTS,
Page 2-319

YES

NO

6

DOES THE HEATER FAN WORK WITH THE ROTARY SWITCH IN THE "RUN" POSITION?

6-84

GO TO INSTRUMENTS,
Page 2-319

YES

NO

TEST OPTIONS

TRY IT.
LOOK.

REASON FOR QUESTION
This quickly verifies that power is getting from the batteries to the rotary switch and the batteries aren't discharged.

TEST OPTIONS

LOOK

REASON FOR QUESTION
Power may not be making it through circuit breaker 2 to the instrument panel.

TEST OPTIONS

TURN HEATER ON AND CHECK FOR AIRFLOW.

REASON FOR QUESTION
The heater fan should work with the rotary switch in the run position.

2-74
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

FROM 6, Page 2-74

7

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

NO

GO TO ALTERNATOR, Page 2-195

YES

8

DOES THE ENGINE COOLING FAN WORK?

NO

GO TO COOLING, Page 2-155

YES

9

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

NO

GO TO INSTRUMENTS, Page 2-319

YES

TEST OPTIONS
1. VOLTS GAGE
2. STE/ICE-R TEST 67,[Page 2-740]
3. MULTIMETER

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

TEST OPTIONS
TRY IT.

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

TEST OPTIONS
TRY IT.

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

NO FAULTS
<table>
<thead>
<tr>
<th>BATTERY VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/CE-R TEST 67</td>
</tr>
<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 glowplugs turn on.</td>
</tr>
</tbody>
</table>
**ELECTRICAL**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**
- SHORT CIRCUIT IN POWER LINES

**POSSIBLE PROBLEMS**
- BODY CONNECTOR HARNESS
- ENGINE CONNECTOR HARNESS
- ROTARY SWITCH

**TEST OPTIONS**

1. STE/ICE-R TEST 90
2. VISUAL CHECK

**REASON FOR QUESTION**
If the short is in the body connector harness or the rotary switch.

---

**A1**

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

**TEST OPTIONS**

1. STE/ICE-R TEST 90
2. VISUAL CHECK

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

---

**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?

**TEST OPTIONS**

1. STE/ICE-R TEST 90
2. VISUAL CHECK

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

---

**A3**

REPAIR OR REPLACE THE ENGINE CONNECTOR HARNESS. GO TO STEP 1, PAGE 2-72 TO CONTINUE TESTING.
REFERENCE INFORMATION

**WARNING**
DISCONNECT NEGATIVE BATTERY CABLE BEFORE DISCONNECTING AND RECONNECTING PROTECTIVE CONTROL BOX/DISTRIBUTION BOX HARNESS.

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

---

**0-1500 AMP DC STE/ICE-R TEST 90**

1. Connect probe.
2. Start Test 90, DC amps.
3. Displayed reading is in amps.

---

Replace PCB, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).

---

Repair harness, refer to (para. 4-85).
Replace harness. Notify DS maintenance.

---
**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)?**

- **B1**
  - **REPLACE ROTARY SWITCH**
  - **YES**
  - **NO**

- **B2**
  - **REPLACE PCB/DISTRIBUTION BOX**
  - **NO**
  - **YES**

- **B3**
  - **REPAIR OR REPLACE THE BODY CONNECTOR HARNESS. GO TO A2 ([Page 2-78]) TO CONTINUE TESTING.**

**TEST OPTIONS**

1. STE/ICE-R TEST 91 ([Page 2-752])
2. MULTIMETER

**REASON FOR QUESTION**

Checking the rotary switch first makes it easier to check the other possible problems.

**KNOWLEDGE OF THE POSSIBLE PROBLEMS**

- SHORT ON BODY CONNECTOR SIDE OF PCB/DISTRIBUTION BOX
- PCB/DISTRIBUTION BOX BODY CONNECTOR
- BODY CONNECTOR CABLE HARNESS

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

- **B2**
  - **REPLACE PCB/DISTRIBUTION BOX**
  - **NO**
  - **YES**

- **B3**
  - **REPAIR OR REPLACE THE BODY CONNECTOR HARNESS. GO TO A2 ([Page 2-78]) TO CONTINUE TESTING.**

**TEST OPTIONS**

1. STE/ICE-R TEST 89 ([Page 2-750])
2. MULTIMETER

**REASON FOR QUESTION**

If there is voltage at any of these pins then the PCB/distribution box must have a short in it.
REFERENCE INFORMATION

ELECTRICAL

Replace rotary switch. Refer to (para. 4-7).

Replace PCB. Refer to (para. 4-5).
Replace distribution box. Refer to (para. 4-5.1).

Repair or replace harness. Notify DS maintenance.

---

### 0-4500 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, 0-4500 ohms. |
| 3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9." |

---

### 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. |

---

**WARNING**

DISCONNECT NEGATIVE BATTERY CABLE BEFORE DISCONNECTING AND RECONNECTING PROTECTIVE CONTROL BOX/DISTRIBUTION BOX HARNESS.

There is battery voltage at the PCB/distribution box 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?

TEST OPTIONS

LOOK AND TOUCH

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

C2

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

TEST OPTIONS

LOOK

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

C3

GO TO LIGHTS, PARAGRAPH 2-33, PAGE 2-389, THEN CONTINUE TESTING AT STEP 3, PAGE 2-72.
REFERENCE INFORMATION

- Battery cables to starter
- Bus bar to solenoid
- PCB engine & body connector
- Light switch
**ELECTRICAL**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**
- POWER CAN BE TURNED OFF

**POSSIBLE PROBLEMS**
- BATTERIES INSTRUMENT CIRCUIT

**TEST OPTIONS**
1. STE/ICE-R TEST 67 (Page 2-749)
2. MULTIMETER

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

**IS THE BATTERY VOLTAGE 23.5 TO 25.5 VOLTS?**

**D1**

**NO**
- **GO TO BATTERY, Page 2-251**

**YES**
- **D2**

**GO TO INSTRUMENTS, PAGE 2-319 THEN CONTINUE TESTING AT STEP 4, PAGE 2-74.**
**BATTERY VOLTAGE**

**STEACE-R TEST 67**


2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries' voltage will drop when glowplugs 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.
BATTERY/ENGINE GROUND CIRCUIT
BODY GROUND CIRCUIT
ELECTRICAL

FRONT HOOD/LIGHTS GROUND CIRCUIT

[Diagram showing connections between LS Marker, LS Lamp Module, LS Headlight, Blackout Lamp, RS Headlight, RS Lamp Module, RS Marker, and Hood Harness Connector, with various points labeled 91B, 91C, 91D, 92A, 92B, 92C, and 92D connected to BODY GRD.]
ALL CIRCUITS MUST RETURN THROUGH VEHICLE GROUND.
ALTERNATOR INTERFACE

ENGINE MECHANICAL POWER FROM CRANKSHAFT VIA BELTS AND PULLEYS.

28 VOLT, 60 AMPERE ALTERNATOR

GROUND

TO TRANS. KICKDOWN 315A

TO COLD ADVANCE 569C

CONTROL CKT

STARTER LOCKOUT CKT

ENGINE RUN PRIMARY

CONTROL GROUND

ENGINE GROUND

BATTERIES
These Fuel System tests can be run any time you think there maybe 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 FO-1 leave open for reference while you are testing.

General Information

This set of tests maybe used when the engine is hard starting, has low power or runs rough. Just follow the path, answering the questions. Additional information and notes are given on the facing page (like this one) when necessary. It is recommended that you refer to your fold-out diagram now because it will help you follow the testing.
FUEL SYSTEM

1. IS THE FUEL SUPPLY AND QUALITY O.K.?
   - YES
     - GO TO A, Page 2-104
   - NO
     - 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.

2. DOES THE ENGINE START AND STAY RUNNING?
   - YES
     - GO TO B, Page 2-106
   - NO
     - 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.

3. DOES THE ENGINE START EASILY WHEN COLD?
   - YES
     - GO TO C, Page 2-110
   - NO
     - TEST OPTIONS
       - TRY STARTING THE ENGINE WHILE IT'S COLD.
     - REASON FOR QUESTION
       - Problem may be the cold advance circuit.

4. GO TO 4, Page 2-96
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 end 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, than 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 then ANSWER NO TO THIS QUESTION.

If you have trouble starting the engine you should have entered here byway of the Startability tests. If you didn’t begin there, go back to Page 2-41 and the 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 than 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

**DIAGNOSTIC FLOWCHART**

1. **FROM 3, Page 2-86**
2. **IS THE FUEL SUPPLY PRESSURE GREATER THAN 3 PSI (20.69 kPa) AT ALL SPEEDS?**
   - NO: GO TO D, Page 2-112
   - YES: TEST OPTIONS
     1. STE/ICE-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.

3. **IS THE FUEL VOLUME AT THE INJECTION PUMP INLET 1 PINT IN 30 SECONDS WHILE CRANKING?**
   - NO: GO TO D, Page 2-112
   - YES: TEST OPTIONS
     Fuel pump volume test
     REASON FOR QUESTION
     This is to verify that the fuel supply lines, fuel pump, and fuel filter are OK.

4. **DOES THE ENGINE RUN SMOOTHLY?**
   - NO: GO TO E, Page 2-116
   - YES: 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.

5. **IS THE IDLE SPEED 625 TO 675 RPM?**
   - NO: SEE NOTE AT RIGHT
   - YES: TEST OPTIONS
     STE/ICE-R TEST 10
     REASON FOR QUESTION
     This is to verify that the idle speed is adjusted properly.
Watch the fuel pump pressure while slowly accelerating the engine from idle to maximum speed. The pressure should always be greater than zero. If pressure, check to be sure it is still above zero even during maximum acceleration (maximum engine power). You can use STE/ICE 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 is dependent 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 glowplug problem and you should run the Glowplug 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 (refer to para. 3-35).

NOTE
Try to adjust the engine idle speed by turning the idle speed screw (refer to para 3-44). Continue testing if you can adjust the speed properly. If you cannot, notify DS maintenance.

Engine must be at normal operating temperature when making speed checks. Air fitter 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 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.

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 GAGE
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 625 - 675.
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's 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/ICE-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.

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

**WHITE**
Go to G, Page 2-122. Also could be injector timing. Notify DS maintenance.

**BLUE**
Blue smoke is a sign of oil entering the combustion chambers. It usually enters pest 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 Mechanical tests, Page 2-47, before you notify DS Maintenance.

**BLACK**
Air intake/exhaust, Page 2-137.
FUEL SYSTEM

DOES THE ENGINE SHUT OFF?

FROM 10, Page 2-100

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.

TEST OPTIONS
PROCEDURE AT RIGHT

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

KNOWLEDGE INFO
INJECTORS O.K.

POSSIBLE PROBLEMS
FUEL SOLENOID
OTHER INJECTION PUMP FAULTS

KNOWLEDGE INFO
EVERYTHING SO FAR IS O.K.

POSSIBLE PROBLEMS
INJECTION PUMP ADVANCE MECHANISM

GO TO H, Page 2-124

NOTIFY DS MAINTENANCE

DO YOU STILL HAVE A FUEL SYSTEM PROBLEM?

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

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

YES

NO
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 rpms 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 ten inch screwdriver.
FUEL SYSTEM

KNOWLEDGE INFO
- FUEL SUPPLY PROBLEM

POSSIBLE PROBLEMS
- FUEL PUMP
- FUEL FILTER
- FUEL LINES
- VENT LINES

DIAGNOSTIC FLOWCHART

A FROM 1, Page 2-99

A1

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

TEST OPTIONS
- TRY IT

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

GO TO D, Page 2-112

NO

YES

A2

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

IS THE FUEL CLEAN?

TEST OPTIONS
- DRAIN SOME FUEL

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

NO

DRAIN AND REFILL WITH FRESH FUEL. CHANGE FILTER.

YES

GO TO D, Page 2-112

TM 9-2320-280-20-1

2-104
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 sink 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, refer to (para 3-33).
**FUEL SYSTEM**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**

**ENGINE DOESN'T STAY RUNNING**

**POSSIBLE PROBLEMS**

- FUEL PUMP
- FUEL SUPPLY LINES
- FUEL RETURN LINES
- FUEL FILTER
- FUEL SOLENOID/WIRING
- HIGH PRESSURE SYSTEM

**B1**

Disconnect the glowplug controller and wire 569B/569D 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 0.5 amps DC flowing through wire 54A?

**TEST OPTIONS**

- STE/ICE Test 90, [page 2-751]
- 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.

**KNOWN INFO**

**OTHER SYSTEMS LISTED ABOVE OK**

**POSSIBLE PROBLEMS**

- FUEL PUMP
- FUEL SUPPLY LINES
- FUEL RETURN LINES
- FUEL FILTER
- FUEL SOLENOID/WIRING
- HIGH PRESSURE SYSTEM

**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**

- STE/ICE Test 24, [page 2-738] 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.

Go to B4, [page 2-108]
NOTE
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.

NOTE
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.

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

<table>
<thead>
<tr>
<th>5 AMPS DC</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 90.</td>
</tr>
<tr>
<td>3. Displayed reading is in amps.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FUEL PUMP PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST #24</td>
</tr>
<tr>
<td>1. Select Fuel Supply Pressure Test (Test #24). Perform CAL.</td>
</tr>
<tr>
<td>2. Crank (or start) engine.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FUEL PUMP VOLUME TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Disconnect fuel line at injection pump inlet and route fuel line into a suitable, 1 quart container.</td>
</tr>
<tr>
<td>2. Crank the engine for 30 seconds.</td>
</tr>
<tr>
<td>3. If the pump and lines are ok, you should get about 1 pint (1/2 quart) (0.5L) in 30 seconds.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FUEL PUMP PRESSURE TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE GAUGE</td>
</tr>
<tr>
<td>1. Connect a tee into the fuel line between the fuel filter outlet and the injection pump inlet.</td>
</tr>
<tr>
<td>2. Attach gauge to tee.</td>
</tr>
<tr>
<td>3. Crank (or Start) engine.</td>
</tr>
</tbody>
</table>
**FUEL SYSTEM**

**DIAGNOSTIC FLOWCHART**

**From B3 Page 2-106**

**B4**

**DOES THE ENGINE RUN POORLY WITH THE RETURN LINE DISCONNECTED?**

**TEST OPTIONS**
- Visual Inspection

**REASON FOR QUESTION**
- Plugged fuel return lines cause back pressure which prevents injection pump from working properly.

**NO**

Repair/Replace Fuel Injector Return Lines

**YES**

**B5**

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

**TEST OPTIONS**
- Run Intake/Exhaust Tests Page 2-137

**REASON FOR TESTS**
- There is still a possible Intake/Exhaust fault. If you came here from Startability then this wasn’t tested.

**B6**

**RUN THE STARTABILITY TEST**

**RUN THE FUEL SYSTEM TEST**

**TEST OPTIONS**
- Run Startability Test Page 2-41
- Run Fuel System Test Page 2-95

**REASON FOR TEST**
- If all efforts have been exhausted, still experience no hot start problem, identify the fuel injection pump model and serial number.
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. 3-35).
Replace fuel lines. Refer to (para. 3-25).

If you came here from the Startability Tests, return to STEP 5. [Page 2-44]
If you haven’t run the Startability Tests yet, go to STEP 1. [Page 2-42]

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>DB2829-4523 (2910-01-199-2355)</td>
<td>7539307</td>
<td>23122 or 28396</td>
<td>31816/4320-01-317-0692</td>
</tr>
<tr>
<td>DB2829-4879 (2910-01-326-9221)</td>
<td>80644583</td>
<td>23122 or 28396</td>
<td>31816/4320-01-317-0692</td>
</tr>
<tr>
<td>DB2831-5149 (2910-01-414-1272)</td>
<td>776848</td>
<td>29124</td>
<td>31506/2910-01-414-5382</td>
</tr>
<tr>
<td>DB2831-5149 (2910-01-434-8597)</td>
<td>776848</td>
<td>29124</td>
<td>31506/2910-01-414-5382</td>
</tr>
</tbody>
</table>
**FUEL SYSTEM**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**

C1

**HARD COLD STARTING**

**POSSIBLE PROBLEMS**

COLD ADVANCE CIRCUIT
GLOWPLUG CIRCUIT
FUEL SYSTEM

---

**TEST OPTIONS**

1. STE/ICE-R Test 89, Page 2-750
2. Multimeter

**REASON FOR QUESTION**

Need battery voltage to energize cold advance solenoid.

---

**KNOWN INFO**

C2

**POWER TO COLD ADVANCE SOLENOID**

**POSSIBLE PROBLEMS**

COLD ADVANCE CIRCUIT
GLOWPLUG CIRCUIT
FUEL SYSTEM

---

**TEST OPTIONS**

Perform checks at right Page 2-111

**REASON FOR QUESTION**

Cold advance circuit can cause hard cold starting.

---

**KNOWN INFO**

C3

**COLD ADVANCE CIRCUIT OK**

**POSSIBLE PROBLEMS**

GLOWPLUG CIRCUIT
FUEL SYSTEM

---

**TEST OPTIONS**

Fuel system tests

**REASON FOR TESTS**

The glowplug circuit operates during cold start.
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 pegs and remember that the cold advance maybe the problem if everything else checks out OK.

The Glowplugs 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 maybe checked as follows:

1. Start the engine.
2. Disconnect wire 569B/569D 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 569D/569B with the engine running. The advance mechanism should move about 1/4 inch.
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.
If you hear a hissing noise while removing the fuel filter cap then 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, refer to (para. 3-27.)

Replace vent valve, refer to (para. 3-24.)

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 upon 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.

Replace fuel tank, refer to (para. 3-24.)
FUEL SYSTEM

FROM D3,
Page 2-112

DIAGNOSTIC FLOWCHART

D4

INSPECT THE FUEL LINES. ARE THE LINES OK?

YES

REPAIR/ REPLACE LINES.

NO

TEST OPTIONS

VISUAL INSPECTION

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?

NO

REPLACE FUEL FILTER.

YES

TEST OPTIONS

VISUAL INSPECTION

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?

NO

SEE NOTE AT RIGHT

REPLACE THE FUEL PUMP. RETURN TO THE TEST YOU CAME FROM AND CONTINUE TESTING

YES

TEST OPTIONS

VISUAL INSPECTION

REASON FOR QUESTION

If the components that drive the fuel pump are worn, then the pump will not operate properly.
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, refer to (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 be affected also.

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 3-33) or notify DS maintenance.

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. Refer to (para 3-23). If the lobe on the camshaft is worn, notify DS maintenance.

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 3-23).
FUEL SYSTEM

DIAGNOSTIC FLOWCHART

E1

RUN THE GLOWPLUG TESTS. RETURN HERE IF NO FAULTS FOUND.

TEST OPTIONS

RUN GLOWPLUG TESTS (Page 2-303), IF YOU ARE SURE THAT THE PROBLEM EXISTS WHEN THE ENGINE IS WARM, YOU CAN SKIP THIS QUESTION.

REASON FOR QUESTION

Glowplugs failures can cause rough running when cold.

E2

CHECK COLD ADVANCE CIRCUIT.
GO TO STEP C2, PAGE 2-110. RETURN HERE IF NO FAULTS FOUND.

TEST OPTIONS

RUN COLD ADVANCE TESTS (Page 2-110)

REASON FOR QUESTION

A faulty cold advance circuit can cause rough running.

GO TO E3, PAGE 2-115
Injection pump timing that is too far advanced can cause glowplugs failure because it increases cylinder temperature. Usually several but not all glowplugs will fail.
FUEL SYSTEM

**E3**

ARE THE FUEL SUPPLY LINES OK?

**TEST OPTIONS**

VISUAL INSPECTION

**REASON FOR QUESTION**

Air leaks, lack of fuel or restricted check valve can cause rough running at different speeds.

**FROM E2, Page 2-116**

![Diagram]

**YES**

REPAIR/REPLACE LINES

**NO**

**POSSIBLE PROBLEMS**

FUEL LINES
FUEL PUMP
FUEL FILTER
INJECTION PUMP
INJECTORS
RETURN CHECK VALVE

**KNOWN INFO**

COLD ADVANCE OK

**E4**

ARE THE FUEL RETURN LINES OK?

**TEST OPTIONS**

VISUAL INSPECTION

**REASON FOR QUESTION**

Restricted return lines or restricted check valve can cause the injection pump to malfunction.

**YES**

REPAIR/REPLACE LINES

**NO**

**POSSIBLE PROBLEMS**

FUEL LINES
FUEL PUMP
FUEL FILTER
INJECTION PUMP
INJECTORS
RETURN CHECK VALVE

**KNOWN INFO**

SUPPLY LINES OK

**E5**

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 ENGINE MECHANICAL TESTS BEFORE YOU NOTIFY DS MAINTENANCE.

**TEST OPTIONS**

RUN ENGINE MECHANICAL TESTS [Page 2-143]
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 (refer to para 3-25).

Check the fitting 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 (refer to para. 3-25).

Replace fuel line (refer to para 3-25).
FUEL SYSTEM

F1

INSPECT FUEL SUPPLY AND RETURN LINES. ARE THE LINES OK?

TEST OPTIONS

VISUAL INSPECTION

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.

NO

REPAIR/REPLACE LINES.

YES

F2

ARE THE INTAKE AND EXHAUST SYSTEMS OK?

TEST OPTIONS

RUN AIR INTAKE/EXHAUST TESTS.

REASON FOR QUESTION
The intake and exhaust systems affect vehicle operation under all conditions.

NO

GO TO AIR INTAKE/EXHAUST TESTS, Page 2-137

YES

F3

WITH ENGINE NOT RUNNING CHECK MOVEMENT OF ACCELERATOR PEDAL. DOES PEDAL HAVE FULL TRAVEL?

TEST OPTIONS

VISUAL INSPECTION

REASON FOR QUESTION
If the pedal sticks you may not be able to fully open the throttle.

NO

SEE NOTE AT RIGHT

YES

NOTIFY DS MAINTENANCE

2-120
REFERENCE INFORMATION

! 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.

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, refer to (para 3-25).

FUEL SYSTEM

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 9-2320-280-10]. If you do not have full pedal travel then disconnect the accelerator linkage from the fuel injection pump and recheck the travel. If you now have full travel then 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

G FROM 10,
Page 2-100

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.

G1

DOES THE EXHAUST SMELL LIKE RAW FUEL?

TEST OPTIONS

GO TO J1,
Page 2-128

YES

NO

G2

DOES THE EXHAUST SMOKE FOR MORE THAN 2 OR 3 MINUTES AFTER STARTING THE ENGINE?

TEST OPTIONS

VISUAL INSPECTION

GO TO STEP 10,
Page 2-100

NO

YES

G3

RUN THE GLOWPLUG TESTS. IF NO FAULTS FOUND, NOTIFY DS MAINTENANCE

TEST OPTIONS

RUN GLOWPLUG TESTS
(Page 2-303)

GLOWPLUGS OK
WHITE SMOKE

REASON FOR QUESTION
Some white smoke after a cold start is normal. The colder it is, the more white smoke you’ll see. The glowplugs 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 Glowplug Tests (Page 2-303), paying special attention to the afterglow operation.

POSSIBLE PROBLEMS
INJECTION TIMING
INTERNAL ENGINE
PROBLEMS
FUEL QUALITY
RETURN CHECK VALVE

POSSIBLE PROBLEMS
ENGINE MECHANICAL

NOW INFO
WHITE SMOKE

NOW INFO
GLOWPLUGS OK
WHITE SMOKE
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 then 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 bed head gasket, cracked block, or a restricted check valve. Check for restricted check valve (para. 3-35).
**FUEL SYSTEM**

**KNOWN INFO**
- ENGINE WON'T SHUT OFF

**POSSIBLE PROBLEMS**
- FUEL SOLENOID
- SOLENOID WIRING
- ROTARY SWITCH
- CONTROL BOX

**H1**
- **DISCONNECT WIRE 54A FROM FUEL SOLENOID. DOES THE ENGINE SHUT OFF?**
  - **TEST OPTIONS**
  - LISTEN
  - **REASON FOR QUESTION**
  - If the engine doesn't shut off then the solenoid is mechanically stuck open.

**H2**
- **TURN ROTARY SWITCH TO STOP, DISCONNECT BODY CONNECTOR AT PROTECTIVE CONTROL BOX. IS VOLTAGE 0 AT WIRE 54A AT FUEL SOLENOID?**
  - **TEST OPTIONS**
  - 1. STE/ICE-R TEST 89
    - *Page 2-730*
  - 2. MULTIMETER
  - **REASON FOR QUESTION**
  - If voltage is 0 then the problem is in the wiring harness to the switch or in the switch.
  - **GO TO K, Page 2-128**

**H3**
- **RECONNECT BODY CONNECTOR. DISCONNECT WIRE 11A FROM ROTARY SWITCH. IS VOLTAGE 0 AT WIRE 54A AT FUEL SOLENOID?**
  - **TEST OPTIONS**
  - 1. STE/ICE-R TEST 89
    - *Page 2-750*
  - 2. MULTIMETER
  - **REASON FOR QUESTION**
  - This wire supplies power to the rotary switch. There should be no power to the solenoid with it disconnected.
  - **REPAIR SHORT IN BODY CONNECTOR HARNESS.**

**REPLACE ROTARY SWITCH. RERUN FUEL SYSTEM TEST TO VERIFY THERE ARE NO OTHER FAULTS.**

2-124
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.

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
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.

For repair instructions (HARNESS REPAIR), refer to (para 4-85).

For repair/replace instructions (ROTARY SWITCH), refer to (para 4-7).

FUEL SYSTEM

0-45 DC 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.

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.

NO STEP

INJECTION PUMP

WIRE 54A
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 Inspection

Reason for Question
To see if there is fuel available to the injection pump.

See Note at Right

I2
Is the glowplug circuit OK? (If you don't know, run the glowplug tests, return here if no faults found).

Test Options
- Glowplugs Test

Reason for Question
On a cool day a faulty glowplug circuit will prevent the engine from starting.

I3
Disconnect wire 569B from the cold advance solenoid.

Test Options
- Ste/ice-r Test 89

Reason for Question
On a cold day a faulty cold advance circuit will prevent the engine from starting.

With rotary switch in the "run" position, do you have battery voltage at wire 569B?

Faulty injection pump notify DS maintenance

Repair 569B or replace harness

Known Info
- Glowplugs OK

Possible Problems
- Fuel solenoid
- Injection pump injectors
- Cold advance

Known Info
- Fuel available to the injection pump
NOTE
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 2-112.

If the line is clogged, then replace it. Start the engine and see if it stays running. If it doesn't start or stay running then 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 then 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.

For repair/replace instructions, refer to (para 4-85).
**NOTE**

If you are getting white smoke due to coolant entering the cylinders then 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 then you may have missed a fuel problem. Re-run 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.

**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 then 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.

For repair/replace instructions (HARNESS), refer to (para 4-85).

For repair/replace instructions (PCB), refer to (para 4-5).

---

**0-45 DC VOLS 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**

**DIAGNOSTIC FLOWCHART**

**M1**

WITH ROTARY SWITCH IN "RUN" POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 5A AT THE ALTERNATOR OUTPUT?

**TEST OPTIONS**

1. STE/ICE-R TEST 89 (Page 2-750)
2. MULTIMETER

**REASON FOR QUESTION**

With rotary switch in run position, W5A is connected to battery voltage through the PCB and it supplies power to the cold advance switch.

**M2**

DISCONNECT WIRE 569C AT COLD ADVANCE SWITCH. WITH ROTARY SWITCH IN "RUN" POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 569C?

**TEST OPTIONS**

1. STE/ICE-R TEST 89 (Page 2-750)
2. MULTIMETER

**REASON FOR QUESTION**

If you have no voltage here then the problem may be the cold advance switch.

**M3**

RECONNECT WIRE 569C. DISCONNECT WIRE 569B FROM COLD ADVANCE SWITCH WITH ROTARY SWITCH IN "RUN" POSITION. DO YOU HAVE BATTERY VOLTAGE AT SWITCH LEAD?

**TEST OPTIONS**

1. STE/ICE-R TEST 89 (Page 2-750)
2. MULTIMETER

**REASON FOR QUESTION**

If you don't have voltage here then the problem is the switch.

---

**KNOWN INFO**

ENGINE CRANKS
NO VOLTAGE AT ADVANCE SOLENOID.

**POSSIBLE PROBLEMS**

PCB
COLD ADVANCE SWITCH WIRING

---

**KNOWN INFO**

PCB OK
ENGINE CRANKS
NO VOLTAGE AT ADVANCE SOLENOID

**POSSIBLE PROBLEMS**

COLD ADVANCE SWITCH WIRING

---

**KNOWN INFO**

PCB OK
ENGINE CRANKS
NO VOLTAGE AT ADVANCE SOLENOID

**POSSIBLE PROBLEMS**

COLD ADVANCE SWITCH WIRING

---

**REPAIR 569C/ REPLACE HARNESS**

**REPLACE COLD ADVANCE SWITCH**

**REPAIR 569B/ REPLACE HARNESS**
REFERENCE INFORMATION

You should only run the engine long enough to determine the gage reading because engine temperature must stay below 90°F (33°C) for the Cold Advance Circuit to function.

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 569C at Cold Advance Switch.
3. Turn Rotary Switch to Run position.
4. Check for battery voltage at wire 569C.

Repair wire or replace harness, refer to (para 4-85).

NOTE
Engine temp must be less than 90°F (33°C) when testing the switch.

For repair/replace instructions, (COLD ADVANCE SWITCH), refer to (para 4-27).

For repair/replace instructions, (HARNESS), refer to (para 4-85).

FUEL SYSTEM

0-45 DC VOLTS ST/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.

COLD ADVANCE CIRCUIT

From Protective Control Box

- 569A
- 5A
- 569C
- Cold Advance Switch
- 569B
- Cold Advance Solenoid
- Injection Pump

Alternator output is hot when the Rotary Switch is in the RUN position.

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.
REFERENCE INFORMATION

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. Repair wiring, refer to (para 4-85).

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, refer to (para 4-85).

Remember to reconnect any wires that were disconnected during troubleshooting.

FUEL SYSTEM

FUEL SOLENOID WIRING

PCB

ENGINE CONNECTOR

G B

BODY CONNECTOR

11A

ROTARY SWITCH

B R S

59C

54A 29C

29B 29A

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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

2-133
FUEL SYSTEM

FROM N3, [Page 2-132]

N4

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

N5

WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DO YOU HAVE CONTINUITY BETWEEN THE TERMINALS FOR WIRES 11A & 29A ON THE ROTARY SWITCH?

NO

REPLACE ROTARY SWITCH

YES

!!

N6

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

NO FAULTS
**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.

Be sure to reconnect the wires at the rotary switch and the fuel solenoid.

For repair/replace instructions (PCB), refer to (para 4-5).

---

**FUEL SYSTEM**

**FUEL SOLENOID WIRING**

- **ENGINE CONNECTOR**
  - **A**
  - **569C**
  - **54A**

- **PCB**
  - **G**
  - **B**
  - **29C**
  - **11A**

- **ROTARY SWITCH**
  - **29A**
  - **14A**
  - **11A**

---

**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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9.9."

---

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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).
2-23. AIR INTAKE/EXHAUST TESTS

These Air Intake/Exhaust System tests can be run anytime you think there maybe 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 anytime you open the hood or check the underside of your vehicle.
INTAKE AIR/ EXHAUST

1. KNOWN INFO
   NOTHING

2. POSSIBLE PROBLEMS
   AIR FILTER
   INDUCTION SYSTEM
   EXHAUST PIPE
   MUFFLER

3. TEST OPTIONS
   1. VISUAL INSPECTION
   2. DASHBOARD INDICATOR
   3. REMOVE AND INSPECT ELEMENT

4. REASON FOR QUESTION
   If the air filter is clogged, the engine will not develop full power. Engine may exhaust black smoke or it may not start at all.

5. IS THE AIR FILTER ELEMENT OK?
   YES
   NO
   REPLACE AIR FILTER ELEMENT

6. 2. KNOWN INFO
    AIR FILTER OK

7. POSSIBLE PROBLEMS
   INDUCTION SYSTEM
   EXHAUST PIPE
   MUFFLER

8. TEST OPTIONS
   VISUAL INSPECTION

9. REASON FOR QUESTION
   If the induction system is broken, debris may enter the engine past the air filter.

10. IS THE INDUCTION SYSTEM INTACT AND NOT BLOCKED?
    YES
    NO
    REPAIR/REPLACE INDUCTION SYSTEM COMPONENTS AS REQUIRED

11. 3. KNOWN INFO
     AIR FILTER OK
     INDUCTION SYSTEM OK

12. POSSIBLE PROBLEMS
    EXHAUST MUFFLER

13. TEST OPTIONS
    1. VISUAL INSPECTION
    2. CHECK FOR BENT OR DENTED EXHAUST PIPES/MUFFLER.

14. REASON FOR QUESTION
    If the exhaust is broken or blocked, the engine will not develop full power or it may not start.

15. IS THE EXHAUST PIPE INTACT AND NOT BLOCKED?
    YES
    NO
    REPAIR/REPLACE INDUCTION SYSTEM COMPONENTS AS REQUIRED

16. GO TO 4.
REFERENCE INFORMATION

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, refer to (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 section, (page 2-319).

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, check gaskets where possible. Replace induction system components, refer to (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, refer to (para 3-12).
**INTAKE AIR/ EXHAUST**

**KNOWN INFO**
- AIR FILTER OK
- INDUCTION SYSTEM OK
- EXHAUST PIPE OK

**POSSIBLE PROBLEMS**
- MUFFLER

**DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**
- VISUAL INSPECTION

**REASON FOR QUESTION**
If the muffler is damaged or blocked, the engine will not develop full power or it may not start.

**IS THE MUFFLER INTACT AND NOT BLOCKED?**

- **NO**
  - REPAIR/ REPLACE MUFFLER
- **YES**
  - NO FAULTS FOUND.
Look for damage caused by rocks such as bent pipes or holes, loose or broken clamps.

Replace muffler, refer to para 3-48.
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.
COMPRESSION / MECHANICAL

START

1

DOES THE ENGINE CRANK AT NORMAL SPEED?

TEST OPTIONS
STE/ICE-R TEST 10 [Page 2-734]

REASON FOR QUESTION
No cranking or slow cranking may indicate a seized or light engine, weak batteries or a bad starter circuit.

Known Info

Nothing

Possible Problems
Engine
Fuel System
Intake/Exhaust
Battery Circuit
Starter Circuit
Lubrication

Yes

Go to A, Page 2-148

No

Go to C, Page 2-148

2

DOES THE VEHICLE START?

TEST OPTIONS
Follow Normal Starting Procedure

Reason for Question
If the engine starts, then most of the fuel system is ok and the intake/exhaust system is probably ok.

Known Info

Battery Circuit OK
Starter Circuit OK
Engine Not Seized

Possible Problems
Fuel System
Engine
Intake/Exhaust

Yes

Go to Startability, Page 2-41

No

Go to C, Page 2-148

3

IS THE ENGINE OIL PRESSURE 40-45 PSI AT 2000 RPM AND THE ENGINE WARM?

TEST OPTIONS
1. Oil Pressure Gauge
2. STE/ICE-R TEST 50 [Page 2-739]

Reason for Question
Without proper oil pressure, the engine won't be lubricated properly.

Known Info

Battery Circuit OK
Starter Circuit OK
Engine Not Seized
Air & Fuel to Cylinders

Possible Problems
Lubrication
Engine
Fuel System
Intake/Exhaust

Yes

Go to Lubrication, Page 2-65

No

Go to Lubrication, Page 2-65

Go to 4, Page 2-148
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 then it could be due to a Starter or Battery Circuit fault or it may be due to an internal engine problem.

COMPRESSION / MECHANICAL

ENGINE RPM
STEACE-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
SENDING UNIT

Oil pressure may go as high as 80 psi 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 1000 psi transducer (blue stripe). Check pressure at idle and at 2000 RPM. If pressure is low, check oil level and condition. Add or change oil as required.

OIL PRESSURE
STEACE-R TEST 50

1. Install STE/ICE-R 0 to1000 PSI 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 minimum at idle and 40-45 psi at 2000 RPM. Pressure may go as high as 80 psi when the engine is cold.
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.

If the engine fails the cylinder unbalance test then it indicates an individual cylinder problem such as a bad fuel injector, excessive blowby, etc.

Loss of power can be caused by internal engine problems, fuel system, air intake/exhaust, or drivetrain problems.
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).

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 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.
**DIAGNOSTIC FLOWCHART**

**COMPRESSiON / MECHANICAL**

**A1**

**IS THE BATTERY CIRCUIT OK?**

- **KNOWN INFO**
  - ENGINE DOESN'T CRANK PROPERLY

- **POSSIBLE PROBLEMS**
  - ENGINE STARTER CIRCUIT
  - BATTERY CIRCUIT

- **TEST OPTIONS**
  1. STE/ICE-R TEST 67, 73, 75
     ([Page 2-740], 746, 748)
  2. RUN BATTERY CIRCUIT TESTS, [Page 2-251]

- **REASON FOR QUESTION**
  A faulty Battery Circuit can cause slow or no cranking.

- **A2**

**IS THE STARTER CIRCUIT OK?**

- **KNOWN INFO**
  - ENGINE DOESN'T CRANK PROPERLY
  - BATTERY CIRCUIT OK

- **POSSIBLE PROBLEMS**
  - ENGINE STARTER CIRCUIT

- **TEST OPTIONS**
  1. STE/ICE-R TESTS 71, 72, 74
     ([Page 2-744], 745, 747)
  2. RUN STARTER CIRCUIT TESTS, [Page 2-251]

- **REASON FOR QUESTION**
  A faulty Starter Circuit can cause slow or no cranking.

- **A3**

**CAN YOU TURN THE CRANKSHAFT MANUALLY?**

- **KNOWN INFO**
  - ENGINE DOESN'T CRANK PROPERLY
  - BATTERY CIRCUIT OK
  - STARTER CIRCUIT OK

- **POSSIBLE PROBLEMS**
  - ENGINE DRIVETRAIN

- **TEST OPTIONS**
  USE A BREAKER BAR AND SOCKET ON CRANKSHAFT PULLEY BOLT

- **REASON FOR QUESTION**
  If you can't turn the engine by hand then the engine is probably seized.

- **NO**

**NOTIFY DS MAINTENANCE**

- **YES**

**NO FAULTS FOUND, GO TO STEP 2 OF THE GO CHAIN, [Page 2-144]**

---

2-148
### 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 glowplugs turn on.

### 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.

The Starter Circuit Tests begin on page 2-321.

*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 glowplugs and try again. If the engine turns now, try cranking it and look for fuel at the eight glowplug holes. If you see fuel at any of the holes then the engine may have had hydrostatic lock. Crank the engine for about 15 seconds to clear the fuel then re-install the glowplugs and try to start the engine. If it still won’t crank, notify DS maintenance.

### STARTER FIRST PEAK CURRENT
**STE/ICE-R TEST 72**

1. Disconnect wire 54A at injection pump to prevent starting.

2. Disconnect glowplugs controller and fan solenoid.

3. Start Test 72, starter first peak current.

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 glowplugs 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 glowplugs 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.
**Diagostic Flowchart**

**Compression / Mechanical**

**Known Info**
- Engine starts
- Abnormal noise or vibration

**Possible Problems**
- Engine mechanical

**Test Options**
- Drive the vehicle

**Reason for Question**
If the problem occurs only when the vehicle is being driven, it's probably not an engine problem.

**Run Transmission/Suspension/Steering Tests**

**Known Info**
- Noise or vibration
- Under all conditions

**Possible Problems**
- Engine drivetrain

**Test Options**
- Look, listen & feel.

**Reason for Question**
There are many problems that can cause noise or vibration.

**Check the items listed on the right hand page. Is everything OK?**

**Repair or replace the faulty component(s) if authorized, otherwise notify DeM maintenance**

**Return to 5. Page 2-146**
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 9-2320-280-10.

WARNING

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

Engine Mounts
Transmission Mounts
Cooling Fan
Belts
Water Pump
Power Steering Pump
Fuel Pump
Alternator
Air Induction Components
Exhaust Components
**COMPRESSIO/N / MECHANICAL**

**TEST OPTIONS**

**C1**

**RUN A POWER TEST WITH THE AIR FILTER REMOVED. DOES THE TEST STILL FAIL?**

**TEST OPTIONS**

**C FROM 6, Page 2-146**

**GO TO AIR INTAKE/EXHAUST TESTS, Page 2-137**

**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.

---

**KNOWN INFO**

**BATTERY AND STARTER CIRCUITS OK**

**POSSIBLE PROBLEMS**

**ENGINE DRIVETRAIN**

**FUEL SYSTEM**

**INTAKE/EXHAUST**

---

**C2**

**HAVE YOU RUN THE FUEL SYSTEM TESTS YET?**

**TEST OPTIONS**

**FUEL SYSTEM TESTS PAGE 2-95**

**GO TO FUEL SYSTEM TESTS, Page 2-95**

**REASON FOR QUESTION**

Many fuel system faults will allow the engine to start and run but prevent it from producing full power.

---

**KNOWN INFO**

**BATTERY AND STARTER CIRCUITS OK**

**AIR INTAKE/EXHAUST OK**

**POSSIBLE PROBLEMS**

**ENGINE DRIVETRAIN**

---

**C3**

**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.**

---

**TM 9-2320-280-20-1**

2-152
If faults are found and corrected go to
STEP 2 of the GO CHAIN.

If no faults are found go to B2,
[page 2-150.]

If faults are found and corrected go to
STEP 2 of the GO CHAIN.

If no faults are found go to B2,
[page 2-150.]
2-25. ENGINE COOLING TESTS

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 2-32 to find out if the gauge is OK.

Fold-out FO-4 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 base antifreeze will be used. The fan is activated when coolant temperature reaches 215°F (102°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, -51.1°C) INHIBITED (MIL-A-46153)</th>
<th>SPECIFIC GRAVITY (60°F) (20°C)</th>
<th>ARCTIC GRADE ANTIFREEZE (-90°F (-67.7°C) MIL-A-11755)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+20</td>
<td>1-1/2</td>
<td>1.022</td>
<td>Freezing point of -90°F (-67.7°C). Issued ready for use and must not be mixed with any other liquid.</td>
</tr>
<tr>
<td>+10</td>
<td>2</td>
<td>1.036</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2-3/4</td>
<td>1.047</td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>3-1/4</td>
<td>1.055</td>
<td></td>
</tr>
<tr>
<td>-20</td>
<td>3-1/2</td>
<td>1.062</td>
<td></td>
</tr>
<tr>
<td>-30</td>
<td>4</td>
<td>1.067</td>
<td></td>
</tr>
<tr>
<td>-40</td>
<td>4-1/4</td>
<td>1.073</td>
<td></td>
</tr>
<tr>
<td>-50</td>
<td>4-1/2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-55</td>
<td>4-3/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BELOW -60</td>
<td>BELOW -51.1</td>
<td>USE ARCTIC GRADE ANTIFREEZE (-90°F (-67.7°C)</td>
<td></td>
</tr>
</tbody>
</table>

Change 1 2-155
ENGINE COOLING

DIAGNOSTIC FLOWCHART

KNOWN INFO

NONE

POSSIBLE PROBLEMS

COOLING COMPONENTS
ENGINE FAN BELTS
WATER PUMP AND
PULLEY

TEST OPTIONS

COOLANT MIXTURE TEST KIT
NSN 6630-00-169-1506.

COOLANT TESTER
NSN 6630-00-105-1418.

REASON FOR QUESTION

The cooling system will not operate properly if the mixture is incorrect.

START

1

!!

IS THE COOLANT MIXTURE CORRECT?
(SEE CHART ON PAGE 2-155)

NO

DRAIN & REFILL COOLANT

YES

!!

2

KNOW KNOWN INFO

COOLANT QUALITY OK

POSSIBLE PROBLEMS

COOLANT LEVEL
COOLING COMPONENTS
ENGINE FAN BELTS
WATER PUMP AND
PULLEY

TEST OPTIONS

VISUAL INSPECTION.

REASON FOR QUESTION

Low coolant levels may cause overheating.

IS THE COOLANT AT THE CORRECT LEVEL?

NO

FILL TO PROPER LEVEL

YES

!!

3

KNOW KNOWN INFO

COOLANT OK

POSSIBLE PROBLEMS

THERMOSTAT
COOLING COMPONENTS
ENGINE FAN BELTS
WATER PUMP AND
PULLEY

TEST OPTIONS

FEEL FOR COOLANT IN UPPER RADIATOR HOSE WHEN ENGINE IS HOT, OR REMOVE THERMOSTAT. EXPOSE IT TO 190°F (88° C) AND SEE IF IT OPENS.

REASON FOR QUESTION

An improperly functioning thermostat can cause operating temperatures that are either too hot or too cold.

IS THE THERMOSTAT WORKING PROPERLY?

NO

REPLACE THERMOSTAT

YES

!!

GO TO 4,
Page 2-158
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, refer to (para 3-60).

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, refer to (para 3-60).

WARNING
Always use caution when approaching a hot engine. Failure to do so may result in serious burns.

Remove and replace the thermostat, refer to (para 3-75).
ENGINE COOLING

DIAGNOSTIC FLOWCHART

FROM
3, Page 2-156

4

FROM
3, Page 2-156

!!

TEST OPTIONS
PRESSURE TESTER.

REASON FOR QUESTION
A defective pressure cap may cause overheating.

INSPECT THE PRESSURE CAP. IS IT IN GOOD CONDITION?

NO

REPLACE PRESSURE CAP

YES

5

TEST OPTIONS
LOOK.

REASON FOR QUESTION
Physical damage and blocked passages can cause cooling problems.

INSPECT ALL RADIATOR HOSES, COOLANT HOSES, SURGE TANK, RADIATOR, OIL COOLER, AND FITTINGS FOR DAMAGE, BLOCKAGE OR LARGE LEAKS IS EVERYTHING IN GOOD SHAPE?

NO

REPAIR/REPLACE AS AUTHORIZED. (FLUSH SYSTEM IF BLOCKED), OTHERWISE NOTIFY DS MAINTENANCE.

YES

6

TEST OPTIONS
LOOK — SEE DESCRIPTION OF OPERATION AT RIGHT.

REASON FOR QUESTION
The engine fan helps cool the engine.

IS THE ENGINE FAN WORKING PROPERLY?

NO

GO TO A, Page 2-164

YES

GO TO 7, Page 2-160
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, refer to (para. 3-60).

Flush cooling system, refer to (para. 3-60).

For surge tank and radiator support replacement procedures, refer to (paras. 3-63 and 3-64).

For oil cooler and oil cooler hose replacement procedures, refer to (paras. 3-7 and 3-8).

Notify DS maintenance to repair radiators.

ENGINE COOLING

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 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 transmission kickdown system disengages the fan drive for 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.

If the vehicle’s serial number is 68555 through 72541 or 100000 through 112867, and you see ADCO stamped on top of the time delay module, replace the module with part NSN 5945-01-193-7175, refer to (para. 4-31).
ENGINE COOLING

KNOWN INFO
COOLANT OK
PRESSURE CAP OK
HOSES OK
SURGE TANK OK
OIL COOLER OK
ENGINE FAN OK

POSSIBLE PROBLEMS
RADIATOR
WATER PUMP & PULLEY BELTS

7

FROM 8,
Page 2-158

INSPECT THE RADIATOR. IS IT IN GOOD CONDITION (FINS NOT BADLY BENT OR BLOCKED)?

YES

NO

STRAIGHTEN AND CLEAN

TEST OPTIONS
LOOK.

REASON FOR QUESTION
Bent or blocked fins prevent efficient cooling of the coolant.

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 BELTS

INSPECT THE WATER PUMP AND PULLEY. ARE THEY IN GOOD CONDITION?

YES

NO

REPLACE PULLEY OR PUMP

TEST OPTIONS
LOOK AND LISTEN.

REASON FOR QUESTION
A bad pulley and water pump won't cool the engine efficiently.

9

KNOWN INFO
RADIATOR/HOSES OK
SURGE TANK OK
OIL COOLER OK
ENGINE FAN OK
PUMP & PULLEY OK

POSSIBLE PROBLEMS
BELTS
INTERNAL ENGINE LEAKS

ARE THE FAN DRIVEBELTS TIGHT AND IN GOOD CONDITION?

YES

NO

REPLACE OR TIGHTEN BELTS

TEST OPTIONS
VISUAL INSPECTION USE BELT TENSION GAUGE.

REASON FOR QUESTION
Loose belts will not drive the fan properly.

GO TO 10,
Page 2-162
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, refer to (para 3-76). A bad water pump needs to be replaced by DS maintenance.

Replace belts, refer to (para. 3-81, all except "A2" vehicles) (para. 3-83, "A2" vehicles) or tighten belts, refer to (para. 3-82, all except "A2" vehicles).
ENGINE COOLING

DIAGNOSTIC FLOWCHART

KNOWLEDGE

EVERYTHING IS OK SO FAR.

POSSIBLE PROBLEMS

HEAD GASKET OR OTHER INTERNAL ENGINE PROBLEMS.

ARE THE HEAD GASKETS OK?

TEST OPTIONS

LOOK

REASON FOR QUESTION
Defective head gaskets can allow coolant into the combustion chambers, oil into the cooling system, or other problems.

FROM 9, Page 2-160

NOTIFY DS MAINTENANCE

NO

YES

NO FAULTS

2-162
REFERENCE INFORMATION

ENGINE COOLING

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 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 glowplugs 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

A1

KNOWN INFO
ENGINE FAN NOT WORKING PROPERLY

POSSIBLE PROBLEMS
FAN OR FAN BELTS
WIRING
FAN TIMER
FAN SOLENOID
FAN TEMPERATURE
SWITCH
PCB

TEST OPTIONS
LOOK FOR CRACKED OR BROKEN BLADES.

A2

KNOWN INFO
FAN OK

POSSIBLE PROBLEMS
BELTS
FAN WIRING
FAN TIMER
FAN SOLENOID
FAN TEMPERATURE
SWITCH
PCB

TEST OPTIONS
USE BELT TENSION GAUGE.

A3

KNOWN INFO
FAN OK
BELTS OK

POSSIBLE PROBLEMS
FAN DRIVE
FAN WIRING
FAN TIMING
FAN SOLENOID
FAN TEMPERATURE
SWITCH
PCB

TEST OPTIONS
TRY IT.

DIAGNOSTIC FLOWCHART

FROM 6

YES

INSPECT THE COOLING FAN. ARE THE FAN BLADES ALL INTACT?

NO

REPLACE FAN

REPLACE FAN DRIVE

TIGHTEN BELTS

WITH THE VEHICLE OFF, TRY TO TURN THE FAN BY HAND. ARE YOU UNABLE TO TURN IT?

NO

YES

REASON FOR QUESTION
A damaged fan does not cool efficiently and could be dangerous to bystanders.

REASON FOR QUESTION
Loose belts will not drive the fan properly.

REASON FOR QUESTION
You should not be able to turn the fan by hand. If you can, the fan drive is bad.

GO TO A4
Replace fan, refer to (para 3-78).

Tighten belts, refer to (para 3-82) (All except "A2" vehicles).

Replace fan drive, refer to (para 3-78).

A YES answer to this question means that you were not able to turn the fan by hand.
ENGINE COOLING

DIAGNOSTIC FLOWCHART

A4

FROM A3,
Page 2-164

!!

TEST OPTIONS

LOOK.

REASON FOR QUESTION
Disconnecting 458B from the switch simulates a hot engine.

NO

DISCONNECT WIRE 458B FROM THE FAN TEMPERATURE SWITCH. WITH THE ENGINE RUNNING, IS THE FAN ENGAGED?

YES

GO TO B,
Page 2-170

A5

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

DISCONNECT WIRE 458A FROM THE FAN TEMPERATURE SWITCH. JUMPER 458A TO 458B. DOES THE FAN DISENGAGE?

YES

GO TO C,
Page 2-174

A6

TEST OPTIONS

1. STENCE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
To check the switch operation. Ideally, check the switch for open and closed operation.

NO

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 2-166

KNOWN INFO

FAN BLADES OK
BELTS OK
FAN DRIVE OK

POSSIBLE PROBLEMS

FAN WIRING
TIME DELAY MODULE
CONTROL VALVE
FAN TEMPERATURE SWITCH
PCB

KNOWN INFO

FAN BLADES OK
BELTS OK
DRIVE ENGAGES.

POSSIBLE PROBLEMS

FAN WIRING
TIME DELAY MODULE
CONTROL VALVE
PCB

GTM 9-2320-280-20-1
REFERENCE INFORMATION

WARNING
Keep hands and arms away from fan blades and drive belts when engine is running or serious injury may result.

See page 2-159 for a description of the operation of the fan system and an easy way to tell if it's engaged or not.

See page 2-159 for a description of the operation of the fan system and an easy way to tell if it's engaged or not.

FAN TEMPERATURE SWITCH

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 switch, refer to (para 4-30).
You can also remove the switch to test it hot and cold.

ENGINE COOLING

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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

KNOWLEDGE

FAN BLADES OK
BELTS OK
FAN TEMPERATURE
SWITCH OK
FAN DRIVE OK

POSSIBLE PROBLEMS

KICK DOWN WIRING
(3L80)
TIME DELAY MODULE
FAN CUT-OFF WIRING
(4L80-E)

A7

IS THERE CONTINUITY FROM WIRE 315D AT THE TIME DELAY MODULE TO WIRE 315B AT THE TRANSMISSION KICKDOWN SWITCH (3L80), FAN CUT-OFF SWITCH (4L80-E)? (DISCONNECT THE WIRES TO MAKE THE MEASUREMENT)

YES

REPAIR/REPLACE WIRES 315D AND 315B

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?

YES

NO

GO TO E, Page 2-164

NO FAULTS

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER.

REASON FOR QUESTION

The transmission kickdown switch (3L80) and fan cut-off switch (4L80-E) will disengage the fan for 20 seconds.

TEST OPTIONS

1. STE/ICE-R TEST 89 (Page 2-756)
2. MULTIMETER.

REASON FOR QUESTION

This will simulate the kickdown system's (3L80) and fan cut-off system's (4L80-E) ability to disengage the fan.
**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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).

**0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

Disconnect the four-way connector at the time delay module and measure the voltage on wire 315D.

**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.
**ENGINE COOLING**

FROM A4 [Page 2-166]

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**
- FAN DRIVE OK
- FAN DOESN'T ENGAGE VIA WIRE 458

**POSSIBLE PROBLEMS**
- FAN WIRING
- TIME DELAY MODULE
- FAN CONTROL VALVE
- PCB/DISTRIBUTION BOX

**TEST OPTIONS**
- TRY IT.
- REASON FOR QUESTION
  - With no power to the solenoid, the fan should engage.

**B1**
DISCONNECT THE CONTROL VALVE ELECTRICAL CONNECTOR AT THE TIME DELAY MODULE. DOES THE FAN ENGAGE?

- NO
  - REPLACE CONTROL VALVE
- YES
  - GO TO B3

**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?

- NO
  - REPAIR/REPLACE WIRE 458B
- YES
  - REPAIR/REPLACE WIRE 458B
  - GO TO B3

**B3**
WITH THE ROTARY SWITCH ON "RUN," IS THERE BATTERY VOLTAGE AT THE HARNESS SIDE OF WIRE 583B IN THE 4-WAY CONNECTOR OF THE TIME DELAY MODULE?

- NO
  - REPAIR/REPLACE WIRE 583B
- YES
  - GO TO B4

**TEST OPTIONS**
- 1. STE/ICE-R TEST 91 [Page 2-752]
- 2. MULTIMETER
- REASON FOR QUESTION
  - Wire 458B connects the switch and the timer.

**TEST OPTIONS**
- 1. STE/ICE-R TEST 89 [Page 2-750]
- 2. MULTIMETER
- REASON FOR QUESTION
  - Wire 583B connects battery voltage to the delay module.
REFERENCE INFORMATION

ENGINE COOLING

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE)
MULTIMETER
1. Set the voltmeter to an ohms scale of about 1000 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).

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.

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

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 2-752)
2. MULITMETER.

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 FROM WIRE 315D AT THE TIME DELAY MODULE HARNESS TO WIRE 315B AT THE KICKDOWN SWITCH (3L80-E) OR FAN CUT-OFF SWITCH (4L80-E)?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULITMETER.

REASON FOR QUESTION
The transmission kickdown (3L80) and fan cut-off (4L80-E) has some control of the engine fan.

NO

REPAIR/REPLACE WIRES 315D AND 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 2-750)
2. MULITMETER.

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

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

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.

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.
**TEST OPTIONS**

1. STE/ICE-R TEST 89 [Page 2-750]
2. MULTIMETER

**REASON FOR QUESTION**

Wire 458A connects battery voltage to the switch.

---

**C3**

**REPAIR/REPLACE WIRE 583B**

---

**C1**

**REPAIR/REPLACE WIRES 458 & 458B**

---

**C2**

**REPAIR/REPLACE WIRE 458 & 458B**

---

**C3**

**REPAIR/REPLACE WIRE 583B**

---

**KNOWN INFO**

DRIVE OK
FAN ENGAGES BUT WON'T DISENGAGE

---

**POSSIBLE PROBLEMS**

PCB/DISTRIBUTION BOX
TIME DELAY MODULE
WIRING
HYDRAULIC SYSTEM

---

**C1**

**REDO THE JUMPER BETWEEN WIRE 458A AND WIRE 458B. TURN THE ROTARY SWITCH TO THE "RUN" POSITION. DOES WIRE 458A HAVE BATTERY VOLTAGE?**

---

**C2**

**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?**

---

**C3**

**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/DISTRIBUTION BOX
TIME DELAY MODULE
WIRING
HYDRAULIC SYSTEM

---

**TM 9-2320-280-20-1**
### 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.

### 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.

### 0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
C3.1

**Known Info**

- Engine coolant temperature below normal (215°F) (102°C)

**Possible Problems**

- Time delay module

**Test Options**

- Multi-meter

**Reason for Question**

- Wire 583 should indicate battery voltage.

**Test Options**

- Multi-meter

**Reason for Question**

- Wire 93 should indicate 0 voltage.

**C3.2**

**Test Options**

- Multi-meter

**Reason for Question**

The need to check out the windings in the control valve to see if they're OK.

**C4**

**Known Info**

- Fan drive OK
- Fan won't disengage

**Possible Problems**

- Time delay module wiring
- Control valve hydraulic system

**Test Options**

- Multi-meter – with an analog multi-meter, 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.
Replace time delay module, refer to (para. 4-31).

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 the control valve, refer to (para. 8-26).

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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

FROM C4, Page 2-176

C5
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?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
The need to test out the ground connection of the time delay module and control valve.

NO
REPLACE WIRING (93B)

YES

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?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
This measurement will help to tell you if the time delay module is OK.

NO
REPLACE TIME DELAY MODULE

YES

C7
IS THERE CONTINUITY FROM WIRE 458B IN THE 4-WIRE CONNECTOR HARNESS TO WIRE 458B AT THE FAN TEMPERATURE SWITCH?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
This measurement will help tell you if the time delay module is OK.

NO
REPLACE TIME DELAY MODULE

YES

GO TO C8, Page 2-186
REFERENCE INFORMATION

Repair wire refer to (para. 4-85) or notify DS maintenance.

Replace the time delay module, refer to (para 4-31).

ENGINE COOLING

<table>
<thead>
<tr>
<th>0-4500 OHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 91</td>
</tr>
<tr>
<td>1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.</td>
</tr>
<tr>
<td>2. Start Test 91, 0-4500 ohms.</td>
</tr>
<tr>
<td>3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTINUITY (RESISTANCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIMETER</td>
</tr>
<tr>
<td>1. Set the voltmeter to an ohms scale of about 1000 ohms.</td>
</tr>
<tr>
<td>2. Connect the RED and BLACK leads to the connections stated in the question.</td>
</tr>
<tr>
<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>
</tr>
</tbody>
</table>

---

FAN TEMPERATURE SWITCH

CONTROL VALVE
ENGINE COOLING

KNOWN INFO
FAN WON'T DISENGAGE WIRING OK

POSSIBLE PROBLEMS
LOW POWER STEERING PRESSURE LEAKS CONTROL VALVE

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 INSPECTION.

REASON FOR QUESTION
Leaky hydraulic hoses may prevent the drive from disengaging.

REPAIR AS REQUIRED

YES

C9

IS THE PRESSURE IN THE CONTROL VALVE SUPPLY HOSE AT LEAST 90 PSI?

TEST OPTIONS
1. STE/ICE-R TEST 50
2. PRESSURE GAUGE.

REASON FOR QUESTION
90 PSI is the minimum required to disengage the drive.

GO TO STEERING, Page 3-459

NO

NO

C10

CONNECT BOTH TIME DELAY MODULE ELECTRICAL CONNECTORS, JUMPER 458A TO 458B. IS THE PRESSURE IN THE FAN DRIVE HOSE AT LEAST 90 PSI?

TEST OPTIONS
1. STE/ICE-R TEST 50
2. PRESSURE GAUGE.

REASON FOR QUESTION
Check to see if control valve is open.

SEE NOTE ON RIGHT OF PAGE

NO

YES

SEE NOTE ON RIGHT OF PAGE
Replace hoses, refer to (para 8-26).

STE/ICE-R TEST #50
0 TO 1000 PSIG PRESSURE

1. Connect transducer to valve after removing connector, refer to (para 8-26). Do offset test.

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, refer to (para 8-26 or 3-78). Check to see if hoses are blocked prior to replacing parts, and perform back flush procedure (para 8-26).

If pressure in the fan drive hose is not at least 90 psi, (620.5 kPa) perform back flush procedure (para 8-26). Recheck pressure. If pressure is not at least 90 psi, replace control valve.

If pressure in the fan drive hose is at least 90 psi, (620.5 kPa) check for blockage in hose between the control valve and fan drive. If hose is not blocked, replace fan drive (para. 3-78).
ENGINE COOLING

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 2-752)
2. MULTIMETER.

REASON FOR QUESTION
Wire 458A connects the switch to the PCB.

KNOWN INFO
NO BATTERY VOLTAGE AT 458A

POSSIBLE PROBLEMS
458A ELECTRICAL SYSTEM

REPAIR/REPLACE WIRES 458A AND 54B

REPLACE THE PCB.
REFERENCE INFORMATION

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.

Replace PCB, refer to (para 4-5).

ENGINE COOLING

0-4500 OHMS
STE/ICE-R TEST 91

1. Connect RED dip and BLACK clip to the terminations indicated 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 4500 ohms, STE/ICE displays “9.9.9.9.”

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
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 KICKDOWN SWITCH (3L80) OR FAN CUT-OFF SWITCH (4L80E)?

TEST OPTIONS
STE/ICE-R TEST 89 (Page 2-750)
MULTIMETER

REASON FOR QUESTION
This will tell you if the time delay module is getting an input from the kickdown system (3L80) or fan cut-off system (4L80-E).

GO TO TRANSMISSION,
Page 2-399 (3L80) or
Page 2-411 (4L80-E)

REPLACE TIME DELAY MODULE

NO

YES

KNOWN INFO
FAN DOESN'T DISENGAGE WHEN KICKDOWN (3L80), OR FAN CUT-OFF (4L80-E) ACTIVATES

POSSIBLE PROBLEMS
KICKDOWN SWITCH (3L80) TIME DELAY MODULE WIRING FAN CUT-OFF SWITCH (4L80-E)

E FROM A8,
Page 2-184
Replace time delay module, refer to (para 4-31).

**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.

**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.
2-26. 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 FO-5 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

1. 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 2-28) FOR OIL AND FILTER CHANGE REQUIREMENTS.
     - REASON FOR QUESTION
       - To make sure the engine has the right oil, and it's clean.
   - CHANGE OR ADD AS REQUIRED
   - NO
   - YES
     - GO TO 2

2. 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.
   - REPAIR AS REQUIRED
   - NO
   - YES
     - GO TO 3

3. IS THE OIL PRESSURE AT THE CORRECT VALUE? (SEE CHART AT RIGHT.)
   - TEST OPTIONS
     - 1. STE/ICE-R TEST 50 (PAGE 2-733) INTERLEAVED WITH RPM.
     - 2. LOOK AT THE GAUGE AND USE STE/ICE-R TEST 10 (PAGE 2-734)
   - 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.
   - NO
   - YES
     - GO TO A, PAGE 2-192

GO TO 4, PAGE 2-190
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 625-675.

**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</td>
</tr>
<tr>
<td>6.2L IDLE (650 ± 25)</td>
<td>10-15 PSI</td>
</tr>
<tr>
<td>6.5L IDLE (700 ± 25)</td>
<td>10-15 PSI</td>
</tr>
<tr>
<td>6.5L DETUNED IDLE (700 ± 25)</td>
<td>10-15 PSI</td>
</tr>
<tr>
<td>2000</td>
<td>40-50 PSI</td>
</tr>
</tbody>
</table>

Remove sending unit, refer to (para. 4-25).

**ENGINE RPM**

**INTERLEAVE WITH 0-1000 PSI PRESSURE**

2. Dial test 01, interleave with RPM. Dial test 50.
3. Start engine and observe display. VTM will display RPM’s, then PSI.
Is the exhaust colorless? (especially no blue smoke)

**TEST OPTIONS**

- Look

**REASON FOR QUESTION**

Blue smoke indicates oil in the exhaust.

No faults found. If you still have a problem, you may want to re-run the test chain to make sure you didn't miss anything.
NOTE

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

WHITE. . . . . . . . . . Go to fuel system, [Paragraph 2-22]. 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 Mechanical Tests [Paragraph 2-18] before you notify DS Maintenance.

BLACK. . . . . . . . Intake/exhaust. [Para. 2-23]
ENGINE LUBRICATION

KNOWN INFO
WRONG OIL PRESSURE

POSSIBLE PROBLEMS
OIL PRESSURE GAUGE
OIL PRESSURE SENSOR
INTERNAL ENGINE PROBLEMS

DIAGNOSTIC FLOWCHART

TEST OPTIONS
N/A

REASON FOR QUESTION
If you used the STE/ICE-R to measure the pressure, then the engine has an internal fault.

A1

DID YOU USE THE VEHICLE'S ON-BOARD GAUGE TO MEASURE THE PRESSURE IN QUESTION 3?

NOTIFY DS MAINTENANCE

NO

A2

MEASURE THE OIL PRESSURE DIRECTLY. IS IT CORRECT?

NOTIFY DS MAINTENANCE

NO

TEST OPTIONS
STE/ICE-R TEST 50 AND RPM INTERLEAVED. (Page 2-339)
EXTERNAL GAUGE AND STE/ICE-R TEST 10. (Page 2-339)

REASON FOR QUESTION
Direct verification of the engine's oil pressure will tell you if the problem is in the gage or the engine.

YES

A3

THE PROBLEM IS IN THE OIL PRESSURE SENDING SYSTEM. GO TO INSTRUMENTS, Page 2-319.

KNOWN INFO
OIL PRESSURE OK

POSSIBLE PROBLEMS
GAUGE
SENSOR
WIRING
Remove sending unit, refer to (para. 4-25)

### ENGINE RPM
INTERLEAVE WITH 0-1000 PSI PRESSURE

<table>
<thead>
<tr>
<th>ENGINE RPM</th>
<th>APPROXIMATE OIL PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP</td>
<td>0 PSI</td>
</tr>
<tr>
<td>6.2L IDLE (650 ± 25)</td>
<td>10-15 PSI</td>
</tr>
<tr>
<td>6.5L IDLE (700 ± 25)</td>
<td>10-15 PSI</td>
</tr>
<tr>
<td>6.5L DETUNED</td>
<td>10-15 PSI</td>
</tr>
<tr>
<td>IDLE (700 ± 25)</td>
<td>40-50 PSI</td>
</tr>
<tr>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>

2. Dial test 01, interleave with RPM. Dial test 50.
3. Start engine and observe display. VTM will display RPM’s, then PSI.
2-27. 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, Paragraph 2-29.

A simplified block diagram for the alternator system is given on page 2-195. A detailed functional flow schematic is provided as foldout FO-6 to help you understand the system as you perform the tests.

NOTE

Dual voltage 100, 200, and 400 amp alternators can be installed in a single voltage system. See Table 2-2 for hookup procedures.

After preliminary common tests, the model of alternator must be identified for specific testing to determine if alternator or regulator is defective.

Table 2-2. Adaption of dual voltage alternator on a single voltage system

<table>
<thead>
<tr>
<th>Dual Voltage Alternator</th>
<th>Single Voltage System</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Amp</td>
<td>Ground wire afixed to regulator base and 14 volt power stud</td>
</tr>
<tr>
<td>200 Amp</td>
<td>Ground wire afixed to regulator base and 14 volt power stud</td>
</tr>
<tr>
<td>400 Amp</td>
<td>No ground wire afixed to regulator or 14 volt power stud</td>
</tr>
</tbody>
</table>
**Known Info**

**Possible Problems**

**Test Options**

**Reason for Question**

---

1. **Are Alternate Drivebelts/Serpentine Belt Tight and in Good Condition (No Cracks, Frays, or Glaze)?**
   - **Known Info:** Nothing
   - **Possible Problems:** Alternate Protective Control Box/Distribution Box Wiring Belts
   - **Test Options:** Visual Inspection, Use Belt Tension Gauge/Check Tensioner Position
   - **Reason for Question:** If belts are loose, worn, or if belt tensioner has fully retracted, the belts will not drive the alternator fast enough to recharge the batteries.

2. **Are All Wire Connections to Alternate Clean, Tight, and Making Good Connection?**
   - **Known Info:** Belts OK
   - **Possible Problems:** Wiring Alternate PCB/Distribution Box
   - **Test Options:** Visual Inspection
   - **Reason for Question:** Loose or dirty connections can prevent a good alternator from charging the batteries.

3. **With Rotary Switch in "Run" Position (Engine Not Running), Do You Have Battery Voltage at Alternate Output Terminal?**
   - **Known Info:** Belts OK Wiring Connections OK
   - **Possible Problems:** Alternate PCB/Distribution Box Wiring
   - **Test Options:** 1. STE/ICE-R Tests 67 and 89 (Interleave) [Pages 2-740, 750] 2. Multimeter
   - **Reason for Question:** The alternator must be connected to batteries to be able to recharge the batteries.

---

**Diagnostic Flowchart**

Start

1. 
   - **Are alternator drivebelts/serpentine belt tight and in good condition (no cracks, frays, or glaze)?**
     - **Known Info:** Nothing
     - **Possible Problems:** Alternate Protective Control Box/Distribution Box Wiring Belts
     - **Test Options:** Visual Inspection, Use Belt Tension Gauge/Check Tensioner Position
     - **Reason for Question:** If belts are loose, worn, or if belt tensioner has fully retracted, the belts will not drive the alternator fast enough to recharge the batteries.

2. 
   - **Are all wire connections to alternator clean, tight, and making good connection?**
     - **Known Info:** Belts OK
     - **Possible Problems:** Wiring Alternate PCB/Distribution Box
     - **Test Options:** Visual Inspection
     - **Reason for Question:** Loose or dirty connections can prevent a good alternator from charging the batteries.

3. 
   - **With rotary switch in "run" position (engine not running), do you have battery voltage at alternator output terminal?**
     - **Known Info:** Belts OK Wiring Connections OK
     - **Possible Problems:** Alternate PCB/Distribution Box Wiring
     - **Test Options:** 1. STE/ICE-R Tests 67 and 89 (Interleave) [Pages 2-740, 750] 2. Multimeter
     - **Reason for Question:** The alternator must be connected to batteries to be able to recharge the batteries.
Cracks, glaze, and frays indicate worn belts, which should be replaced (para. 3-81, all except M1123 and "A2" vehicles) (para. 3-83, M1123 and "A2" vehicles). Use a belt tension gauge to determine if the belts need to be tightened, refer to (para 3-82, all except M1123 and "A2" vehicles).

**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 (heavy gauge wire 6A) wire at the starter. Don’t just check for voltage; a loose connection will have voltage but can’t carry much current.

3. **PCB/DISTRIBUTION BOX**

   **WARNING**

   Disconnect negative battery cable before disconnecting and reconnecting PCB/distribution box harness.

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

   Unscrew 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 9-4910-571-12&P FOR MORE INFORMATION.
START ENGINE. DOES ENGINE IDLE AT CORRECT SPEED (6.2L 625-675 RPM)? (6.5L 700-750 RPM)?

LOCK THROTTLE AT 1200-1500 RPM.

IS VOLTAGE AT ALTERNATOR OUTPUT TERMINAL 27-29 VOLTS?

IS VOLTAGE AT BATTERY TERMINALS 27-29 VOLTS? (SAME AS ALTERNATOR OUTPUT)

REPAIR/REPLACE WIRING SEE NOTE AT RIGHT

GO TO 7, Page 2-200

REASON FOR QUESTION
If engine idles too low, alternator is not driven fast enough to charge batteries.

REASON FOR QUESTION
Alternator voltage must be slightly higher than battery voltage to recharge batteries.

REASON FOR QUESTION
If battery voltage is much lower than alternator output, wiring resistance is too high.

TEST OPTIONS
1. STE/ICE-R TEST 67 (Page 2-740)
2. MULTIMETER

TEST OPTIONS
1. STE/ICE-R TEST 10 (interleave with control function 01 page 2-734) thru 89, page 750
2. MULTIMETER

TEST OPTIONS
STE/ICE-R TEST 10 (Page 2-734)

TEST OPTIONS
BATTERIES OK
BELTS OK
ALTERNATOR
CONNECTIONS OK
PCB/DISTRIBUTION BOX OK
ALTERNATOR DRIVE OK

TEST OPTIONS
BATTERIES OK
BELTS OK
ALTERNATOR
CONNECTIONS OK
PCB/DISTRIBUTION BOX OK
ALTERNATOR DRIVE OK

TEST OPTIONS
BATTERIES OK
BELTS OK
ALTERNATOR
CONNECTIONS OK
PCB/DISTRIBUTION BOX OK
ALTERNATOR DRIVE OK
ALTERNATOR OUTPUT OK

KNOWN INFO
BATTERIES OK
BELTS OK
ALTERNATOR
CONNECTIONS OK
PCB/DISTRIBUTION BOX OK
ALTERNATOR DRIVE OK

KNOWN INFO
BATTERIES OK
BELTS OK
ALTERNATOR
CONNECTIONS OK
PCB/DISTRIBUTION BOX OK
ALTERNATOR DRIVE OK
ALTERNATOR OUTPUT OK

KNOWN INFO
BATTERIES OK
BELTS OK
ALTERNATOR
CONNECTIONS OK
PCB/DISTRIBUTION BOX OK
ALTERNATOR DRIVE OK
ALTERNATOR OUTPUT OK

POSSIBLE PROBLEMS
ALTERNATOR Wiring

POSSIBLE PROBLEMS
ALTERNATOR Wiring

POSSIBLE PROBLEMS
ALTERNATOR Wiring

ADJUST IDLE RPM SEE NOTE AT RIGHT

NO

YES

NO

YES

GO TO B, Page 2-204

GO TO 7, Page 2-200

FROM 3, Page 2-196

ROCK THROTTLE AT 1200-1500 RPM.
1. Start Test 10, Engine RPM.

2. Crank or start the engine. Displayed reading is RPM. Cranking RPM should be at least 100. Idle RPM should be 625 - 675.

3. If the engine doesn't start on its own power, you should check the battery and starter circuits.

**NOTES ON IDLE ADJUSTMENT**

If idle can be adjusted to within limits, go to step 5.

If idle CANNOT be adjusted to within limits, you may have a problem with the fuel system. You can either continue here or run the fuel system tests and return here.

### 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. Idle RPM should be 625 - 675.

### 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.

### 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. Battery voltage will drop when glowplugs turn on.

### NOTES

**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.**

Output for 60 amp alternator is wire 5A and stud. All other alternators have a large stud on side of housing as output terminal to connect wire 6.

**NOTES**

1. Check the wiring and the pins at sockets E & F at PCB/distribution box engine connector.

2. Check the wiring and the pins at sockets D & G at PCB/distribution box body connector.

3. Check and clean starter solenoid and battery box power stud.

4. Check and clean battery cables and clamps.

5. Look for loose, dirty, or broken connections and repair as necessary. If terminal voltage is still low, harness should be replaced. Notify DS maintenance.
WITH ENGINE RUNNING, MEASURE CURRENT FROM ALTERNATOR WIRE OUTPUT TERMINAL.

IS CURRENT GREATER THAN 30 AMPS?

REPLACE ALTERNATOR
RERUN ALTERNATOR TESTS

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.
NOTE

Wire 5A is output path for 60 amp alternator. All other 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 60 and 200 amp alternators, (refer to chapter 4). To replace 100 amp alternator, (refer to chapter 12). To replace 100, 200, and 400 amp dual voltage alternators, (refer to chapter 4).

### 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.
**ALTERNATOR**

**A**

From 3, Page 2-196

**IS THE STARTER MOTOR VOLTAGE THE SAME AS BATTERY VOLTAGE?**

- **NO**
  - REPAIR/REPLACE WIRE 6A

- **YES**
  - **!!**
  - REPAIR/REPLACE WIRE 81A

**A1**

**POSSIBLE PROBLEMS**

- PCB/DISTRIBUTION BOX WIRING

**KNOWLED INFO**

- BATTERY IS NOT CONNECTED TO ALTERNATOR WHEN ROTARY SWITCH IS IN RUN POSITION

**A2**

**DISCONNECT THE BATTERY NEGATIVE CABLE. DISCONNECT ENGINE CONNECTOR AT PCB/DISTRIBUTION BOX. RECONNECT THE BATTERY NEGATIVE CABLE. IS THERE BATTERY VOLTAGE AT SOCKET E OF THE PCB/DISTRIBUTION BOX ENGINE CONNECTOR HARNESS?**

- **NO**
  - REPAIR/REPLACE WIRE 6A

- **YES**
  - REPAIR/REPLACE WIRE 81A

**TEST OPTIONS**

1. STE/ICE-R TESTS 67, 68 (Pages 2-740, 741)
2. MULTIMETER

**REASON FOR QUESTION**

The cable connecting the batteries to the alternator goes to the starter first.

**A3**

**REMOVE THE BATTERY NEGATIVE CABLE. IS THERE CONTINUITY (LESS THAN 20 OHMS RESISTANCE) FROM SOCKET F OF PCB/DISTRIBUTION BOX ENGINE CONNECTOR HARNESS TO WIRE 5A END AT ALTERNATOR?**

- **NO**
  - SEE NOTE ON RIGHT HAND PAGE

- **YES**
  - REPLACE PCB/DISTRIBUTION BOX

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

**REASON FOR QUESTION**

If the box is connected to the alternator, then the relay in the PCB/distribution box is no good.
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 6768, AND THEN REPEAT. SEE TM 9-4910-571-12&P FOR MORE INFORMATION.

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.

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9”.

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, notify DS Maintenance.

Replace PCB, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).

WARNING

DISCONNECT NEGATIVE BATTERY CABLE BEFORE DISCONNECTING AND RECONNECTING PROTECTIVE CONTROL BOX/DISTRIBUTION BOX HARNESS.

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

TM 9-2320-280-20-1

Change 1  2-203
ALTERNATOR

DIAGNOSTIC FLOWCHART

B FROM 5 [Page 2-198]

B1
IDENTIFY MODEL ALTERNATOR. TESTING IS DIFFERENT FOR EACH MODEL. IS THIS A 60 AMP PRESTOLITE ALTERNATOR?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Connections and testing procedures are not the same for different model alternators.

B2
STOP ENGINE. DISCONNECT WIRE 568A FROM ALTERNATOR WIRE 568. TURN THE ROTARY SWITCH TO "RUN". MEASURE VOLTAGE AT THE WIRE THAT IS NOT CONNECTED TO THE ALTERNATOR. IS THERE BATTERY VOLTAGE?

TEST OPTIONS
1. STE/ICE-R TEST 89 [Page 2-750]
2. MULTIMETER

REASON FOR QUESTION
Wire 568a and 568 carry ignition current to turn on regulator.

B3
CONNECT WIRE 568A AND 568. TURN ROTARY SWITCH TO "RUN". MEASURE VOLTAGE AT ALTERNATOR END OF WIRE 568. IS THERE BATTERY VOLTAGE AT ALTERNATOR END OF WIRE 568?

TEST OPTIONS
1. STE/STE-R TEST 89 [PAGE 2-750]
2. MULTIMETER

REASON FOR QUESTION
Wire 568A and 568 carry ignition current to turn on regulator.

B

NO

YES

SEE NOTE ON OPPOSITE PAGE

REPLACE WIRE 568

GO TO B4 [Page 2-206]
REFERENCE INFORMATION

NOTE
For 60 amp Prestolite alternator, continue B.
For 100 amp Prestolite alternator, go to C.
For 200 amp Prestolite alternator, go to D.
For 200 amp single voltage Niehoff alternator, go to E.
For 100 amp single voltage Niehoff alternator, go to F.
For 100 amp dual voltage Niehoff alternator, go to F.1.
For 200 amp dual voltage Niehoff alternator, go to G.
For 400 amp dual voltage Niehoff alternator, go to H.

NOTE
Voltage on wire 568 signals regulator to turn on.
Without voltage, regulator can't operate. Wire 568A is connected with wire 5A inside engine wire harness. If there is no loose end on wire 568A, wire harness repair is required. Notify DS Maintenance.

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

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

From B3, Page 2-204

DIAGNOSTIC FLOWCHART

TEST OPTIONS
Adjusting procedure on right hand page using STE/ICE-R tests 10 and 82 (pages 2-734 and 2-750).

REASON FOR QUESTION
The alternator may just need to be adjusted.

KNOWN INFO

ALTERNATOR OUTPUT NOT CORRECT
FIELD VOLTAGE OK

POSSIBLE PROBLEMS

ALTERNATOR

B4

RECONNECT WIRE 568. TRY ADJUSTING ALTERNATOR. IS ALTERNATOR OUTPUT VOLTAGE ADJUSTABLE TO 27-29 VOLTS?

NO

REPLACE ALTERNATOR (para 4-2)

YES

B5

AFTER ADJUSTING 60 AMP PRESTOLITE ALTERNATOR, GO TO STEP 6, PAGE 2-198 AND CONTINUE TESTING.
1. Turn engine off.
2. Remove protective cover from alternator wiring.
3. Remove the potting material.
4. Remove hex head plug to expose adjustment screw.
5. Start engine and lock throttle at 1200-1500 RPM by using STE/ICE-R test 10.
6. Connect the Red test lead to wire 5A and the Black lead to engine ground.
7. Monitor alternator output voltage with STE/ICE-R test 89.
8. Use a cross tip screwdriver to adjust the alternator output voltage 28.0 ± 0.5 Volts.
9. Unlock throttle, replace hex head plug, repot the area with silicon caulk, and replace the protective cover.

### 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. Idle RPM should be 625-675.

### 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.

**NOTE**
Regulator cannot be tested independently from alternator on 60 amp alternator system.
ALTERNATOR

C
FROM B1,
Page 2-204

DIAGNOSTIC FLOWCHART

C1
IS THIS A 100 AMP PRESTOLITE ALTERNATOR?

NO
SEE NOTE ON OPPOSITE PAGE.

YES

C2
STOP ENGINE. DISCONNECT WIRE 568 FROM WIRE 568A. TURN ROTARY SWITCH TO "RUN". MEASURE VOLTAGE AT END OF WIRE 568A. IS THERE BATTERY VOLTAGE IN CONNECTOR AT END OF 568A WIRE?

NO
REPLACE WIRE HARNESS. NOTIFY DS.

YES

C3
TURN ROTARY SWITCH OFF AND RECONNECT WIRES 568 AND 568A. REMOVE REGULATOR COVER AND INSPECT CONNECTION. TURN ROTARY SWITCH ON. MEASURE VOLTAGE AT END OF WIRE 568. IS THERE BATTERY VOLTAGE ON END OF WIRE 568?

NO
REPLACE WIRE 568.

YES
GO TO C4, Page 2-210

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Must know model of alternator to perform proper tests.

TEST OPTIONS
1. TEST/ICE-R test 89 0-45 volts (Page 2-750)
2. Multimeter

REASON FOR QUESTION
Determine if regulator turn on signal is present.

TEST OPTIONS
1. TEST/ICE-R test 89 0-45 Volts (Page 2-750).
2. Multimeter.

REASON FOR QUESTION
Determine if regulator turn on signal is at stud.
NOTE
For 60 amp Prestolite alternator, go to B, page 2-204.
For 100 amp Prestolite alternator, continue C.
For 200 amp Prestolite alternator, go to D, page 2-212.
For 200 amp single voltage Niehoff alternator, go to E, page 2-218.
For 100 amp single voltage Niehoff alternator, go to F, page 2-222.
For 100 amp dual voltage Niehoff alternator, go to F.1, page 2-224.2.
For 200 amp dual voltage Niehoff alternator, go to G, page 2-224.4.
For 400 amp dual voltage Niehoff alternator, go to H, page 2-224.10.

NOTE
Voltage on wire 568 signals regulator to turn on.
Without voltage, regulator can’t operate. Wire 568A is connected with wire 5A inside engine wire harness. If there is no loose end on wire 568A, wire harness repair is required. Notify DS Maintenance.

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.

NEWER MODEL REGULATOR

<table>
<thead>
<tr>
<th>REGULATOR</th>
<th>WIRE 2A</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIRE 568A</td>
<td></td>
</tr>
<tr>
<td>WIRE 568</td>
<td></td>
</tr>
<tr>
<td>WIRE 5A</td>
<td></td>
</tr>
<tr>
<td>WIRE 3B</td>
<td></td>
</tr>
</tbody>
</table>
If voltage exceeded 35 volts, regulator over-voltage protection has failed.

**REPLACE REGULATOR (Para 12-21) or (Para 12-22)**

**TEST OPTIONS**

- REPLACE ALTERNATOR (Para 12-23) or (Para 12-24)

**KNOWN INFO**

- VOLTAGE OUTPUT INCORRECT
- WIRING OR IGNITION OK

**POSSIBLE PROBLEMS**

- ALTERNATOR REGULATOR

**TEST OPTIONS**

- 1. STE/ICE-R Tests 10 and 89 (pages 2-734 and 2-750).
- 2. MULTIMETER

**REASON FOR QUESTION**

Determine if alternator or regulator is defective.
REFERENCE INFORMATION

CAUTION
Ensure all electrical loads are disconnected or turned off. Higher voltage could damage components in other devices.

1. Disconnect battery ground cable.
2. Loosen screws.
3. Remove clamp pins from slots.
4. Loosen connector nut.
5. Remove regulator from alternator.
   Secure regulator out of the way.
6. Connect battery ground cable.

NOTE
Jumper wires must be able to handle 15 amp current (14 gauge or larger diameter).

NOTE
Multimeter set to read over 75 vdc.

<table>
<thead>
<tr>
<th>ENGINE RPM</th>
<th>STE/ICE-R TEST 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Start Test 10, Engine RPM.</td>
<td></td>
</tr>
<tr>
<td>2. Crank or start the engine. Displayed reading is RPM. Cranking RPM should be approximately 100. Set idle speed to 850 RPM.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0-45 DC VOLTS</th>
<th>STE/ICE-R TEST 89</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Connect RED clip to indicated test point, 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>
ALTERNATOR

DIAGNOSTIC FLOWCHART

D FROM B1, Page 2-204

D1

IS THIS A 200 AMP PRESTOLITE ALTERNATOR?

YES

SEE NOTE ON OPPOSITE PAGE.

NO

D2

STOP ENGINE. DISCONNECT BATTERY GROUND CABLE. REMOVE END OF CABLE/WIRE 6 FROM ALTERNATOR OUTPUT STUD. CHECK FOR BURNED, BROKEN, OR DAMAGED REVERSE POLARITY FUSE. IS FUSE OK?

TEST OPTIONS
Visual

REASON FOR QUESTION
Must know model of alternator to perform proper tests.

NO

REPLACE DAMAGED REVERSE POLARITY FUSE.

YES

D3

REMOVE COVER ON REGULATOR. TURN ROTARY SWITCH TO "RUN". MEASURE VOLTAGE AT IGNITION STUD (WIRE 5A) ON REGULATOR. IS THERE BATTERY VOLTAGE AT IGNITION STUD (END OF WIRE 5A)?

TEST OPTIONS
STE-ICE-R Test 89 Page 2-750

NOTIFY DS MAINTENANCE TO REPAIR WIRING HARNESS.

KNOWLEDGE
VOLTAGE OUTPUT INCORRECT
POSSIBLE PROBLEMS
FUSIBLE LINK
WIRING
ALTERNATOR
REGULATOR

REASON FOR QUESTION
Defective fusible link could cause low or zero output.

NO

Go to D4, Page 2-214
NOTE

For 60 amp Prestolite alternator, go to B. [page 2-204]
For 100 amp Prestolite alternator, go to C. [page 2-205]
For 200 amp Prestolite alternator, continue D.
For 200 amp single voltage Niehoff alternator, go to E. [page 2-218]
For 100 amp single voltage Niehoff alternator, go to F. [page 2-222]
For 100 amp dual voltage Niehoff alternator, go to F.1, [page 2-224.2]
For 200 amp dual voltage Niehoff alternator, go to G, [page 2-224.6]
For 400 amp dual voltage Niehoff alternator, go to H, [page 2-224.10]

Replacement of Reverse Polarity Fuse
1. Remove nut, lockwasher, washer, fuse, insulator and cable 6 from output stud.
2. Examine fuse for burns and breaks. Replace fuse and insulator if damaged.
3. Install new fuse and insulator on output stud with washer, lockwasher, and nut. Tighten nut 10-15 lb-in. (14-20 N•m).

1. Disconnect battery ground cable.
2. Remove four screws, lockwashers, gasket, and cover from regulator.
3. Remove potting material as necessary to gain access to studs.

<table>
<thead>
<tr>
<th>0-45 DC VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 89</td>
</tr>
<tr>
<td></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

KNOWN INFO
- VOLTAGE OUTPUT INCORRECT
- FUSIBLE LINK OK

POSSIBLE PROBLEMS
- ALTERNATOR
- REGULATOR
- TEMPERATURE COMPENSATION ERROR

DIAGNOSTIC FLOWCHART

FROM D3, Page 2-212

D4

CHECK IF ALTERNATOR HAS BEEN ADJUSTED FOR TEMPERATURE EXTREMES (ARCTIC OR DESERT). IF SO, RESET REGULATOR FOR 28 VOLT OUTPUT. START ENGINE AND CHECK OUTPUT VOLTAGE AT 850 RPM. IS OUTPUT VOLTAGE 27-29 VOLTS?

YES

GO TO D5, Page 3-316

NO

GO TO STEP 6, Page 2-199

TEST OPTIONS
- STE/ICE-R Tests 10 and 89 (pages 2-734 and 2-750).

REASON FOR QUESTION
- Regulator may have wrong temperature compensation setting.
TEMPERATURE-ENVIRONMENT ADJUSTMENT

1. Disconnect battery ground cable.
2. Remove four screws securing regulator to alternator.
3. Position regulator to allow access to the buss bar link. The buss bar link and voltage setting terminals are located under sealant. It maybe necessary to scrape away some of the sealant to access the buss bar link and terminals.
4. To adjust the voltage setting to 27.2 volts (for hot or desert condition), loosen screw E0 and remove screws E1 and E2. Rotate bus bar link to E2. Reinstall screws E1 and E2 and tighten screw E0.
5. Apply RTV sealant to fully cover buss bar link and voltage setting terminals.
6. Install regulator to alternator with four screws.
7. Connect battery ground cable.
8. Check output voltage, it should read 27.2 volts.

**NOTE**

To reset alternator output voltage to 28 volts, the buss bar link should be connected between E0 and E1. The terminal connection E0 and E3 provides an output voltage of 28.8 volts (for arctic conditions). When operation in hot weather or arctic conditions cease, the alternator output voltage should be reset to its normal 28.0 volt setting.

9. Mark the output voltage setting on the alternator and annotate the information in the vehicle log book for future reference.

**NOTE**

This procedure resets the alternator output approximately 0.8 volts on either side of 28 volts, but will not correct for larger errors.

**NOTE**

If an overcharge condition exists, wiring to regulator is satisfactory.

---

### 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 850.

### 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

D5

REMOVE AND TAG LEADS FROM REGULATOR TERMINALS P,Z,V,Y, AND W. INSULATE ALL LEADS EXCEPT Y AND W. REFER TO PROCEDURE ON NEXT PAGE. RUN FULL FIELD TEST ON ALTERNATOR. IS OUTPUT VOLTAGE 35-40 VOLTS?

NO

ALTERNATOR DEFECTIVE, REPLACE, para 4-109.

YES

REGULATOR DEFECTIVE, REPLACE, para 4-114.

FROM D4, Page 2-214

TEST OPTIONS
STE-ICE-R Test 89 (para 2-750).

REASON FOR QUESTION
Determine if alternator or regulator is defective.
FULL FIELD TEST
1. Disconnect battery ground cable.

NOTE
Tag leads before removal.
2. Remove five screws, lockwashers, and leads from bottom of regulator.
3. Insulate leads from V, P, and Z terminals.
4. Connect 6 volt lantern battery NSN 6135-00-643-1310, (or equivalent that can supply 1.0 amp current at 6 volts) with (+) battery and lead connector to W lead and (-) battery and lead connector to Y lead. Insulate all connections.
5. Monitor voltage across alternator output studs. Meter must be capable of reading 50 volts.

CAUTION
Ensure all vehicle and on board equipment are turned off. Higher voltages could damage components.
6. Connect battery ground cable.
7. Start vehicle and run engine to 900 rpm. Run only long enough to obtain a stable output voltage reading.
8. Stop engine, remove 6 volt battery and leads.

NOTE
If installing alternator, reconnect regulator (para 4-114).

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.
E1

IS THIS A NIEHOFF 200 AMP SINGLE VOLTAGE ALTERNATOR?

TEST OPTIONS
Visual

REASON FOR QUESTION
Must know model of alternator to perform proper tests.

NO
SEE NOTE ON OPPOSITE PAGE

YES

E2

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 (page 734 and 750)

NO
IF OUTPUT VOLTAGE IS OVER 30.5 VOLTS, REPLACE REGULATOR, (Para. 4-114) OR (Para. 4-115).

YES
GO TO E3, Page 2-218.2

KNOWN INFO
VOLTAGE OUTPUT INCORRECT

POSSIBLE PROBLEMS
FUSIBLE LINK
WIRING
ALTERNATOR
REGULATOR
NOTE
For 60 amp Prestolite alternator, go to B, page 2-204.
For 100 amp Prestolite alternator, go to C, page 2-208.
For 200 amp Prestolite alternator, go to D, page 2-212.
For 200 amp single voltage Niehoff alternator, continue with E.
For 100 amp single voltage Niehoff alternator, go to F, page 2-222
For 100 amp dual voltage Niehoff alternator, go to F.1, page 2-224.2
For 200 amp dual voltage Niehoff alternator, go to G, page 2-224.6
For 400 amp dual voltage Niehoff alternator, go to H, page 2-224.10

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.

---

### 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.
**E3**

**TEST OPTIONS**
Visual

**REASON FOR QUESTION**
Determine if connections are good at alternator and starter.

**KNOWLEDGE INFO**
Voltage Output Incorrect

**POSSIBLE PROBLEMS**
- Fusible Link Wiring
- Alternator Regulator

**E4**

**TEST OPTIONS**
Visual

**REASON FOR QUESTION**
Fusible link connects alternator output stud to wire 6.

**STOP ENGINE. CHECK WIRE 6 AT ALTERNATOR AND STARTER FOR LOOSENESS OR CORROSION. ARE TERMINAL CONNECTIONS OK?**

**CLEAN AND SECURE TERMINAL CONNECTIONS.**

**NO**

**REPLACE FUSIBLE LINK. THEN GO TO STEP 5, Page 2-198**

**YES**

**GO TO E5, Page 2-220**
1. Disconnect battery ground cable.
2. Remove boot from alternator output terminal.
3. Remove nut, lockwasher, washers, and fusible link from terminal.
4. Inspect fusible link.
5. Replace fusible link if damaged or appears burned.
6. Connect battery ground cable.

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**

**Known Info**
- Voltage output incorrect
- Fusible link OK

**Possible Problems**
- Alternator
- Regulator
- Wiring

**Test Options**
- STE/ICE Test 89, page 2-750

**Reason for Question**
As wire 568A is stubbed off, the voltage from wire 5A on red terminal signals regulator to turn on.

**Diagram**

**E5**
- Turn Rotary Switch to “Run” position. Check for battery voltage at red (energize) terminal on regulator. Is battery voltage present?

- **Yes**
  - Notify DS Maintenance to repair or replace wiring harness.

- **No**
  - 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 rise during connection to 180 - 220 AMPS?

  - **Yes**
    - Replace alternator, (Para. 4-109). Then go to step 5, page 2-198

  - **No**
    - Replace regulator, (Para. 4-114). Then go to step 5, page 2-198
1. Slide boot back from wire lug to expose red terminal.
2. Make contact at stud.

### 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.

### Engine RPM
STE/ICE-R TEST 10

1. Start Test 10, Engine RPM.
2. Crank or start the engine. Displayed reading is RPM. Set engine to fast idle of 1200 - 1500 RPM.

### 0-1500 Amps DC
STE/ICE-R TEST 90

1. Connect probe.
2. Start Test 90, DC amps.
3. Displayed reading is in amps.
ALTERNATOR DIAGNOSTIC FLOWCHART

F1

IS THIS A NIEHOFF 100 AMP SINGLE VOLTAGE ALTERNATOR?

TEST OPTIONS
Visual

REASON FOR QUESTION
Must know model of alternator to perform proper tests.

F2

START ENGINE AND ALLOW TO IDLE AT 1200-1500 RPM.

TEST OPTIONS
STE/ICE Test 10 and 89, (pages 2-734 and 2-750).

REASON FOR QUESTION
Determine if high or low output voltage.

F3

STOP ENGINE. DISCONNECT WIRE 568A FROM ALTERNATOR WIRE 568. TURN ROTARY SWITCH TO "RUN". MEASURE VOLTAGE AT THE WIRE THAT IS NOT CONNECTED TO THE ALTERNATOR. IS THERE BATTERY VOLTAGE?

TEST OPTIONS
STE/ICE Test 89, (page 2-750).

REASON FOR QUESTION
Wire 568A and wire 568 carry ignition current to turn on regulator.

KNOWN INFO
VOLTAGE OUTPUT INCORRECT

POSSIBLE PROBLEMS
WIRING
ALTERNATOR
REGULATOR

KNOWN INFO
VOLTAGE OUTPUT INCORRECT

POSSIBLE PROBLEMS
WIRING
ALTERNATOR
REGULATOR

GO TO F4,
Page 2-224
REFERENCE INFORMATION

NOTE
For 60 amp Prestolite alternator, go to B, page 2-204.
For 100 amp Prestolite alternator, go to C, page 2-208.
For 200 amp Prestolite alternator, go to D, page 2-212.
For 200 amp single voltage Niehoff alternator, continue with E.
For 100 amp single voltage Niehoff alternator, continue with F.
For 100 amp dual voltage Niehoff alternator, go to F.1, page 2-224.2.
For 200 amp dual voltage Niehoff alternator, go to G, page 2-224.6.
For 400 amp dual voltage Niehoff alternator, go to H, page 2-224.10.

NOTE
The regulator for this model alternator has overvoltage protection. Any output voltage over 30.5 volts is an overvoltage.
Output voltage of 25-30.5 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.

NOTE
Voltage on wire 568 signals regulator to turn on. Without voltage, regulator can’t operate. Wire 568A is connected with wire 5A inside engine wire harness. If there is no loose end on wire 568A, wire harness repair is required.
**ALTERNATOR DIAGNOSTIC FLOWCHART**

**KNOWN INFO**
- VOLTAGE OUTPUT INCORRECT
- REGULATOR HAS ENERGIZING VOLTAGE

**POSSIBLE PROBLEMS**
- ALTERNATOR
- REGULATOR
- WIRE

**F4**
CONNECT WIRE 568A AND 568. DISCONNECT WIRE 568 FROM ALTERNATOR. TURN ROTARY SWITCH TO “RUN”. MEASURE VOLTAGE AT ALTERNATOR END OF WIRE. IS THERE VOLTAGE AT BATTERY END OF WIRE 568?

- **YES**
  - REPLACE WIRE 568

- **NO**
  - REPLACE WIRE 568 FROM F3, Page 2-222

**TEST OPTIONS**
1. STE/ICE Test 89, (page 2-750)
2. Multimeter

**REASON FOR QUESTION**
Wire 568A and wire 568 carry ignition current to turn on regulator.

**KNOWN INFO**
- VOLTAGE OUTPUT INCORRECT
- REGULATOR HAS ENERGIZING VOLTAGE

**POSSIBLE PROBLEMS**
- ALTERNATOR
- REGULATOR

**F5**
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 RISE DURING CONNECTION TO 90-110 AMPS?

- **NO**
  - REPLACE ALTERNATOR, (Para. 12-24). THEN GO TO Step 5, Page 2-198

- **YES**
  - REPLACE REGULATOR, (Para. 12-22). THEN GO TO STEP 5, Page 2-198

**TEST OPTIONS**
- STE/ICE Test 10 and 90, (pages 2-734 and 2-751).

**REASON FOR QUESTION**
This connection applies full current loading to field coil. Alternator current output should be near maximum.
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>
ALTERNATOR

IS THIS A NIEHOFF 100 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

START ENGINE AND ALLOW TO IDLE AT 1200 - 1500 RPM FOR 2 - 3 MINUTES.

TEST OPTIONS
STE/ICE-R TEST 10, (interleave with control function 01 of page 2-734 then 89, page 2-750)

REASON FOR QUESTION
Determine if high or low output voltage.

NO

YES

If output voltage is over 30.5 volts, replace regulator (Para. 4-5.6).

DISCONNECT ALTERNATOR-TO-REGULATOR CABLE. START ENGINE AND SET IDLE 1200 - 1500 RPM. USING 15-AMP CAPACITY JUMPER WIRE, MOMENTARILY CONNECT TO ENGINE GROUND. DOES CURRENT AND VOLTAGE RISE DURING CONNECTION?

TEST OPTIONS
STE/ICE-R TEST 10 AND 90 (pages 2-734 and 2-751)

REASON FOR QUESTION
This connection applies full current loading to field coil. Alternator current output should be near maximum.

NO

Replace regulator (Para. 4-5.6). Then go to 5, page 2-198

YES

Replace regulator (Para. 4-5.6). Then go to 5, page 2-198

KNOWN INFO
Voltage Incorrect

POSSIBLE PROBLEMS
Wiring
Alternator
Regulator

KNOWN INFO
Voltage Output Incorrect
Regulator has Energizing Voltage

POSSIBLE PROBLEMS
Alternator
Regulator
Wiring
NOTE
For 60 amp Prestolite alternator, go to B, page 2-204.
For 100 amp Prestolite alternator, go to C, page 2-208.
For 200 amp Prestolite alternator, go to D, page 2-212.
For 200 amp single voltage Niehoff alternator, go to E, page 2-216.
For 100 amp single voltage Niehoff alternator, go to F, page 2-222.
For 100 amp dual voltage Niehoff alternator, continue with F.1.
For 200 amp dual voltage Niehoff alternator, go to G, page 2-224.6.
For 400 amp dual voltage Niehoff alternator, go to H, page 2-224.10.

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.
ALTERNATOR

KNOWN INFO
VOLTAGE OUTPUT INCORRECT
REGULATOR HAS ENERGIZING VOLTAGE

POSSIBLE PROBLEMS
ALTERNATOR REGULATOR WIRING

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
Determine if high or low output voltage.

IF OUTPUT VOLTAGE IS NOT CORRECT, REPLACE REGULATOR (Para 4-5.6). RECHECK VOLTAGE. IF VOLTAGE IS STILL NOT CORRECT, REPLACE ALTERNATOR (Para 4-5.2)

FROM F.1-3, [Page 2-224.2]

F.1-4

IDLE ENGINE AT 1200-1500 RPM. DOES VOLTAGE ON 14 VOLT OUTPUT TERMINAL (YELLOW INSULATOR) MEASURE BETWEEN 13.4-14.6 VOLTS?

NO

YES

F.1-5

TURN ROTARY SWITCH TO RUN POSITION. CHECK FOR BATTERY VOLTAGE AT RED (ENERGIZE) TERMINAL ON REGULATOR. IS BATTERY VOLTAGE PRESENT?

NO

NOTIFY DS MAINTENANCE TO REPAIR OR REPLACE WIRING HARNESS

YES

REPLACE REGULATOR (Para 4-5.6). THEN GO TO 5, [Page 2-198]
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>
<th>STE/ICE-R TEST 89</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Connect RED clip to the indicated test point, 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>
ALTERNATOR

DIAGNOSTIC FLOWCHART

G1
IS THIS A NIEHOFF 200 AMP DUAL VOLTAGE ALTERNATOR?

G2
START ENGINE AND ALLOW TO IDLE AT 1200-1500 RPM FOR 2-3 MINUTES.
RECHECK VOLTAGE OUTPUT.
IS ALTERNATOR OUTPUT LESS THAN 26 VOLTS?

G3
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?

TEST OPTIONS
Visual

REASON FOR QUESTION
Must know model of alternator to perform proper tests.

TEST OPTIONS
STE/ICE-R TEST 10, (interleave with control function 01 of page 2-734 then 89, page 2-750)

REASON FOR QUESTION
Determine if high or low output voltage.

TEST OPTIONS
STE/ICE-R TEST 10 AND 90 (pages 2-734 and 2-751)

REASON FOR QUESTION
This connection applies full current loading to field coil. Alternator current output should be near maximum.

KNOWN INFO
VOLTAGE OUTPUT INCORRECT
POSSIBLE PROBLEMS
WIRING
ALTERNATOR
REGULATOR

KNOWN INFO
VOLTAGE OUTPUT INCORRECT
REGULATOR HAS ENERGIZING VOLTAGE
POSSIBLE PROBLEMS
ALTERNATOR
REGULATOR

REPLACE ALTERNATOR (Para 4-5.7). THEN GO TO 5, Page 2-198
REPLACE REGULATOR (Para 4-5.10). THEN GO TO 5, Page 2-198

NOTE ON OPPOSITE PAGE

NO

NO

YES

YES

## REFERENCE INFORMATION

### ALTERNATOR

### NOTE

For 60 amp Prestolite alternator, go to B, page 2-204.
For 100 amp Prestolite alternator, go to C, page 2-208.
For 200 amp Prestolite alternator, go to D, page 2-212.
For 200 amp single voltage Niehoff alternator, go to E, page 2-218.
For 100 amp single voltage Niehoff alternator, go to F, page 2-222.
For 100 amp dual voltage Niehoff alternator, go to F.1, page 2-224.2.
For 200 amp dual voltage Niehoff alternator, continue with G.
For 400 amp dual voltage Niehoff alternator, go to H, page 2-224.10.

### 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.

### 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
REGULATOR HAS ENERGIZING VOLTAGE

POSSIBLE PROBLEMS
ALTERNATOR REGULATOR WIRING

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
Determine if high or low output voltage.

DIAGNOSTIC FLOWCHART

G4

IF OUTPUT VOLTAGE IS NOT CORRECT, REPLACE REGULATOR (Para 4-5.10). RECHECK VOLTAGE. IF VOLTAGE IS STILL NOT CORRECT, REPLACE ALTERNATOR (Para 4-5.7)

G5

TURN ROTARY SWITCH TO RUN POSITION. CHECK FOR BATTERY VOLTAGE AT RED (ENERGIZED) TERMINAL ON REGULATOR. IS BATTERY VOLTAGE PRESENT?

1. STE/ICE-R TEST 89
2. MULTIMETER

NOTIFY DS MAINTENANCE TO REPAIR OR REPLACE WIRING HARNESS

REPLACE REGULATOR (Para 4-5.10). THEN GO TO 5, Page 2-198

FROM G23
Page 2-224.2

IDLE ENGINE AT 1200-1500 RPM. DOES VOLTAGE ON 14 VOLT OUTPUT TERMINAL (YELLOW INSULATOR) MEASURE BETWEEN 13.4-14.6 VOLTS?
1. Slide boot back from wire lug to expose red terminal.
2. Make contact at stud.

---

**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.
H1

IS THIS A NIEHOFF 400 AMP DUAL VOLTAGE ALTERNATOR?

TEST OPTIONS
VISUAL
REASON FOR QUESTION
Must know model of alternator to perform tests.

H2

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
(Interleave with control function 01 of page 2-734 then 89, page 2-750)
REASON FOR QUESTION
Determine if high or low output voltage.

H3

IDLE ENGINE AT 1200-1500 RPM. DOES VOLTAGE ON 14 VOLT OUTPUT TERMINAL (YELLOW INSULATOR) MEASURE BETWEEN 13.4-14.6 VOLTS?

TEST OPTIONS
MULTIMETER
REASON FOR QUESTION
Determine if high or low output voltage.

H4

GO TO H4, Page 2-224.12

H FROM B1, Page 2-204

SEE NOTE OPPOSITE PAGE

KNOWN INFO
VOLTAGE OUTPUT INCORRECT

POSSIBLE PROBLEMS
ALTERNATOR REGULATOR WIRING

KNOWN INFO
VOLTAGE OUTPUT INCORRECT
REGULATOR HAS ENERGIZING VOLTAGE

POSSIBLE PROBLEMS
ALTERNATOR REGULATOR

IF OUTPUT VOLTAGE IS NOT CORRECT, REPLACE REGULATOR (Para 4-5.14) RECHECK VOLTAGE. IF VOLTAGE IS STILL NOT CORRECT, REPLACE ALTERNATOR (Para 4-5.12)
REFERENCE INFORMATION

NOTE
For 60 amp Prestolite alternator, go to B, page 2-204.
For 100 amp Prestolite alternator, go to C, page 2-208.
For 200 amp Prestolite alternator, go to D, page 2-212.
For 200 amp single voltage Niehoff alternator, go to E, page 2-218.
For 100 amp single voltage Niehoff alternator, go to F, page 2-222.
For 100 amp dual voltage Niehoff alternator, go to F.1, page 2-224.2.
For 200 amp dual voltage Niehoff alternator, continue with G.
For 400 amp dual voltage Niehoff alternator, go to H, page 2-224.10.

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.

---

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

FROM H3, Page 2-224.10

TEST OPTIONS
1. STE/ICE-R TEST 89 (page 2-750)
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 2-734 and 2-751)

REASON FOR QUESTION
This connection applies full current loading to field coil. Alternator current output should be near maximum.

ALTERNATOR

SELECT 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

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 REGULATOR (Para 4-5.11), THEN GO TO 5 [Page 2-198]

YES

REPLACE REGULATOR (Para 4-5.14), THEN GO TO 5 [Page 2-198]
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>
2-28. PROTECTIVE CONTROL BOX/DISTRIBUTION BOX TESTS

This protective control box /distribution box test can be run any time you think there may be a problem with the protective control box or distribution box, or if you were sent here from another system chain.

NOTE

• To perform PCB/distribution box diagnostics, a PCB test module is needed.
• For fabrication of PCB/distribution box test module, refer to Appendix D, Figs. 96-113, or requisitioned with NSN 6625-01-440-4522.
1. Engage parking brake. Ensure all vehicle grounds affecting protective control box/distribution 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 2-230.
1. Remove instrument panel, refer to (para. 4-12).
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, refer to (para. 4-12).
DISCONNECT BATTERY GROUND CABLE.

DISCONNECT THE BODY AND ENGINE WIRING HARNESS CANNON PLUGS FROM PROTECTIVE CONTROL BOX/DISTRIBUTION BOX. NOTE: THE DISTRIBUTION BOX HAS AN ADDITIONAL GLOWPLUG HARNESS.

CONNECT DIAGNOSTIC TEST MODULE HARNESS RECEPTACLE AND CONNECTORS TO BODY AND ENGINE WIRING HARNESS CANNON PLUGS.

GO TO 7, Page 2-232
Disconnect negative battery cable before disconnecting and reconnecting protective control box/distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.
PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

KNOWLEDGE

POSSIBLE PROBLEMS
- BATTERIES BAD
- LEAD 57B BAD GROUND
- PARKING BRAKE SWITCH BAD
- BODY HARNESS WIRES BAD
- GLOWPLUG CONTROLLER BAD
- ALTERNATOR BAD
- HARNESS WIRE 2A BAD
- IGNITION SWITCH BAD
- HARNESS WIRE 29A BAD
- HARNESS WIRE 29C BAD
- PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD

TEST OPTIONS
1. TRY IT
2. VISUAL

REASON FOR QUESTION
If no LEDs are ON, that would indicate malfunctioning batteries.

DIAGNOSTIC FLOWCHART

CONNECT BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

TEST OPTIONS

REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

VISUAL

REASON FOR QUESTION
If these LEDs are not ON, that would indicate protective control box (PCB)/distribution box malfunctions.

IS LED 7 "ON"?

REPAIR/PROPERLY GROUND BODY HARNESS WIRE 57B

VISUAL

REASON FOR QUESTION
If this LED is not ON, that would indicate a bad connection to ground.

ARE LEDS 3 AND 4 "ON"?

GO TO 10,
Page 2-234

FROM 6,
Page 2-230

GO TO 1,
Page 2-252

BATTERIES OK

CONNECT BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 1,
Page 2-252

SET BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 6,
Page 2-229

BATTERIES OK

PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD

SERVICE BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 10,
Page 2-234

SET BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 6,
Page 2-229

BATTERIES OK

SERVICE BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 10,
Page 2-234

SERVICE BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 6,
Page 2-229

BATTERIES OK

SERVICE BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 10,
Page 2-234

SERVICE BATTERY GROUND CABLE WITH IGNITION SWITCH IN THE "OFF" POSITION. ARE ANY LEDS "ON"? (REFER TO TABLE AT RIGHT)

GO TO 6,
Page 2-229
REFERENCE INFORMATION

NOTE
This analyzer requires all glow plugs to be serviceable and the battery to be fully charged in order to operate properly. Prior to performing diagnostic checks, ensure these two items are checked. If either of these two items is found to be faulty, repair/replace prior to beginning checks. Failure to do so will cause the analyzer to give false readings, thereby causing the needless replacement of serviceable components.

![WARNING]

Disconnect negative battery cable before disconnecting and reconnecting protective control box/distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace protective control box, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).

Repair lead connectors, refer to (para. 4-85).
Repair lead, refer to (para. 4-85).

PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

<table>
<thead>
<tr>
<th>IGNITION SWITCH POSITION</th>
<th>DIAGNOSTIC CHECKS (GO TASKS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>LED’s 1, 3, 4, 6, 7, “ON”; Remaining LED’s “OFF”</td>
</tr>
<tr>
<td></td>
<td>If all LED’s are “OFF”, battery power is not available.</td>
</tr>
<tr>
<td></td>
<td>If LED 3 or 4 is “OFF”, refer to PCB/distribution box.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is “OFF”, body harness wire 57B is not grounded.</td>
</tr>
<tr>
<td>RUN - (PCB)</td>
<td>LED’s 1, 2, 3, 4, 5, 6, 7, 8, 11, 13 “ON”.</td>
</tr>
<tr>
<td>(ENGINE NOT RUNNING-PCB)</td>
<td>LED 13 “OFF” after a few seconds (glow plug warm up time).</td>
</tr>
<tr>
<td>(ENGINE RUNNING-PCB)</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>LED’s 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></td>
<td>If all LED’s are “OFF”, no battery power is available.</td>
</tr>
<tr>
<td></td>
<td>If LED 3 or 4 is “OFF”, refer to PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is “OFF”, body harness wire 57B is not grounded.</td>
</tr>
<tr>
<td></td>
<td>If LED 2 is “OFF”, all glow plugs are serviceable, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is “OFF”, refer to PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is “OFF”, replace the PCB is LED 13 is “ON”.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 and 13 are “OFF”, the ignition switch is defective and/or harness wires 29A and 29C are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 13 is “OFF” and LED 5 is “ON” and the engine is not at operating temperature from a previous run, replace the PCB. The PCB is operational if the engine is at operating temperature from a previous run.</td>
</tr>
<tr>
<td></td>
<td>If LED 6 is “OFF” and the parking brake lever is engaged the parking brake switch is defective or the wires in the body harness are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 8 is “OFF”, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 11 is “OFF”, check the glow plug controller. If the glow plug controller is functioning properly, replace the PCB.</td>
</tr>
<tr>
<td>RUN - (Distribution Box)</td>
<td>LED’s 1, 2, 3, 4, 5, 6, 7, 8, 13 “ON”; remaining LED’s “OFF”</td>
</tr>
<tr>
<td>(ENGINE NOT RUNNING-</td>
<td>LED 13 “OFF” after a few seconds (glow plug warm up time).</td>
</tr>
<tr>
<td>Distribution Box)</td>
<td>LED 13 “OFF” if engine is at operating temperature.</td>
</tr>
<tr>
<td></td>
<td>LED 6 “OFF” if parking brake lever is released.</td>
</tr>
<tr>
<td></td>
<td>LED 6 “ON” if parking brake lever is engaged.</td>
</tr>
<tr>
<td></td>
<td>If LED 2, 3, 4, or 8 is “OFF”, replace distribution box.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is “OFF”, body harness wire 57B is not grounded.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is “OFF”, replace distribution box if LED 13 is “ON”.</td>
</tr>
<tr>
<td></td>
<td>If LED’s 5 and 13 are “OFF”, the ignition switch and/or harness wires 29A and 29C are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 13 is “OFF” and LED 5 is “ON”, and engine is not at operating temperature from a previous run, replace the PCB. Distribution box operation if engine is at operating temperature from a previous run. If LED 6 is “OFF” and the parking brake lever is engaged the parking brake switch is defective or the wires in the body harness are defective.</td>
</tr>
<tr>
<td></td>
<td>LED 10 momentarily “ON” and then remains “OFF” (starter motor frequency lockout).</td>
</tr>
<tr>
<td></td>
<td>If LED 11 and 13 remain “ON” or engine does not crank; check battery voltage; charge is low.</td>
</tr>
<tr>
<td></td>
<td>If LED 10 does not momentarily come “ON” and then stays “OFF”, replace PCB.</td>
</tr>
<tr>
<td>START (ENGINE CRANKING-</td>
<td>LED 10 momentarily “ON”.</td>
</tr>
<tr>
<td>PCB)</td>
<td>If LED 13 is “ON” or engine does not crank; check battery voltage; charge is low.</td>
</tr>
<tr>
<td></td>
<td>If LED 10 does not momentarily come “ON” and then stays “OFF”, and ignition switch is operating properly, replace distribution box.</td>
</tr>
<tr>
<td>RUN (ENGINE CRANKING-</td>
<td>LED’s 1, 2, 3, 4, 5, 6, 7, 8, 9, 12 “ON”.</td>
</tr>
<tr>
<td>Distribution Box)</td>
<td>LED 11 cycling “ON” and “OFF” (glow plug controller operation); “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” (glow plug controller operation).</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></td>
<td>If LED 2, 3, 4, 5, or 8 is “OFF” and all glow plugs are serviceable replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is “OFF”, the body harness wire 57B is not grounded.</td>
</tr>
<tr>
<td></td>
<td>If LED 9 is “OFF” and LED 12 is “ON”, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED’s 9 and 12 are “OFF”, there is no alternator output (alternating current tap) available and/or engine harness wire 2A is defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 11 is “OFF” and the engine is not at operating temperature from a previous run, replace the PCB. If the glow plug controller is functioning properly, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>LED’s 1, 2, 3, 4, 5, 6, 7, 8, 12 “ON”, remaining LED’s “OFF”</td>
</tr>
<tr>
<td></td>
<td>LED 6 “OFF” if parking brake lever is released.</td>
</tr>
<tr>
<td></td>
<td>LED 6 “ON” if parking brake lever is released.</td>
</tr>
<tr>
<td></td>
<td>If LED 2, 3, 4, 5, or 8 is “OFF” replace distribution box.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is “OFF”, body harness wire 57B is not grounded.</td>
</tr>
<tr>
<td></td>
<td>If LED 12 is “OFF”, there is no alternator output (alternating current tap) available and/or engine harness wire 2A is defective.</td>
</tr>
</tbody>
</table>

Change 1 2-233
PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

FROM 9, Page 2-232

10

WITH THE IGNITION SWITCH IN "RUN" (ENGINE NOT RUNNING) POSITION, ARE ANY LEDs "ON"? (REFER TO TABLE AT RIGHT)

TEST OPTIONS
1. TRY IT
2. VISUAL

YES

GO TO 1, Page 2-252

NO

11

IS LED 7 "ON"?

TEST OPTIONS
VISUAL

NO

REPAIR GROUND BODY HARNESS WIRE 57B

YES

12

ARE LEDS 2, 3, AND 4 "ON"?

TEST OPTIONS
VISUAL

NO

REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

YES

GO TO 13, Page 2-236

KNOWN INFO
BATTERIES OK
LEAD 57B GROUND OK

POSSIBLE PROBLEMS
PARKING BRAKE SWITCH BAD
BODY HARNESS WIRES BAD
GLOWPLUG CONTROLLER BAD
ALTERNATOR BAD
HARNESS WIRE 2A BAD
IGNITION SWITCH BAD
HARNESS WIRE 29A BAD
HARNESS WIRE 29C BAD
PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD
### REFERENCE INFORMATION

**NOTE**
This analyzer requires all glow plugs be serviceable and the batteries fully charged in order to operate properly. Prior to performing diagnostic checks, ensure these two items are checked. If either of these two items are found to be faulty, repair/replace prior to beginning checks. Failure to do so will cause the analyzer to give false readings, therefore causing the needless replacement of serviceable components.

### PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

#### DIAGNOSTIC CHECKS
(For Vehicles with protective control box/distribution box)

<table>
<thead>
<tr>
<th>OFF</th>
<th>LED's 1, 3, 4, 6, 7, &quot;ON&quot;; Remaining LED's &quot;OFF&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If all LED's are &quot;OFF&quot;, battery power is not available.</td>
</tr>
<tr>
<td></td>
<td>If LED 3 or 4 is &quot;OFF&quot;, replace the PCB/distribution box.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is &quot;OFF&quot;, body harness wire 57B is not grounded.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RUN - (PCB)</th>
<th>LED's 1,2,3,4,5,6,7,8,11,13 &quot;ON&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED 13 &quot;OFF&quot; after a few seconds (glow plug warm up time).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(ENGINE NOT RUNNING-PCB)</th>
<th>LED 13 &quot;OFF&quot; if engine is at operating temperature.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED 11 cycling &quot;ON&quot; and &quot;OFF&quot; (glow plug controller operation)</td>
</tr>
<tr>
<td></td>
<td>LED's 9, 10, 12 &quot;OFF&quot;.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(ENGINE NOT RUNNING-Distribution Box)</th>
<th>Release parking brake lever. LED 6 &quot;OFF&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Engage parking brake lever. LED 6 &quot;ON&quot;.</td>
</tr>
<tr>
<td></td>
<td>If all LED's are &quot;OFF&quot;, no battery power is available.</td>
</tr>
<tr>
<td></td>
<td>If LED 3 or 4 is &quot;OFF&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is &quot;OFF&quot;, harness wire 57B is not grounded</td>
</tr>
<tr>
<td></td>
<td>If LED 2 is &quot;OFF&quot;, and all glow plugs are serviceable, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, the ignition switch or harness wires 29A and 29C are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 13 is &quot;OFF&quot; and LED 5 is &quot;ON&quot;, the engine is not at operating temperature from a previous run.</td>
</tr>
<tr>
<td></td>
<td>If LED 6 is &quot;OFF&quot; and the parking brake lever is engaged the parking brake switch is defective or the wires in the body harness are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 8 is &quot;OFF&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 11 is &quot;OFF&quot;, check the glow plug controller. If the glow plug controller is functioning properly, replace the PCB.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Distribution Box)</th>
<th>LED's 1, 2, 3, 4, 5, 6, 7, 8,13 &quot;ON&quot;; remaining LED's &quot;OFF&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED 13 &quot;OFF&quot; after a few seconds (glow plug warm up time).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>START (ENGINE CRANKING-PCB)</th>
<th>LED 13 &quot;OFF&quot; if engine is at operating temperature.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED 6 &quot;OFF&quot; if parking brake lever is released.</td>
</tr>
<tr>
<td></td>
<td>LED 6 &quot;ON&quot; if parking brake lever is engaged</td>
</tr>
<tr>
<td></td>
<td>If LED 3, 4, 5, 8 is &quot;OFF&quot;, replace distribution box.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is &quot;OFF&quot;, harness wire 57B is not grounded</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, replace distribution box if LED 13 is &quot;ON&quot;.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, the ignition switch and/or harness wires 29A and 29C are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 13 is &quot;OFF&quot; and LED 5 is &quot;ON&quot;, and engine is not at operating temperature from a previous run.</td>
</tr>
<tr>
<td></td>
<td>If LED 6 is &quot;OFF&quot; and the parking brake lever is engaged the parking brake switch and/or the wires in the body harness are defective.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(ENGINE NOT RUNNING-Distribution Box)</th>
<th>LED 10 momentarily &quot;ON&quot; and then remains &quot;OFF&quot; (starter motor frequency lockout).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If LED 11 and 13 remain &quot;ON&quot; or engine does not crank; check battery voltage; charge is low.</td>
</tr>
<tr>
<td></td>
<td>If LED 10 does momentarily come &quot;ON&quot; and then stays &quot;OFF&quot;, replace PCB.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>START (ENGINE CRANKING- Distribution Box)</th>
<th>LED 10 momentarily &quot;ON&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If LED 13 is &quot;ON&quot; or engine does not crank; check battery voltage; charge is low.</td>
</tr>
<tr>
<td></td>
<td>If LED 10 does not momentarily come &quot;ON&quot; and then stays &quot;OFF&quot;, and ignition switch is operating properly, replace distribution box.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RUN (ENGINE RUNNING-PCB)</th>
<th>LED's 1,2,3,4,5,6,7,8,9,12 &quot;ON&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED 11 cycling &quot;ON&quot; and &quot;OFF&quot; (glow plug controller operation); &quot;OFF&quot; time interval increases as engine warms up.</td>
</tr>
<tr>
<td></td>
<td>LED 11 &quot;OFF&quot; (when engine is at operating temperature).</td>
</tr>
<tr>
<td></td>
<td>LED 11 may remain &quot;OFF&quot; (when engine is at operating temperature from previous run).</td>
</tr>
<tr>
<td></td>
<td>LED 13 &quot;OFF&quot;.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Distribution Box)</th>
<th>Release parking brake lever. LED 6 &quot;OFF&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Engage parking brake lever. LED 6 &quot;ON&quot;.</td>
</tr>
<tr>
<td></td>
<td>If LED 2, 3, 4, 5, or 8 is &quot;OFF&quot; and all glow plugs are serviceable replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is &quot;OFF&quot;, the body harness wire 57B is not grounded.</td>
</tr>
<tr>
<td></td>
<td>If LED 9 is &quot;OFF&quot; and LED 12 is &quot;ON&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 and 12 are &quot;OFF&quot;, there is no alternator output (alternating current tap) available and/or the engine harness wire 2A is defective.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(ENGINE NOT RUNNING-Distribution Box)</th>
<th>If LED 3 or 4 is &quot;OFF&quot;, replace the PCB/distribution box.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, the ignition switch is defective and/or harness wires 29A and 29C are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 13 is &quot;OFF&quot; and LED 5 is &quot;ON&quot;, the engine is not at operating temperature from a previous run.</td>
</tr>
<tr>
<td></td>
<td>If LED 6 is &quot;OFF&quot; and the parking brake lever is engaged the parking brake switch is defective or the wires in the body harness are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 8 is &quot;OFF&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 11 is &quot;OFF&quot;, check the glow plug controller. If the glow plug controller is functioning properly, replace the PCB.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RUN (ENGINE RUNNING-Distribution Box)</th>
<th>LED's 1, 2, 3, 4, 5, 6, 7, 8, 12 &quot;ON&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED 6 &quot;OFF&quot; if parking brake lever is released.</td>
</tr>
<tr>
<td></td>
<td>LED 6 &quot;ON&quot; if parking brake lever is engaged</td>
</tr>
<tr>
<td></td>
<td>If LED 2, 3, 4, 5, or 8 is &quot;OFF&quot;, replace distribution box.</td>
</tr>
<tr>
<td></td>
<td>If LED 7 is &quot;OFF&quot;, harness wire 57B is not grounded</td>
</tr>
<tr>
<td></td>
<td>If LED 9 is &quot;OFF&quot; and LED 12 is &quot;ON&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, replace the PCB.</td>
</tr>
<tr>
<td></td>
<td>If LED 5 is &quot;OFF&quot;, the ignition switch and/or harness wires 29A and 29C are defective.</td>
</tr>
<tr>
<td></td>
<td>If LED 13 is &quot;OFF&quot; and LED 5 is &quot;ON&quot;, and engine is not at operating temperature from a previous run.</td>
</tr>
<tr>
<td></td>
<td>If LED 6 is &quot;OFF&quot; and the parking brake lever is engaged the parking brake switch and/or the wires in the body harness are defective.</td>
</tr>
</tbody>
</table>

**WARNING**
Disconnect negative battery cable before disconnecting and reconnecting protective control box/distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace protective control box, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).
**PROTECTIVE CONTROL BOX/DISTRIBUTION BOX**

**KNOWN INFO**
- Batteries OK
- Lead 57B ground OK

**POSSIBLE PROBLEMS**
- Parking brake switch bad
- Body harness wires bad
- Glowplug controller bad
- Alternator bad
- Harness wire 2A bad
- Ignition switch bad
- Harness wire 29A bad
- Harness wire 29C bad
- Protective control box/distribution box bad

**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 protective control box (PCB)/distribution box.

**DIAGNOSTIC FLOWCHART**

**13**
- **DID LED 13 COME “ON” WITH PCB?**
  - **IF ENGINE IS AT OPERATING TEMPERATURE, LED 13 WILL NOT COME ON. WITH DISTRIBUTION BOX, LIGHT WILL COME ON WHEN ENGINE IS AT OPERATING TEMPERATURE.**
  - **GO TO A1,** [Page 2-238]

**14**
- **IS LED 5 “ON”?**
- **VISUAL**

**15**
- **IS LED 6 “ON”?**
- **VISUAL**

**GO TO 16,** [Page 2-238]
Disconnect negative battery cable before disconnecting and reconnecting protective control box/distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace protective control box, refer to (para. 4-5).

Replace distribution box, refer to (para. 4-5.1).

Repair lead connectors, refer to (para. 4-85).

Repair leads, refer to (para. 4-85).
PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

DIAGNOSTIC FLOWCHART

16

IS LED 8 “ON”? FOR DISTRIBUTION BOX, IF YES, GO TO 18.

YES

NO

REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

17

IS LED 11 “ON”? DURING GLOW PLUG CYCLING, LED 11 MAY FLICKER. NOTE: LED 11 IS NOT USED WITH THE DISTRIBUTION BOX

YES

NO

GO TO D1, Page 2-314

18

WITH THE IGNITION SWITCH IN THE “START” (ENGINE CRANKING) POSITION, DO LEDS 11 AND 13 GO “OUT”, AND DOES ENGINE CRANK? NOTE: LED 11 DOES NOT FUNCTION WITH DISTRIBUTION BOX.

YES

NO

CHECK BATTERY VOLTAGE AND CHARGE IF NEEDED

GO TO 19, Page 2-240

TM 9-2320-280-20-1

KNOWN INFO

BATTERIES OK
LEAD 57B GROUND OK
IGNITION SWITCH OK
HARNESS WIRE 29A OK
HARNESS WIRE 29C OK
PARKING BRAKE SWITCH OK
BODY HARNESS WIRES OK

POSSIBLE PROBLEMS

GLOWPLUG CONTROLLER BAD
ALTERNATOR BAD
HARNESS WIRE 2A BAD
PROTECTIVE CONTROL BOX/ DISTRIBUTION BOX BAD

TEST OPTIONS

1. TRY IT
2. VISUAL

REASON FOR QUESTION

If this LED is not ON, that would indicate a protective control box/distribution box malfunction.

VISUAL

IF LED 8 IS NOT ON, THAT WOULD INDICATE A GLOWPLUG CONTROLLER MALFUNCTION.

IF LED 11 IS NOT ON, THAT WOULD INDICATE A PROTECTIVE CONTROL BOX/DISTRIBUTION BOX MALFUNCTION.

2-238 Change 1
Disconnect negative battery cable before disconnecting and reconnecting protective control box or distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace protective control box, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).

Replace glowplug controller, refer to (para. 4-29).

Service/repair batteries, refer to (para. 4-79).
PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

KNOWN INFO
BATTERIES OK
LEAD 57B GROUND OK
IGNITION SWITCH OK
HARNESS WIRE 29A OK
HARNESS WIRE 29C OK
PARKING BRAKE SWITCH OK
BODY HARNESS WIRES OK

POSSIBLE PROBLEMS
ALTERNATOR BAD
HARNESS WIRE 2A BAD
PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If this LED is not momentarily ON, that would indicate a protective control box (PCB)/distribution box malfunction.

YES

NO

REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If these LEDs are not ON, that would indicate a protective control box (PCB)/distribution box malfunction.

YES

NO

REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If this LED is not ON, that would indicate a bad connection to ground.

YES

NO

REPAIR GROUND BODY HARNESS WIRE 57B

GO TO 22,
Page 2-242

FROM 18,
Page 2-238

DOES LED 10 MOMENTARILY
COME “ON” THEN STAY “OFF”? 

WITH THE IGNITION SWITCH IN
THE “RUN” (ENGINE RUNNING)
POSITION, ARE LEDs 2,3,4,5,
AND 8 “ON”? 

IS LED 7 “ON”? 

Page 2-238

Page 2-242
Disconnect negative battery cable before disconnecting and reconnecting protective control box or distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace protective control box, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).

Repair lead connectors, refer to (para. 4-85).
Repair leads, refer to (para. 4-85).
**KNOWN INFO**
- BATTERIES OK
- LEAD 57B GROUND OK
- IGNITION SWITCH OK
- HARNESS WIRE 29A OK
- HARNESS WIRE 29C OK
- PARKING BRAKE SWITCH OK
- BODY HARNESS WIRES OK
- GLOWPLUG CONTROLLER OK

**POSSIBLE PROBLEMS**
- ALTERNATOR BAD
- HARNESS WIRE 2A BAD
- PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD

---

**PROTECTIVE CONTROL BOX/DISTRIBUTION BOX**

**DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**

**REASON FOR QUESTION**
- If this LED condition does not exist, that would indicate a protective control box (PCB)/distribution box malfunction.

**22**

**IS LED 9 “OFF” AND 12 “ON”**?

**NOTE:** LED 9 DOES NOT FUNCTION WITH DISTRIBUTION BOX.

**VISUAL**

**YES**

**REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX BAD**

**NO**

**23**

**ARE LEDS 9 AND 12 “ON”**?

**NOTE:** LED 9 DOES NOT FUNCTION WITH DISTRIBUTION BOX. IF LED 12 IS ON, GO TO 27, PAGE 2-244.

**VISUAL**

**YES**

**CHECK ALTERNATOR OUTPUT AND/OR REPAIR ENGINE HARNESS WIRE 2A**

**NO**

**24**

**WHILE ENGINE IS NOT AT OPERATING TEMPERATURE, IS LED 11 “ON”**?

**NOTE:** LED 11 DOES NOT FUNCTION WITH DISTRIBUTION BOX.

**VISUAL**

**YES**

**GO TO D1, PAGE 2-314 AND BEGIN TEST CHAIN AGAIN IF GLOWPLUG CONTROLLER IS REPLACED**

**NO**

**25**

**GO TO 25, PAGE 2-244**
Disconnect negative battery cable before disconnecting and reconnecting protective control box or distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace protective control box, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).

Repair lead connectors, refer to (para. 4-85).
Repair leads, refer to (para. 4-85).

Repair glowplug controller, refer to (para. 4-29).
**PROTECTIVE CONTROL BOX/DISTRIBUTION BOX**

**KNOWN INFO**
- Batteries OK
- Lead 57B ground OK
- Ignition switch OK
- Harness wire 29A OK
- Harness wire 29C OK
- Parking brake switch OK
- Body harness wires OK
- Glowplug controller OK
- Alternator OK
- Harness wire 2A OK

**POSSIBLE PROBLEMS**
- Protective control box bad

**TEST OPTIONS**
- Visual

**REASON FOR QUESTION**
If LED is not cycling ON and OFF, that would indicate a protective control box (PCB) malfunction.

**DIAGNOSTIC FLOWCHART**

1. **25**
   - IS LED 11 CYCLING “ON” AND “OFF”?
   - **NOTE:** LED 11 DOES NOT FUNCTION WITH DISTRIBUTION BOX.
   - **!!**
   - **REPLACE PROTECTIVE CONTROL BOX**

2. **26**
   - AT ENGINE OPERATING TEMPERATURE, DOES LED 11 STOP CYCLING “ON” AND “OFF”?
   - **NOTE:** LED 11 DOES NOT FUNCTION WITH DISTRIBUTION BOX.
   - **VISUAL**
   - **NO**
   - **YES**
   - **GO TO D1, Page 2-314 AND BEGIN TEST CHAIN AGAIN IF GLOW PLUG CONTROLLER IS REPLACED**

3. **27**
   - NO PROTECTIVE CONTROL BOX OR DISTRIBUTION BOX FAULT FOUND.

4. **GO TO 28, Page 2-246**
Disconnect negative battery cable before disconnecting and reconnecting protective control box/distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.

Replace protective control box, refer to (para. 4-5).
28

DISCONNECT BATTERY GROUND CABLE.

29

DISCONNECT BODY AND ENGINE WIRING HARNESS CANNON PLUGS FROM DIAGNOSTIC TEST MODULE.

DISCONNECT CONNECTORS FROM PROTECTIVE CONTROL BOX/DISTRIBUTION BOX.

30

CONNECT BODY AND ENGINE WIRING HARNESS CANNON PLUGS TO PROTECTIVE CONTROL BOX/DISTRIBUTION BOX.

CONNECT BATTERY GROUND CABLE.
WARNING

Disconnect negative battery cable before disconnecting and reconnecting protective control box or distribution box harness. Failure to do so may result in injury to personnel or damage to equipment.
IF LED 5 IS "ON," REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX, OR REPAIR/REPLACE IGNITION SWITCH AND/OR HARNESS WIRES 29A AND 29C.
Replace protective control box, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).
Repair/replace rotary switch, refer to (para. 4-7).
Repair/replace leads 29A and 29C, refer to (para. 4-85).
2-29. BATTERY CIRCUIT TEST

These Battery Circuit tests maybe 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 FO-7 may be left open for reference while testing.
BATTERY CIRCUIT

DIAGNOSTIC FLOWCHART

1. ARE ALL BATTERY CONNECTIONS CLEAN AND TIGHT?
   - **Possible Problems:**
     - Batteries
     - Cables
     - Alternator Circuit
     - Cable Connections
   - **Test Options:**
     - Visual
   - **Reason for Question:**
     - A loose or dirty connection can make good batteries look bad and may not allow current to flow.

2. ARE THE BATTERIES FILLED TO THE PROPER LEVEL?
   - **Possible Problems:**
     - Batteries
     - Cables
     - Alternator Circuit
   - **Test Options:**
     - Visual
   - **Reason for Question:**
     - Batteries need water for the electrolyte solution. Batteries don't work right if the electrolyte level is low.

3. IS BATTERY VOLTAGE 23.5 - 25.5 VOLTS?
   - **Possible Problems:**
     - Batteries
     - Cables
     - Alternator Circuit
   - **Test Options:**
     1. STE/ICE-R Test 67
     2. Multimeter
   - **Reason for Question:**
     - If the battery voltage is not correct, you may have bad batteries or a problem in the alternator circuit.

4. GO TO A, Page 2-254
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 STE/ACE-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 glowplugs turn on.
BATTERY CIRCUIT DIAGNOSTIC FLOWCHART

KNOWN INFO
CONNECTIONS OK
WATER LEVEL OK
BATTERY VOLTAGE OK
ALTERNATOR CIRCUIT OK

POSSIBLE PROBLEMS
BATTERIES
CABLES

TEST OPTIONS
STE/ICE-R TESTS 73, 75
(Page 2-746, 748)

REASON FOR QUESTION
If either resistance reading is too high, the batteries are probably weak and may not produce enough power.

IS BATTERY PAIR RESISTANCE LESS THAN 25 MILLIOHMS AND BATTERY RESISTANCE CHANGE LESS THAN 50 MILLIOHMS/SECOND?

NO

GO TO B, Page 3-258

YES

TEST OPTIONS
1. STE/ICE-R TEST 69
(Page 2-742)
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 VOLTS?

NO

REPAIR/REPLACE WIRE 7A

YES

TEST OPTIONS
1. STE/ICE-R TEST 89
(Page 2-750)
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 VOLTS? TEST POINT IS THE POWER STUD, GROUND IS THE STARTER TERMINAL.

NO

REPAIR/REPLACE WIRE 6A

YES

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**

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 volts maximum.

**BATTERY INTERNAL RESISTANCE**

STE/ICE-R TEST 73

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glowplug 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**

STE/ICE-R TEST 75

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glowplug controller and fan solenoid.
3. Start Test 75, battery resistance change.
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.

**0-45 DC VOLTS**

STE/ICE-R TEST 69

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

**DIAGNOSTIC FLOWCHART**

**A1**

**KNOWN INFO**

- **BATTERY VOLTAGE IS NOT CORRECT**

**POSSIBLE PROBLEMS**

- **BATTERY OR BATTERIES CABLES ALTERNATOR**

**TEST OPTIONS**

1. **STE/ICE-R TEST 89**
   (Page 2-252)

2. **MULTIMETER**

**REASON FOR QUESTION**

A good battery has 12 volts at 70° F (22° C).

**FOLLOWING TEST RESULTS**

**YES**

**DOES EACH BATTERY MEASURE 11-13 VOLTS?**

**NO**

**RECHARGE OR REPLACE BATTERY**

**A2**

**KNOWN INFO**

- **BATTERIES OK**

**POSSIBLE PROBLEMS**

- **CABLES**

**TEST OPTIONS**

1. **STE/ICE-R TEST 89**
   (Page 2-250)

2. **MULTIMETER**

**REASON FOR QUESTION**

Everything else checks out OK. These cables are the only thing in the battery circuit we haven't tested.

**FOLLOWING TEST RESULTS**

**YES**

**CHECK THE VOLTAGE DROP ACROSS EACH CABLE IN THE BATTERY BOX (SEE NOTE AT RIGHT). ARE ALL VOLTAGE DROPS LESS THAN 0.25 VOLTS MAX?**

**NO**

**REPAIR/ REPLACE BAD CABLE OR CABLES**

**A3**

**KNOWN INFO**

- **BATTERY VOLTAGE NOT CORRECT**

**POSSIBLE PROBLEMS**

- **BATTERIES ALTERNATOR**

**YOUR BATTERIES ARE OVERCHARGED OR DISCHARGED. RUN THE ALTERNATOR TESTS. IF NO FAULTS ARE FOUND, REPLACE THE DEFECTIVE BATTERY OR BATTERIES.**
Measure from the positive poet to the negative poet of each battery.

For battery replacement instructions, refer to (para. 4-79).

**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. 4-73).

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.

Sea paragraph 4-79. (Also check each battery’s specific gravity in accordance with TM 9-6140-200-14.)

Replace battery refer to (para. 4-79).
BATTERY CIRCUIT

DIAGNOSTIC FLOWCHART

B1

IS EACH BATTERY RESISTANCE LESS THAN 25 MILLIOMHS AND EACH BATTERY RESISTANCE CHANGE LESS THAN 50 MILLIOMHS/SECOND?

NO

REPLACE DEFECTIVE BATTERY

YES

B2

CHECK THE VOLTAGE DROP ACROSS ALL CABLES IN THE BATTERY BOX (SEE NOTE AT RIGHT) AND THE POSITIVE AND NEGATIVE CABLES TO THE STARTER. ARE ALL VOLTAGE DROPS LESS THAN 0.25 VOLS?

NO

REPAIR/REPLACE BAD CABLE OR CABLES

YES

B3

NO FAULTS FOUND. (IF YOU USED TESTS 73 & 75 IN STEP 4, P. 2-254, 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.

TEST OPTIONS

REARRANGE BATTERY BOX TO TEST ONE BATTERY.

RUN STE/ICE-R TESTS 73,75. (Page 2-746, 748).

REASON FOR QUESTION

If either resistance reading is too high, the batteries are probably weak and may not produce enough power.

TEST OPTIONS

1. STE/ICE-R TEST 89 (Page 2-750)

2. STE/ICE-R TEST 74 (STARTER CKT RESISTANCE) OR TEST 69 (NEGATIVE CABLE DROP) OR TEST 68 (STARTER MOTOR VOLTAGE) (Page 2-750, 747, 742, 741)

3. MULTIMETER

REASON FOR QUESTION

Everything else has checked OK. These cables are the only thing in the battery circuit we haven't tested.
Replace batteries, refer to (para 4-79).

NOTE
Check these cables
WIRE 68, correcting 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, refer to (para 4-79).

NOTE
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.

BATTERY INTERNAL RESISTANCE
STE/ICE-R TEST 73

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glowplug 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
STE/ICE-R TEST 75

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glowplug controller and fan solenoid (to keep waveform clean).
3. Start Test 75, battery resistance change.
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.

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

1. Connect RED clip to the indicated test point, BLACK dip to negative or ground.
2. Start Test 89, DC volts.
3. Displayed reading is in volts.
2-30. STARTER CIRCUIT TESTS

GENERAL DESCRIPTION

The Starter Circuit consists of the batteries, starter solenoid, starter motor, rotary switch, neutral safety switch, protective control box/distribution box, and related electrical wiring. The relationship of these parts is shown in the block diagram above, and a simplified functional flow schematic is provided on the foldout FO-8.

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 starter solenoid is energized. The solenoid contacts 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 deenergizes the starter solenoid which, in turn, disengages the starter motor from the engine.

Solenoid current flows from the rotary switch through the neutral safety switch and protective control box/distribution box to the solenoid.
STARTER CIRCUIT

1. CHECK ALL CABLES AND CONNECTIONS (BATTERY, STARTER, SOLENOID, ROTARY SWITCH, PCB/DISTRIBUTION BOX). REPAIR, CLEAN, OR REPLACE AS REQUIRED.

2. CHECK BATTERY VOLTAGE WHILE TRYING TO CRANK THE ENGINE. IS THE BATTERY VOLTAGE AT LEAST 18 VOLTS?

REASON FOR QUESTION
Bad connections are a very common problem.

TEST OPTIONS
VISUAL INSPECTION

GO TO BATTERY CIRCUIT [Page 2-252]

GO TO 3, [Page 2-264]
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 (heavy gauge wire 6A) wire 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 protective control box/distribution box harness.

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

3. PROTECTIVE CONTROL BOX/DISTRIBUTION BOX - Unscrew 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.

---

**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 glowplugs 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.
3. **Does the engine crank at least 200 RPM?**

**Test Options:**
1. **Listen**
2. STE/ICE-R TEST 10

**Reason for Question:** If the engine cranks you know the engine is not locked and the rotary switch is OK.

- **NO**
  - Go to A, Page 2-268
  - H Page 2-296

- **YES**
  - Go to A, Page 2-268
  - H Page 2-296

4. **Does the starter crank the engine without any grinding, squeaking, or unusual noise?**

**Test Options:**
- **Listen**

**Reason for Question:** This is a check for mechanical problems such as improperly shimmed starter, damaged flywheel, or burnt starter.

- **NO**
  - Go to B, Page 2-272

- **YES**
  - Go to A, Page 2-268
  - H Page 2-296

**Known Info**
- Cables & Connectors appear OK

**Possible Problems**
- Batteries
- Starter/Solenoid
- Rotary Switch
- Engine Lock
- PCB/Distribution Box

**Known Info**
- Rotary Switch OK
- Engine Not Locked
- PCB/Distribution Box OK

**Possible Problems**
- Starter
- Starter Shims
- Fly Wheel
- Batteries

```
FROM 2, Page 2-262
```
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 625-675 (6.2L and 6.5L).
5. **DOES THE STARTER STOP CRANKING WHEN THE ROTARY SWITCH IS RETURNED TO THE “RUN” OR “STOP” POSITIONS?**

- **KNOWN INFO**
  - CRANKS OK

- **POSSIBLE PROBLEMS**
  - ROTARY SWITCH STARTER
  - PCB/DISTRIBUTION BOX

- **TEST OPTIONS**
  - LISTEN

- **REASON FOR QUESTION**
  - The starter solenoid could be stuck or, more likely there may be a short to the solenoid.

- **YES**
  - GO TO C, Page 2-276

- **NO**
  - GO TO D, Page 2-282

6. **IS THE AVERAGE STARTER CURRENT BETWEEN 200 & 300 AMPS?**

- **KNOWN INFO**
  - ROTARY SWITCH OK
  - ENGINE NOT LOCKED
  - PCB/DISTRIBUTION BOX OK

- **POSSIBLE PROBLEMS**
  - BATTERIES
  - STARTER/SOLENOID

- **TEST OPTIONS**
  - 1. STE/ICE-R TEST 71 (Page 2-744)
  - 2. MULTIMETER

- **REASON FOR QUESTION**
  - This will tell if the starter is OK and if the batteries have enough power to crank the engine.

- **YES**
  - GO TO D, Page 2-282

- **NO**
  - GO TO C, Page 2-276

7. **IS THE BATTERY VOLTAGE AT LEAST 18.5 VOLTS WHILE CRANKING?**

- **KNOWN INFO**
  - ROTARY SWITCH OK
  - ENGINE NOT LOCKED
  - STARTER OK

- **POSSIBLE PROBLEMS**
  - BATTERIES

- **TEST OPTIONS**
  - 1. STE/ICE-R TEST 67 (Page 2-740)
  - 2. MULTIMETER

- **REASON FOR QUESTION**
  - A good cranking voltage, combined with a good starter current shows that the batteries are OK.

- **YES**
  - NO FAULTS FOUND

- **NO**
  - GO TO BATTERY TESTS, Page 2-252
## 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 per 1000 amps. To get current, multiply millivolts by 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 glowplugs 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.
A1

DOES THE ENGINE CRANK AT ALL?

TEST OPTIONS
LISTEN

REASON FOR QUESTION
If the engine cranks, then the rotary switch, neutral safety switch and PCB/distribution box are all working.

NO

GO TO E,
Page 2-284

YES

A2

IS THE BATTERY VOLTAGE 23-25 VOLTS?

TEST OPTIONS
1. STE/ICE-R TEST 67
   (Page 2-740)
2. MULTIMETER

REASON FOR QUESTION
If batteries are weak they can't provide enough current to crank the engine properly.

NO

REPLACE BATTERIES OR CHECK EACH BATTERY

YES

A3

IS THE BATTERY VOLTAGE AT LEAST 18.5 VOLTS DURING CRANKING?

TEST OPTIONS
1. STE/ICE-R TEST 67
   (Page 2-740)
2. MULTIMETER

REASON FOR QUESTION
Batteries must be able to maintain voltage or the engine won't crank.

NO

REPLACE BATTERIES

YES

GO TO A4,
Page 2-270

KNOWN INFO
ENGINE DOESN'T CRANK AT 200 RPM

POSSIBLE PROBLEMS
BATTERIES
STARTER
NEUTRAL SAFETY SWITCH
CABLES/WIRING
ENGINE MECHANICAL ROTARY SWITCH
PCB/DISTRIBUTION BOX

KNOWN INFO
ENGINE CRANKS SLOW

POSSIBLE PROBLEMS
BATTERIES
STARTER
ENGINE MECHANICAL CABLES/CONNECTORS

KNOWN INFO
BATTERY VOLTS OK STARTER OK

POSSIBLE PROBLEMS
WEAK BATTERIES
ENGINE MECHANICAL CABLES/CONNECTORS STARTER

STARTER CIRCUIT

STARTER CIRCUIT

STARTER 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 glowplugs turn on.

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.

Connect red to positive = power stud
Connect black to negative = battery side of current shunt
Replace batteries, refer to (para 4-79).

VOLTS GAUGE
STARTER CIRCUIT

FROM A3, Page 2-268

IS THE STARTER AVERAGE CURRENT 200-300 AMPS?

TEST OPTIONS
1. STE/ICE-R TEST 71 (Page 2-744)
2. MULTIMETER @ SHUNT

REASON FOR QUESTION
This is to check the condition of the starter and the batteries.

GO TO D, Page 2-262

NO

YES

KNOWLEDGE INFO

BATTERY VOLTAGE OK
ENGINE CRANKS SLOW

POSSIBLE PROBLEMS
WEAK BATTERIES
STARTER
ENGINE MECHANICAL
CABLES/CONNECTIONS

A4

ARE THE CABLE VOLTAGE DROPS LESS THAN 0.25 VOLTS?

TEST OPTIONS
1. STE/ICE-R TESTS 69, 89 (Page 2-742, 750)
2. MULTIMETER

REASON FOR QUESTION
High voltage drops indicate bad cables or connections.

REPAIR/REPLACE CABLES OR CONNECTIONS

NO

YES

A5

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 2-24, (Page 2-143)
REFERENCE INFORMATION

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 68, 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, refer to (para 4-73).

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 volts max.

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.

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 = 1000 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

B1

REPLACE STARTER

NO

YES

B2

NOTIFY DS LEVEL MAINTENANCE

NO

YES

B3

PUT STARTER BACK ON ENGINE. BE VERY CAREFUL TO SHIM THE STARTER PROPERLY.

NO

YES

TEST OPTIONS

VISUAL

REASON FOR QUESTION

If defects are visible, starter is faulty.

VISUAL

REASON FOR QUESTION

Bad or missing teeth on flywheel can cause engine to crank improperly or not at all.

N/A

REASON FOR QUESTION

The starter may have been improperly installed with the wrong shims and/or bolts.

GO TO B4, Page 2-274
Remove Starter motor.
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, refer to (para 4-8).

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, refer to (para 4-8).
STARTER CIRCUIT DIAGNOSTIC FLOWCHART

FROM B3, Page 2-272

B4

DOES STARTER ENGAGE AND DISENGAGE PROPERLY?

TEST OPTIONS

VISUAL (LISTEN)

REASON FOR QUESTION
If starter still does not engage and disengage properly, it must be defective.

POSSIBLE PROBLEMS

STARTER ENGINE

KNOWN INFO

BATTERIES OK
WIRING OK
STARTER NOT VISIBLY DEFECTIVE

REPLACE STARTER

NO

YES

B5

RETURN TO STARTER CIRCUIT, RUN STEP 4, Page 2-204.
Replace starter, refer to (para 4-8).
**KNOWN INFO**

ENGINE WON'T STOP CRANKING

**POSSIBLE PROBLEMS**

ROTARY SWITCH PCB/DISTRIBUTION BOX WIRING STARTER

---

**C1**

**DISCONNECT NEGATIVE BATTERY CABLE TO STOP CRANKING.**

**REASON FOR QUESTION**

No matter what's wrong, the starter can't crank without battery power.

---

**C2**

**DISCONNECT WIRES AT ROTARY SWITCH. WITH SWITCH IN "OFF" 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 (Page 2-752)
2. MULTIMETER

**REASON FOR QUESTION**

A good switch exhibits these open circuits in the "OFF" position.

---

**C3**

WITH ROTARY SWITCH IN "RUN" POSITION, DO YOU GET:
OPEN CIRCUIT FROM B TO S?
OPEN CIRCUIT FROM R TO S?
SHORT CIRCUIT FROM B TO R?

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

**REASON FOR QUESTION**

A good switch has these opens and shorts.

---

**NO**

REPLACE SWITCH

---

**YES**

REPLACE SWITCH

---

**GO TO C4,** (Page 2-278)
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, refer to (para 4-7).

---

### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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
- ROTARY SWITCH OK

POSSIBLE PROBLEMS
- PCB/DISTRIBUTION BOX WIRING STARTER

C4

RECONNECT ROTARY SWITCH. TURN SWITCH TO “STOP.” CHECK FOR OPEN CIRCUIT IN THE PCB BODY CONNECTOR HARNESS BETWEEN THE FOLLOWING SOCKETS; G-A, G-B, A-B, F-A, AND F-B. ARE THEY ALL OPEN CIRCUITS?

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION
Continuity between any of these pins indicates a short between the wires in body harness.

NO

YES

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?

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION
Continuity between these pins indicates a short in the engine harness.

NO

YES

REPAIR WIRES OR REPLACE HARNESS

C6

IS THERE AN OPEN CIRCUIT FROM SOCKET E OF PCB/DISTRIBUTION BOX ENGINE CONNECTOR HARNESS TO ENGINE GROUND?

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION
Continuity indicates shorted connector in the starter solenoid.

NO

YES

REPLACE STARTER

GO TO C7. Page 2-280
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, refer to (para. 4-85).

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, refer to (para. 4-85).

Replace starter, refer to (para. 4-8).

---

### PCB/DISTRIBUTION BOX BODY CONNECTOR

#### 0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”

#### CONTINUITY (RESISTANCE)

**MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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

C7

RECONNECT WIRE 74A TO STARTER. IS BATTERY VOLTAGE LESS THAN 20 VOLTS?

TEST OPTIONS
1. STE/ICE-R TEST 67
   (Page 2-740)
2. MULTIMETER

REASON FOR QUESTION
Low battery voltage may, under the proper conditions, cause the starter solenoid to remain energized.

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/DISTRIBUTION BOX. RE-RUN STARTER CIRCUIT TEST CHAIN (STEP 1) [Page 2-262].
REFERENCE INFORMATION

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 glowplugs turn on.

STARTER CIRCUIT

Replace PCB, refer to (para. 4-5).
Replace distribution box (para. 4-5.1).

Replace batteries, refer to (para. 4-79).
Replace distribution box (para. 4-5.1).
STARTER CIRCUIT

DIAGNOSTIC FLOWCHART

D1

IS BATTERY VOLTAGE 23-25.5 VOLTS?

- RECHARGE OR REPLACE BATTERIES

- NO

- YES

D2

IS BATTERY INTERNAL RESISTANCE LESS THAN 25 MILLIOHMS AND BATTERY RESISTANCE CHANGE LESS THAN 50 MILLIOHMS/SECOND?

- REPLACE BATTERIES

- NO

- YES

D3

ARE THE POSITIVE AND NEGATIVE CABLE DROPS 0.25 VOLTS EACH?

- REPLACE CABLE

- NO

- YES

TEST OPTIONS

1. STE/ICE-R TEST 67 (Page 2-740)
2. MULTIMETER

REASON FOR QUESTION
Low voltage may indicate low battery capacity.

TEST OPTIONS

STE/ICE-R TESTS 73,75 (Page 2-748, 748)

REASON FOR QUESTION
Battery resistance and resistance change is an indication of the ability of the battery to supply current.

TEST OPTIONS

1. STE/ICE-R TESTS 69,89 (Page 2-742, 745)
2. MULTIMETER

REASON FOR QUESTION
High cable resistance may limit current flow.
### 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 glowplugs turn on.

Replace batteries, refer to (para 4-79).

---

### 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 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 volts max.

---

### BATTERY INTERNAL Resistance
**STE/ICE-R TEST 73**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glowplug 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, refer to (para 4-77 or 4-8).

---

### BATTERY RESISTANCE CHANGE
**STE/ICE-R TEST 75**

1. Disconnect wire 54A at injection pump to prevent starting.
2. Disconnect glowplug controller and fan solenoid (to keep waveform clean).
3. Start Test 75, battery resistance change.
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.

---

### 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.

---

### VOLTAGE MULTIMETER

1. Set the voltmeter to a DC volta 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.
**KNOWN INFO**
- ENGINE WON'T CRANK

**POSSIBLE PROBLEMS**
- BATTERY
- STARTER
- PCB/DISTRIBUTION BOX
- ROTARY SWITCH
- NEUTRAL SAFETY SWITCH
- WIRING/CABLES
- LOCKED ENGINE

**TEST OPTIONS**
1. STE/ICE-R TEST 67
   (Page 2-740)
2. MULTIMETER

**REASON FOR QUESTION**
Low battery voltage can prevent cranking.

---

**KNOWN INFO**
- BATTERY SHOULD AT LEAST CRANK ENGINE SLOWLY.

**POSSIBLE PROBLEMS**
- STARTER
- PCB/DISTRIBUTION BOX
- ROTARY SWITCH
- NEUTRAL SAFETY SWITCH
- WIRING/CABLES
- LOCKED ENGINE

**TEST OPTIONS**
1. STE/ICE-R TEST 68
   (Page 2-741)
2. MULTIMETER

**REASON FOR QUESTION**
Must have voltage available at starter to crank.

---

**KNOWN INFO**
- VOLTAGE AVAILABLE AT STARTER

**POSSIBLE PROBLEMS**
- BATTERY
- STARTER
- PCB/DISTRIBUTION BOX
- ROTARY SWITCH
- NEUTRAL SAFETY SWITCH
- WIRING/CABLES
- LOCKED ENGINE

**TEST OPTIONS**
1. STE/ICE-R TEST 70
   (Page 2-743)
2. MULTIMETER

**REASON FOR QUESTION**
Must have voltage at switch terminal to energize solenoid.

---

**DIAGNOSTIC FLOWCHART**

**E1**
- IS BATTERY VOLTAGE AT LEAST 20 VOLTS?
  - NO: REPLACE BATTERIES
  - YES: GO TO E2

**E2**
- DO YOU HAVE BATTERY VOLTAGE AT STARTER MOTOR (WIRE 6A)?
  - NO: GO TO F, Page 2-288
  - YES: GO TO E3

**E3**
- WITH ROTARY SWITCH IN “START” POSITION, DO YOU HAVE BATTERY VOLTAGE AT SOLENOID SWITCH TERMINAL (74A)?
  - NO: GO TO G, Page 2-290
  - YES: GO TO E4, Page 2-286
REFERENCE INFORMATION

Replace batteries, refer to (para 4-79).

STARTER CIRCUIT

<table>
<thead>
<tr>
<th>BATTERY VOLTAGE</th>
<th>STE/ICE-R TEST 67</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Start Test 67, battery voltage.</td>
<td></td>
</tr>
<tr>
<td>2. Displayed reading is in volts. Batteries should be 23-25.5 volts. Batteries voltage will drop when glowplugs turn on.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BATTERY VOLTAGE</th>
<th>MULTIMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set the voltmeter to a DC volts scale at least 40 volts.</td>
<td></td>
</tr>
<tr>
<td>2. Connect the RED lead to positive and the BLACK lead to negative.</td>
<td></td>
</tr>
<tr>
<td>3. Be sure to read the correct scale.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STARTER MOTOR VOLTAGE</th>
<th>STE/ICE-R TEST 68</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Start Test 68, starter motor voltage.</td>
<td></td>
</tr>
<tr>
<td>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 18 volts.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STARTER SOLENOID VOLTAGE</th>
<th>STE/ICE-R TEST 70</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Start Test 70, starter solenoid voltage.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>
STARTER CIRCUIT

FROM E3,
Page 3-384

REPLACE STARTER.

DIAGNOSTIC FLOWCHART
Replace starter, refer to (para 4-8)
STARTER CIRCUIT

DIAGNOSTIC FLOWCHART

F1

KNOWN INFO
BATTERY VOLTAGE NOT AVAILABLE AT SOLENOID STUD.

POSSIBLE PROBLEMS
CABLES, CONNECTIONS

F2

KNOWN INFO
BATTERY CONNECTIONS OK

POSSIBLE PROBLEMS
CABLE

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-750)
2. MULTIMETER

REASON FOR QUESTION
Dirty battery connections can prevent current flow.

F3

IS THE STARTER POSITIVE CABLE (WIRE 6A) VOLTAGE DROP LESS THAN 0.25 VOLTS?

REPLACE CABLE

NO

YES

NO FAULTS FOUND. RUN BATTERY TESTS (Page 2-251).

NO

YES

REPLACE CABLE

REASON FOR QUESTION
High voltage drop indicates high resistance in the cable.
Replace cable, refer to (para 4-77).

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.

**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.

**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

G1

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)?

NO

GO TO I, Page 2-288

YES

TEST OPTIONS
1. STE/ICE-R TEST 89 [Page 2-750]
2. MULTIMETER

G2

DISCONNECT WIRE 14B AT NEUTRAL SAFETY SWITCH. IS THERE CONTINUITY ACROSS NEUTRAL SAFETY SWITCH? (WIRE 14 TO WIRE 14)

NO

REPLACE NEUTRAL SAFETY SWITCH

YES

TEST OPTIONS
1. STE/ICE-R TEST 91 [Page 2-752]
2. MULTIMETER

G3

DISCONNECT BODY CONNECTOR FROM PROTECTIVE CONTROL BOX/DISTRIBUTION BOX. IS THERE CONTINUITY FROM WIRE 14B AT NEUTRAL SAFETY SWITCH TO BODY CONNECTOR HARNESS SOCKET “A”?

NO

REPAIR 14B OR REPLACE HARNESS

YES

GO TO G4, Page 2-292

TEST OPTIONS
1. STE/ICE-R TEST 91 [Page 2-752]
2. MULTIMETER

REASON FOR QUESTION
Current flows to neutral safety switch before reaching solenoid.

REASON FOR QUESTION
If there is no continuity, then current will not flow through switch.

REASON FOR QUESTION
An open wire here could have prevented current flow between PCB/distribution box and neutral switch.
REFERENCE INFORMATION

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 1000 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

Replace rotary switch, refer to (para. 4-7).

The connections for the neutral safety switch can be reached by removing the engine cover. The connections are near the gear shift lever.

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

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

Repair wiring or replace switch, refer to (para. 4-7).

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

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.

PCB/DISTRIBUTION BOX BODY CONNECTOR

!!

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

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

Repair wiring or replace switch, refer to (para. 4-7).

PCB/DISTRIBUTION BOX BODY CONNECTOR
STARTER CIRCUIT

DISCONNECT WIRE 29A FROM ROTARY SWITCH. IS THERE CONTINUITY FROM WIRE 29A AT ROTARY SWITCH TO SOCKET “B” OF PCB/DISTRIBUTION BOX BODY CONNECTOR HARNESS?

REPAIR WIRE 29A OR 29C OR REPLACE HARNESS

RECONNECT PCB/DISTRIBUTION BOX BODY CONNECTOR HARNESS. DO YOU HAVE BATTERY VOLTAGE AT THE “R” TERMINAL OF THE ROTARY SWITCH WITH THE SWITCH IN “RUN” AND IN “START”?

REPLACE ROTARY SWITCH

GO TO G6, [Page 2-294]
REFERENCE INFORMATION

WARNING

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

There is battery voltage at the PCB/distribution box 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.

Repair wiring or replace harness, refer to (para. 4-85).

Replace rotary switch, refer to (para. 4-7).

STARTER CIRCUIT

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.

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

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 1000 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).
DISCONNECT BATTERY NEGATIVE CABLE. RECONNECT NEUTRAL SAFETY SWITCH. DISCONNECT ENGINE CONNECTOR FROM PCB/DISTRIBUTION BOX. IS THERE CONTINUITY FROM ENGINE CONNECTOR HARNESS SOCKET “I” TO THE STARTER SOLENOID WIRE 74A?

TEST OPTIONS

1. STE/ICE-R TEST 91
   [Page 2-752]
2. MULTIMETER

REASON FOR QUESTION

If there is continuity there, you know all the wiring is good and the problem is in the PCB/distribution box.

POWER AVAILABLE TO PCB/DISTRIBUTION BOX

PCB/DISTRIBUTION BOX WIRING

WIRING OK

PCB/DISTRIBUTION BOX

REPAIR 74A OR REPLACE HARNESS

REPLACE PCB/DISTRIBUTION BOX. IF YOU STILL HAVE A PROBLEM, RE-RUN THE TEST CHAIN [Page 2-261].
REFERENCE INFORMATION

WARNING

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

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

Replace PCB, refer to (para. 4-5).
Replace distribution box, refer to (para. 4-5.1).

---

STARTER CIRCUIT

0-4500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the terminals indicated in the question.
2. Start Test 91, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms indicates continuity. If the resistance is over 4500 ohms, STE/ICE-R displays “9.9.9.9.”

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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

H1

**H FROM 3, Page 2-264**

**REPLACE GLOWPLUGS AND TRY TURNING ENGINE WITH A BREAKER BAR. DOES IT TURN?**

- **KNOWNS INFO**: CAN'T TURN ENGINE MANUALLY
- **POSSIBLE PROBLEMS**:
  - INTERNAL MECHANICAL PROBLEM
  - HYDRAULIC LOCK

- **NOTIFY DS MAINTENANCE**

- **NO**

- **YES**

**H2**

**DOES THE ENGINE TURN SMOOTHLY AND WITHOUT ANY UNUSUAL NOISES?**

- **KNOWNS INFO**: HYDRAULIC LOCK REMOVED
- **POSSIBLE PROBLEMS**:
  - INTERNAL MECHANICAL PROBLEM

- **NOTIFY DS MAINTENANCE**

- **NO**

- **YES**

**H3**

**REINSTALL GLOWPLUGS AND RE-RUN STARTER SYSTEM TESTS (GO TO PAGE 2-261). IF ENGINE LOCKS AGAIN NOTIFY DS MAINTENANCE.**

- **KNOWNS INFO**: ENGINE CAN ROTATE SMOOTHLY
- **POSSIBLE PROBLEMS**
REFERENCE INFORMATION

WARNING

Disconnect wire 54A to prevent accidental starting. Failure to do so may result in serious injury or death.
STARTER CIRCUIT

I1

DISCONNECT WIRE 11A AT ROTARY SWITCH. IS THERE BATTERY VOLTAGE AT WIRE 11A?

TEST OPTIONS
1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
Power must be available to rotary switch.

I2

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
2. MULTIMETER

REASON FOR QUESTION
Continuity here indicates rotary switch is OK.

I3

REPAIR WIRE 14A OR REPLACE HARNESS.

KNOWN INFO
ROTOR SWITCH OK

POSSIBLE PROBLEMS
WIRING
REFERENCE INFORMATION

REAR OF ROTARY SWITCH

STARTER CIRCUIT

<table>
<thead>
<tr>
<th>VOLTAGE 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>

<table>
<thead>
<tr>
<th>CONTINUITY (RESISTANCE) MULTIMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set the voltmeter to an ohms scale of about 1000 ohms.</td>
</tr>
<tr>
<td>2. Connect the RED and BLACK leads to the connections stated in the question.</td>
</tr>
<tr>
<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>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0-45 DC VOLTS STE/ICE-R TEST 89</th>
</tr>
</thead>
<tbody>
<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>0-4500 OHMS STE/ICE-R TEST 91</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.</td>
</tr>
<tr>
<td>2. Start Test 91, 0-4500 ohms.</td>
</tr>
<tr>
<td>3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.”</td>
</tr>
</tbody>
</table>
2-300 Change 1

STARTER CIRCUIT

DISCONNECT BATTERY NEGATIVE CABLE. DISCONNECT BODY CONNECTOR FROM PCB/DISTRIBUTION BOX. IS THERE CONTINUITY FROM SOCKET G OF BODY CONNECTOR HARNESS TO WIRE 11A AT ROTARY SWITCH?

REPAIR WIRE 11A OR REPLACE HARNESS

RECONNECT WIRE 11A AT ROTARY SWITCH. DISCONNECT ENGINE CONNECTOR OF PCB/DISTRIBUTION BOX. RECONNECT BATTERY NEGATIVE CABLE. IS THERE BATTERY VOLTAGE AT SOCKET E OF CONNECTOR HARNESS?

REPAIR WIRE 81A OR REPLACE HARNESS

REPLACE PROTECTIVE CONTROL BOX/DISTRIBUTION BOX.
### Reference Information

#### WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB/distribution box harness. There is battery voltage at the PCB/distribution box at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel. Replace harness or repair wiring, refer to (para. 4-85).

#### WARNING

Disconnect negative battery cable before disconnecting and reconnecting PCB/distribution box harness. There is battery voltage at the PCB/distribution box at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel. Replace harness or repair wiring, refer to (para. 4-85).

### Starter Circuit

#### 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 1000 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).

#### 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.

#### 0-4500 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 4500 ohms, STE/ICE displays '9.9.9.9.'
2-31. GLOWPLUGS CIRCUIT TESTS (PROTECTIVE CONTROL BOX)

These tests of the Glowplugs Circuit can be run anytime you think there may be a problem with the glowplugs, 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 glowplug circuit depend on each other and on other engine circuits.

Refer to fold-out page FO-9 and leave it open for reference while preforming 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.
GLOWPLUGS

START

1

TO RUN THE GLOWPLUG 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.

TEST OPTIONS

BATTERY TESTS (Page 2-251)

REASON FOR QUESTION
The glowplugs and their control circuits require battery power to work.

TEST OPTIONS

VISUAL INSPECTION

REASON FOR QUESTION
Loose or dirty connections can hinder current flow or cause mixups in the control signals.

2

!!

CHECK ALL THE GLOWPLUG CIRCUIT CONNECTIONS (GLOWPLUGS, GLOWPLUG CONTROLLER, PROTECTIVE CONTROL BOX). ARE ALL THE CONNECTIONS CLEAN AND TIGHT?

KNOWN INFO

BATTERIES OK

POSSIBLE PROBLEMS

GLOWPLUGS
GLOWPLUG CONTROLLER
PCB
CABLES

TEST OPTIONS

REPAIR AS NECESSARY

NO

3

TURN THE ROTARY SWITCH TO "RUN". DO THE GLOWPLUGS DRAW 75-125 AMPS? (SEE NOTE ON RIGHT HAND PAGE).

KNOWN INFO

BATTERIES OK
CABLES/CONNECTIONS SEEM OK

POSSIBLE PROBLEMS

GLOWPLUGS
GLOWPLUG CONTROLLER
PCB
CABLES

TEST OPTIONS

1. STE/ICE-R TEST 80 (Page 2-749)
2. MULTIMETER

REASON FOR QUESTION
If the current is OK, then the glowplugs and protective control box are OK.

NO

YES

GO TO A, Page 2-306

GO TO 4, Page 2-305
REFERENCE INFORMATION

GLOWPLUGS

If the engine cranks OK (or starts), then the batteries are good enough for testing the glowplugs. 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.

NOTE

The WAIT-TO-START lamp is NOT diagnosed in this section. If the lamp does not work properly, the glowplug circuit may be affecting its operation. Run these tests to check out the glowplug circuit. If the lamp still does not work properly, go to the INSTRUMENTS section for a full diagnosis of the lamp's problem.

WARNING

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

There is battery voltage at the PCS 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 - unscrew BOTH connectors and look for bent or broken pins, pins pushed out of their socket, or dirt and corrosion in the connections.
3. GLOWPLUG 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 glowplugs controller connector has no pin in it.
4. GLOWPLUGS - Check that all the glowplug 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 GLOWPLUG OPERATION

The glowplugs 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.

NOTE

To check for glowplug current draw, start STE/ICE-R Test 80, battery current. Turn off all accessories (lights, heater, wipers etc). STE/ICE-R should immediately measure at least 74 amps. Take note, however, that if all your glowplugs are working, the current draw should be close to or more than 100 amps, especially if it's cold. If it's near freezing and the glowplugs only draw 75-80 amps, you probably have a few bad glowplugs.

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 = 1000 amps. To get current, multiply millivolts x 10.

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.
GLOWPLUGS

FROM 3, Page 2-304

4

DO THE GLOWPLUGS CYCLE PROPERLY? (SEE THE NORMAL GLOWPLUG OPERATION DESCRIPTION ON THE RIGHT HAND PAGE.)

TEST OPTIONS
1. STE/ICE-R TEST 80
   (Page 2-748)
2. MULTIMETER

REASON FOR QUESTION
If the glowplugs cycle, the glowplug controller is working. Since current draw is OK, the only thing left to check is the cycling.

YES

NO

GO TO B, Page 2-330

5

NO GLOWPLUGS FAULT FOUND.
REFERENCE INFORMATION

NORMAL GLOWPLUG OPERATION
The glowplugs 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 glowplugs should keep cycling like this, due to the glowplug cycle timer in the glowplugs controller. If you start the engine, they will cycle until the engine is warm, due to the afterglow cycle timer in the glowplug controller. When the engine gets up to 120 °F (49 °C), the glowplugs should stop cycling completely.

ENGINE NOT RUNNING
ROTARY SWITCH IN RUN POSITION.
If the glowplugs are cycling properly, you should hear a click from the protective control box (PCB) when the glowplugs turn on and when they turn off. This is the glowplug cycle timer, a thermal circuit breaker. A good way to check for cycling is STE/ICE-R test 80, battery current. When the glowplugs turn on, STE/ICE-R will measure 74-125 amps. When the glowplugs turn off, the STE/ICE-R will measure 3-8 amps.

ENGINE RUNNING.
ROTARY SWITCH IN RUN
If the glowplugs are cycling properly, you can hear a click from the protective control box (PCB) when the glowplugs 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 glowplugs turn on, STE/ICE-R will measure 74-125 amps. When the glowplugs turn off, STE/ICE-R will measure 3-8 amps. As the engine gets warmer, the glowplugs 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 glowplug operation. The glowplugs drew so much current that the volts gage should jump about half-an-inch to the left when the glowplugs come on. Before starting the engine, you should hear the glowplug power relay click open and closed as the glowplugs cycle. (You can hear the relay after the engine has started by leaning your head under the dash near the protective control box.) This method won't tell you if all the glowplugs are working properly, but it at least shows that the glowplugs are trying to work and that the glowplug power relay is working.

EXPECTED GLOWPLUG CURRENT

<table>
<thead>
<tr>
<th>ROTARY SWITCH IN RUN POSITION:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOWPLUGS ON : 74 - 125 AMPS 74 is only for weak batteries. You should get at least 100 amps when glowplugs are working properly.</td>
</tr>
<tr>
<td>GLOWPLUGS 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.</td>
</tr>
</tbody>
</table>

BATTERY CURRENT
STE/ICE-R TEST 80

1. Start Test 80, battery current.
2. Displayed reading is in amps. The reading will be greater then 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 = 1000 amps. To get current, multiply millivolts x 10.
GLOWPLUGS

DIAGNOSTIC FLOWCHART

A
FROM 3,
Page 2-301

KNOWLEDGE

GLOWPLUGS DO NOT
DRAW ENOUGH
CURRENT

POSSIBLE PROBLEMS

GLOWPLUGS
GLOWPLUG
CONTROLLER
CABLES

TEST OPTIONS

1. STE/ICE-R TEST 80
(PH.4-2034)
2. MULTIMETER

REASON FOR QUESTION
A working glowplug draws 12-15
amps. If at least one glowplug is
working, the protective control box
is OK.

NO

TOTAL
Page 2-312

GLOWPLUGS CYCLE
PROPERLY?

A2

KNOWLEDGE

GLOWPLUGS DRAW SOME
BUT NOT ENOUGH
CURRENT.
PCB OK

POSSIBLE PROBLEMS

GLOWPLUGS
GLOWPLUG
CONTROLLER
CABLES

TEST OPTIONS

1. STE/ICE-R TEST 80
(PH.4-748)
2. MULTIMETER

REASON FOR QUESTION
If the glowplugs cycle properly,
the glowplug controller is OK.

NO

TOTAL
Page 2-310

YES

!!

A3

KNOWLEDGE

GLOWPLUGS DRAW SOME
BUT NOT ENOUGH
CURRENT
PCB OK
GLOWPLUG
CONTROLLER OK

POSSIBLE PROBLEMS

GLOWPLUGS
CABLES

TEST OPTIONS

SEE THE PROCEDURE ON THE
RIGHT HAND PAGE AND USE:
1. STE/ICE-R TEST #91
(PH.4-752)
2. MULTIMETER

REASON FOR QUESTION
Since the glowplugs 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.

CHECK THE GLOWPLUGS AND
WIRES USING THE PROCEDURE
ON THE RIGHT-HAND PAGE.
REPAIR OR REPLACE PARTS AS
REQUIRED. RE-RUN THE MAIN
TEST CHAIN.
Dead glowplugs draw virtually no current, but other parts of the vehicle are drawing some current, up to 8 amps. If any glowplugs are drawing any current, then the protective control box is probably OK.

For a good description of how glowplugs cycle and how to check for proper cycling, refer to page 2-307.

**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.

If most or all of the glowplugs are bad, you may also have a problem with the protective control box or the glowplug 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 glowplugs, rerun the glowplugs test chain paying special attention to the glowplugs cycling, especially that they turn OFF when they should.

Replace glowplugs, wires, or harness, refer to (para 3-38).

---

### BATTERY CURRENT STE/ACE-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 = 1000 amps. To get current, multiply millivolts x 10.

### CHECKING GLOWPLUGS & THEIR WIRES

1. Disconnect ALL the glowplugs.

2. Disconnect the negative battery cable. Disconnect the PCB connector harness from the PCB. Reconnect the negative battery cable. Measure the resistance between pin Din the engine connector harness of the protective control box and ground. There should NOT be continuity (resistance reading off-the-scale). If there is continuity, repair or replace the harness.

3. Repeat the following for each glowplug
   a. Reconnect the wiring harness to the glowplug while you repeat the resistance measurement described in step 2. When you reconnect the wire to the glowplug, the resistance should drop to between 1 and 2 ohms (glowplugs are typically 1.6 ohms).
   b. If step a passed; disconnect the glowplug again, making sure the resistance goes off-scale again. Repeat step a for the next glowplug.
   c. If step a failed; then either the glowplug or its wire is no good. Take the wire off the glowplug again and measure the resistance from the glowplug to the engine block. If the resistance is 1-2 ohms, then the cable is no good, otherwise replace the glowplug and check the cable for continuity, just to be sure.

4. Reconnect the PCB and all wires.
GLOWPLUGS

**KNOWN INFO**
- GLOWPLUG CURRENT OK
- NOT CYCLING PROPERLY

**POSSIBLE PROBLEMS**
- PCB

**TEST OPTIONS**
1. STE/ICE-R TEST 80 (Page 2-315)
2. MULTIMETER

**REASON FOR QUESTION**
If the glowplug controller is shorted, the glowplug power relay in the protective control box will always be closed.

**B1**
TURN ROTARY SWITCH TO "STOP". DISCONNECT GLOWPLUG CONTROLLER. TURN ROTARY SWITCH TO "RUN". DO GLOW PLUGS STILL DRAW CURRENT?

**GO TO E, Page 2-315**

**B2**
MEASURE VOLTAGE AT SOCKET 6 OF GLOWPLUG CONTROLLER CONNECTOR HARNESS. IS THERE BATTERY VOLTAGE AT THIS SOCKET?

**!!)**
NO

**REPLACE PCB**

YES

**REPLACE PCB**

**B3**
SHORT IN ENGINE CONNECTOR HARNESS. REPAIR OR REPLACE HARNESS.
REFERENCE INFORMATION

NOTE

Ensure that alternator "AC" tap is functioning correctly by measuring DC volts at wire 2A. Reading should be between 9-16 Vdc. If this voltage is not present, glowplug system will never stop cycling.

Refer to the functional flow schematic. If the glowplug controller is shorted (continuity from pin 6 to pin 3), the glowplug power relay will always be energized and the glowplugs will always be drawing current.

Since the glowplugs draw current without the glowplug controller connected, there must be a short in the harness or a stuck relay in the protective control box (PCB). If there were a short in the harness directly to the glowplugs, the glowplugs would have burned out long ago and you wouldn’t be here. The only other short in the harness that would make the glowplugs turn on without the glowplug controller installed would show up as battery voltage at pin 6 of the controller’s connector.

Replace PCB, refer to (para. 4-5).

Check the end of the harness at the protective control box, glowplugs, 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 protective control box.

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.

For repair or replacement of wiring, refer to (para. 4-85).
GLOWPLUGS

**KNOWN INFO**
GLOWPLUGS DON'T DRAW ANY CURRENT

**POSSIBLE PROBLEMS**
GLOWPLUG CONTROLLER WIRING (OPEN CIRCUIT)
8 BAD GLOWPLUGS PCB

**TEST OPTIONS**
1. STE/ICE-R TEST 89 (Page 2-750)
2. MULTIMETER

**REASON FOR QUESTION**
There should not be voltage at glowplugs with switch off.

---

**C1**
TURN ROTARY SWITCH TO "STOP". IS THERE LESS THAN 0.5 VOLTS AT GLOWPLUG WIRES?

NO

SHORT IN HARNESS

YES

---

**C2**
TURN THE ROTARY SWITCH TO "RUN". IS THERE LESS THAN 0.5 VOLTS AT THE GLOWPLUG WIRES?

NO

REPLACE GLOWPLUGS

YES

---

**C3**
TURN ROTARY SWITCH TO "STOP". MAKE SURE GLOWPLUG CONTROLLER IS CONNECTED. IS THERE CONTINUITY FROM SOCKET 'A' TO SOCKET 'B' OF PCB ENGINE CONNECTOR HARNESS?

NO

GO TO D, Page 2-314

YES

REPLACE PCB

---

**TEST OPTIONS**
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

**REASON FOR QUESTION**
Continuity indicates the harness and controller are ok.
Non-continuity indicates an open in the harness or controller.
Replace harness. Notify DS Maintenance.

Replace glowplugs, refer to (para 3-38).

**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.

Replace PCB, refer to (para 4-5).

---

**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.

---

**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.

---

**0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

---

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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).
GLOWPLUGS

DIAGNOSTIC FLOWCHART

**KNOWN INFO**
OPEN CIRCUIT IN GLOW-PLUG CONTROLLER OR WIRING

**POSSIBLE PROBLEMS**
WIRING GLOWPLUG CONTROLLER

**D1**
IS THERE CONTINUITY BETWEEN PCB ENGINE CONNECTOR HARNESS SOCKET "B" AND GLOWPLUG CONTROLLER HARNESS CONNECTOR SOCKET "3"?

**TEST OPTIONS**
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

**REASON FOR QUESTION**
This checks the return wire from the glowplug controller to the protective control box.

**NO**
REPAIR/REPLACE WIRE 459B

**YES**

**KNOWN INFO**
OPEN CIRCUIT IN GLOW-PLUG CONTROLLER OR WIRING

**POSSIBLE PROBLEMS**
WIRING GLOWPLUG CONTROLLER

**D2**
IS THERE CONTINUITY BETWEEN PCB ENGINE CONNECTOR HARNESS SOCKET "A" AND GLOWPLUG CONTROLLER HARNESS CONNECTOR SOCKET "6"?

**TEST OPTIONS**
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

**REASON FOR QUESTION**
This checks the main power wire from the protective control box to the glowplug controller.

**NO**
REPLACE WIRE 543 &/OR 569B

**YES**

**D3**
REPLACE GLOWPLUG CONTROLLER. DOES THE ENGINE START EASILY WHEN COLD?

**REASON FOR TESTS**
You verified that the wiring is OK so the controller must be bad.

**NO**
GO TO C, Page 2-110

**YES**

NO FAULTS
REFERENCE INFORMATION

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.

NOTE

You will not be able to check the solid-state controller using the pin-to-pin resistance check. The solid-state controller is identified by a green finish and a larger case.

Replace glowplug controller, refer to (para 4-29).

GLOWPLUGS

Engine Connector Harness with sockets "A" & "B" highlighted.

Glowplug Controller Harness with sockets 3 & 6 highlighted.

Glowplug Controller

<table>
<thead>
<tr>
<th>0-4500 OHMS</th>
<th>STE/ICE-R TEST 91</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.</td>
<td></td>
</tr>
<tr>
<td>2. Start Test 91, 0-4500 ohms.</td>
<td></td>
</tr>
<tr>
<td>3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays '9.9.9.9.'</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTINUITY (RESISTANCE) MULTIMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set the voltmeter to an ohms scale of about 1000 ohms.</td>
</tr>
<tr>
<td>2. Connect the RED and BLACK leads to the connections stated in the question.</td>
</tr>
<tr>
<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>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PIN-TO-PIN</th>
<th>RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

130 Ω ± Ω
0.40 Ω TO 0.75 Ω
27 Ω ± 3 Ω
.45 Ω MAXIMUM
GLOWPLUGS CIRCUIT

KNOWN INFO
GLOWPLUG CURRENT OK
PCB OK
GLOWPLUGS NOT CYCLING

POSSIBLE PROBLEMS
WIRING
GLOWPLUG CONTROLLER

DIAGNOSTIC FLOWCHART

E From B1,
Page 2-310

E1
DISCONNECT BATTERY NEGATIVE CABLE. DISCONNECT PCB ENGINE CONNECTOR. IS THERE CONTINUITY FROM ENGINE CONNECTOR HARNESS SOCKET ‘C’ TO GLOWPLUG CONTROLLER HARNESS SOCKET 4?

TEST OPTIONS
1. STE/ICE-R TEST 91
   (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
Wire 570A controls glowplug cycling.

NO
REPAIR WIRE 570A OR REPLACE HARNESS

YES
REPLACE CONTROLLER

E2
RECONNECT PCB ENGINE CONNECTOR. IS THERE CONTINUITY FROM GLOWPLUG CONTROLLER HARNESS SOCKET 5 TO ENGINE GROUND?

TEST OPTIONS
1. STE/ICE-R TEST 91
   (Page 2-752)
2. MULTIMETER

REASON FOR TESTS
The controller can't work properly without a proper ground.

NO
REPAIR WIRE 93A OR REPLACE HARNESS

YES
REPLACE CONTROLLER
REFERENCE INFORMATION

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.

Repair wiring or replace harness, refer to (para 4-34).

GLOWPLUGS CIRCUIT

| 0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

| CONTINUITY (RESISTANCE) |
| Multimeter |
1. Set the voltmeter to an ohms scale of about 1000 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).
2-31.1. GLOWPLUGS CIRCUIT TESTS (DISTRIBUTION BOX)

These tests of the Glowplugs Circuit can be run anytime you think there may be a problem with the glowplugs, 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 glowplug circuit depend on each other and on other engine circuits.
START

1

TO RUN THE GLOWPLUG 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.

TEST OPTIONS
BATTERY TESTS
(PAGE 2-251)

REASON FOR QUESTION
The glowplugs and their control circuits require battery power to work.

2

CHECK ALL THE GLOWPLUG CIRCUIT CONNECTIONS (GLOWPLUGS, GLOWPLUG HARNESS CONNECTIONS). ARE ALL THE CONNECTIONS CLEAN AND TIGHT?

TEST OPTIONS
VISUAL INSPECTION

REASON FOR QUESTION
Loose or dirty connections can hinder current flow or cause mixups in the control signals.

3

MEASURE THE RESISTANCE FROM PINS A THROUGH H OF GLOWPLUG HARNESS AND GROUND. IS THE READING 2 TO 3 OHMS?

TEST OPTIONS
1. STE/ICE-R TEST 80
(PAGE 2-749)
2. MULTIMETER

REASON FOR QUESTION
If the resistance is OK, then the glowplugs and harness are OK.

4

GO TO A,
(PAGE 2-318.6)

GO TO 4,
(PAGE 2-318.4)
If the engine cranks ok (or starts), then the batteries are good enough for testing the glowplugs. 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.

**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. **DISTRIBUTION BOX** - unscrew the three connectors and look for bent or broken pins, pins pushed out of their socket, or dirt and corrosion in the connections.
3. **GLOWPLUGS** - Check that all the glowplug 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 GLOWPLUG OPERATION**

The glowplugs are heated quickly for 5 to 20 seconds. This cycle is active while the "Wait-to-Start" light is on. The length of "on" time is dependent on battery voltage, the weaker the batteries the longer the "on" time. This cycle will only repeat if the run start switch has been off for more than 2 1/2 minutes. After the initial 5 to 20 seconds preglow, the system goes to afterglow. Afterglow provides lower voltage to the glowplugs to keep them at operating temperature for approximately 60 seconds.

**NOTE**

To check for glowplug current draw, start STE/ICE-R Test 80, battery current. Turn off all accessories (lights, heater, wipers etc). STE/ICE-R should immediately measure at least 74 amps. Take note, however, that if all your glowplugs are working, the current draw should be close to or more than 100 amps, especially if it's cold. If it's near freezing and the glowplugs only draw 75-80 amps, you probably have a few bad glowplugs.
DO THE GLOWPLUGS CYCLE PROPERLY? (SEE THE NORMAL GLOWPLUG OPERATION DESCRIPTION ON THE RIGHT HAND PAGE.)

GO TO B.  

NO GLOWPLUGS FAULT FOUND.

TEST OPTIONS
1. STE/ICE-R TEST 80
   [Page 2-749]
2. MULTIMETER

REASON FOR QUESTION
If the glowplugs cycle, the glowplug controller is working. Since current draw is OK, the only thing left to check is the cycling.

FROM 3.  
[Page 2-318.2]

NO

YES

4

5

KNOWN INFO
BATTERIES OK
GLOWPLUGS OK
DISTRIBUTION BOX OK

POSSIBLE PROBLEMS
CABLES
GLOWPLUG
CONTROL CIRCUIT

GLOWPLUGS

DIAGNOSTIC FLOWCHART

2-318.4 Change 1
REFERENCE INFORMATION

NORMAL GLOWPLUG OPERATION
The glowplugs 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 glowplugs should keep cycling like this, due to the glowplug cycle timer in the glowplugs controller. If you start the engine, they will cycle until the engine is warm, due to the afterglow cycle timer in the glowplug controller. When the engine gets up to 120 °F (49 °C), the glowplugs should stop cycling completely.

EXPECTED GLOWPLUG CURRENT

<table>
<thead>
<tr>
<th>ROTARY SWITCH IN RUN POSITION;</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOWPLUGS ON : 74 - 125 AMPS 74 is only for weak batteries. You should get at least 100 amps when glowplugs are working properly.</td>
</tr>
<tr>
<td>GLOWPLUGS 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.</td>
</tr>
</tbody>
</table>

ENGINE NOT RUNNING, ROTARY SWITCH IN RUN
If the glowplugs are cycling properly, you should hear a click from the distribution box when the glowplugs turn on and when they turn off. This is the glowplug cycle timer, a thermal circuit breaker. A good way to check for cycling is STE/ICE-R test 80, battery current. When the glowplugs turn on, STE/ICE-R will measure 74-125 amps. When the glowplugs turn off, the STE/ICE-R will measure 3-8 amps.

ENGINE RUNNING, ROTARY SWITCH IN RUN
If the glowplugs are cycling properly, you can hear a click from the distribution box when the glowplugs 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 glowplugs turn on, STE/ICE-R will measure 74-125 amps. When the glowplugs turn off, STE/ICE-R will measure 3-8 amps. As the engine gets warmer, the glowplugs 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 glowplug operation. The glowplugs draw so much current that the volts gage should jump about half-an-inch to the left when the glowplugs come on. Before starting the engine, you should hear the glowplug power relay click open and closed as the glowplugs cycle. (You can hear the relay after the engine has started by leaning your head under the dash near the distribution box.) This method won't tell you if all the glowplugs are working properly, but it at least shows that the glowplugs are trying to work and that the glowplug power relay is working.

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 = 1000 amps. To get current, multiply millivolts x 10.
GLOWPLUGS

A1

TURN THE ROTARY SWITCH TO "RUN". DO THE GLOWPLUGS DRAW AT LEAST 15 AMPS?

NO

GO TO C. [Page 2-318.10]

YES

TEST OPTIONS

1. STE/ICE-R TEST 80 [Page 2-749]
2. MULTIMETER

REASON FOR QUESTION

A working glowplug draws 12-15 amps. If at least one glowplug is working, the distribution box is OK.

A2

DO THE GLOWPLUGS CYCLE PROPERLY?

NO

GO TO B. [Page 2-318.8]

YES

TEST OPTIONS

1. STE/ICE-R TEST 80 [Page 2-749]
2. MULTIMETER

REASON FOR QUESTION

If the glowplugs cycle properly, the glowplug controller is OK.

A3

CHECK THE GLOWPLUGS AND WIRES USING THE PROCEDURE ON THE RIGHT-HAND PAGE. REPAIR OR REPLACE PARTS AS REQUIRED. RERUN THE MAIN TEST CHAIN.

TEST OPTIONS

SEE THE PROCEDURE ON THE RIGHT-HAND PAGE AND USE:
1. STE/ICE-R TEST #91 [Page 2-752]
2. MULTIMETER

REASON FOR QUESTION

Since the glowplugs draw some current and cycle properly, the only reason they wouldn't draw enough current is that the glowplugs themselves are bad or the wires are no good.
REFERENCE INFORMATION

Dead glowplugs draw virtually no current, but other parts of the vehicle are drawing some current, up to 8 amps. If any glowplugs are drawing any current, then the distribution box and glowplug circuit is probably OK.

For a good description of how glowplugs cycle and how to check for proper cycling, refer to page 2-307.

WARNING

Disconnect negative battery cable before disconnecting and reconnecting distribution box harness.

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

If most or all of the glowplugs are bad, you may also have a problem with the distribution box or the glowplug 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 glowplugs, rerun the glowplugs test chain paying special attention to the glowplugs cycling, especially that they turn OFF when they should.

Replace glowplugs, wires, or harness, refer to (para. 3-38).

GLOWPLUGS

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 = 1000 amps. To get current, multiply millivolts x 10.

CHECKING GLOWPLUGS & THEIR WIRES

1. Disconnect ALL the glowplugs.

2. Disconnect the negative battery cable. Disconnect the distribution box connector harness from the distribution box. Reconnect the negative battery cable. Measure the resistance between pin D in the engine connector harness of the distribution box and ground. There should NOT be continuity (resistance reading off-the-scale). If there is continuity, repair or replace the harness.

a. If step a passed; disconnect the glowplug again, making sure the resistance goes off-scale again. Repeat step a for the next glowplug.

b. If step a failed; then either the glowplug or its wire is no good. Take the wire off the glowplug again and measure the resistance from the glowplug to the engine block. If the resistance is 1 - 2 ohms, then the cable is no good, otherwise replace the glowplug and check the cable for continuity, just to be sure.

c. If step a failed; then either the glowplug or its wire is no good. Take the wire off the glowplug again and measure the resistance from the glowplug to the engine block. If the resistance is 1 - 2 ohms, then the cable is no good, otherwise replace the glowplug and check the cable for continuity, just to be sure.

4. Reconnect the distribution box and all wires.
**KNOWN INFO**

- **GLOWPLUG CURRENT OK NOT CYCLING PROPERLY**
- **POSSIBLE PROBLEMS**

**POSSIBLE PROBLEMS**

- DISTRIBUTION BOX

---

**TEST OPTIONS**

- 1. STE/ICE-R TEST 80
  
- 2. MULTIMETER

---

**REASON FOR QUESTION**

If the distribution box is shorted, the glowplug power relay in the distribution box will always be closed.

---

**GLOWPLUGS**

**DIAGNOSTIC FLOWCHART**

**B1**

TURN ROTARY SWITCH TO “STOP”. DISCONNECT DISTRIBUTION BOX. TURN ROTARY SWITCH TO “RUN”. DO GLOW PLUGS STILL DRAW CURRENT?

- **NO**
  
- **YES**

  **REPLACE DISTRIBUTION BOX**

**B2**

MEASURE VOLTAGE AT SOCKET 6 OF GLOWPLUG CONTROLLER CONNECTOR HARNESS. IS THERE BATTERY VOLTAGE AT THIS SOCKET?

- **NO**

  **REPLACE DISTRIBUTION BOX**

- **YES**

**B3**

SHORT IN ENGINE CONNECTOR HARNESS. REPAIR OR REPLACE HARNESS.
NOTE
Ensure that alternator "AC" tap is functioning correctly by measuring DC volts at wire 2A. Reading should be between 9-16 Vdc. If this voltage is not present, glowplug system will never stop cycling.

Refer to the functional flow schematic. If the distribution box is shorted (continuity from pin 6 to pin 3), the glowplug power relay will always be energized and the glowplugs 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 glowplugs draw current without the distribution box connected, there must be a short in the harness or a stuck relay in the distribution box. If there were a short in the harness directly to the glowplugs, the glowplugs would have burned out long ago and you wouldn't be here. The only other short in the harness that would make the glowplugs turn on without the distribution box installed would show up as battery voltage at pin 6 of the controller's connector.

Replace distribution box, refer to (para. 4-5.1).

Check the end of the harness at the distribution box, glowplugs, 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 distribution box harness.

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

For repair or replacement of wiring, refer to (para. 4-85).
GLOWPLUGS

KNOWN INFO
GLOWPLUGS DON'T DRAW ANY CURRENT

POSSIBLE PROBLEMS
GLOWPLUG CONTROLLER WIRING (OPEN CIRCUIT) BAD GLOWPLUGS DISTRIBUTION BOX

TEST OPTIONS
1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
There should not be voltage at glowplugs with switch off.

C1

C2

C3

TEST OPTIONS
1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
To see if power is getting to glowplugs.

Known Info
NO SHORTS GLOWPLUGS DRAW ZERO AMPS

POSSIBLE PROBLEMS
GLOWPLUG CONTROLLER BAD GLOWPLUGS DISTRIBUTION BOX

TEST OPTIONS
1. STE/ICE-R TEST 89
2. MULTIMETER

REASON FOR QUESTION
Continuity indicates the harness and controller are ok. Non-continuity indicates an open in the harness or distribution box.

Known Info
NO SHORTS GLOWPLUGS DRAW NO CURRENT NO VOLTAGE AT GLOWPLUGS

POSSIBLE PROBLEMS
OPEN IN DISTRIBUTION BOX OPEN IN WIRING
REFERENCE INFORMATION

Replace harness. Notify DS Maintenance.

Replace glowplugs, refer to (para. 3-38).

WARNING

Disconnect negative battery cable before disconnecting and reconnecting distribution box harness.

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

Replace distribution box, refer to (para. 4-5.1).

<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>0-4500 OHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/ICE-R TEST 91</td>
</tr>
<tr>
<td>1. Connect RED clip and BLACK clip to the indicated test points in the question. RED to the first, BLACK to the second.</td>
</tr>
<tr>
<td>2. Start Test 91, 0-4500 ohms.</td>
</tr>
<tr>
<td>3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTINUITY (RESISTANCE) MULTIMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set the voltmeter to an ohms scale of about 1000 ohms.</td>
</tr>
<tr>
<td>2. Connect the RED and BLACK leads to the connections stated in the question.</td>
</tr>
<tr>
<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>
</tr>
</tbody>
</table>
GLOWPLUGS

KNOWN INFO
OPEN CIRCUIT IN GLOW-PLUG CONTROLLER OR WIRING

POSSIBLE PROBLEMS
WIRING GLOWPLUG CONTROLLER

D1

IS THERE CONTINUITY BETWEEN DISTRIBUTION BOX ENGINE CONNECTOR HARNESS SOCKET “B” AND GLOWPLUG CONTROLLER HARNESS CONNECTOR SOCKET “3”? NO

REPAIR/REPLACE WIRE 459B

YES

TEST OPTIONS
1. STE/ICE-R TEST 91 [Page 2-752]
2. MULTIMETER

REASON FOR QUESTION
This checks the return wire from the glowplug controller to the distribution box.

NO FAULTS

D2

IS THERE CONTINUITY BETWEEN DISTRIBUTION BOX ENGINE CONNECTOR HARNESS SOCKET “A” AND GLOWPLUG CONTROLLER HARNESS CONNECTOR SOCKET “6”? NO

REPLACE WIRE 583A AND/OR 569C

YES

TEST OPTIONS
1. STE/ICE-R TEST 91 [Page 2-752]
2. MULTIMETER

REASON FOR QUESTION
This checks the main power wire from the distribution box to the glowplug controller.

D3

REPLACE GLOWPLUG CONTROLLER. DOES THE ENGINE START EASILY WHEN COLD?

NO

GO TO C. [Page 2-110]

YES

REASON FOR TESTS
You verified that the wiring is OK so the controller must be bad.
REFERENCE INFORMATION

WARNING
Disconnect negative battery cable before disconnecting and reconnecting distribution box harness.
There is battery voltage at the distribution box at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

GLOWPLUGS

Glowplug Controller Harness with sockets 3 & 6 highlighted

<table>
<thead>
<tr>
<th>Engine Connector Harness with sockets “A” &amp; “B” highlighted</th>
</tr>
</thead>
</table>

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays ‘9.9.9.9.’

Disconnect negative battery cable before disconnecting and reconnecting distribution box harness.
There is battery voltage at the distribution box at all times. Failure to disconnect battery cable will result in damage to equipment or injury to personnel.

WARNING
GLOWPLUGS CIRCUIT

DIAGNOSTIC FLOWCHART

**KNOWN INFO**
- GLOWPLUG CURRENT OK
- DISTRIBUTION BOX OK
- GLOWPLUGS NOT CYCLING

**POSSIBLE PROBLEMS**
- WIRING
- GLOWPLUG CONTROLLER

---

**KNOWN INFO**
- GLOWPLUG CURRENT OK
- DISTRIBUTION BOX OK
- GLOWPLUGS NOT CYCLING

**POSSIBLE PROBLEMS**
- WIRING
- GLOWPLUG CONTROLLER

---

**TEST OPTIONS**
1. STE/ICE-R TEST 91
   [Page 2-752]
2. MULTIMETER

**REASON FOR QUESTION**
Wire 570A controls glowplug cycling.

---

**E1**
**E From B1, [Page 2-318.8]**

**DISCONNECT BATTERY NEGATIVE CABLE. DISCONNECT DISTRIBUTION BOX ENGINE CONNECTOR. IS THERE CONTINUITY FROM ENGINE CONNECTOR HARNESS SOCKET 'C' TO GLOWPLUG CONTROLLER HARNESS SOCKET 4?**

**TEST OPTIONS**
1. STE/ICE-R TEST 91
   [Page 2-752]
2. MULTIMETER

**REASON FOR QUESTION**
Wire 570A controls glowplug cycling.

---

**NO**

**REPAIR WIRE 570A OR REPLACE HARNESS**

**YES**

---

**E2**

**RECONNECT DISTRIBUTION BOX ENGINE CONNECTOR. IS THERE CONTINUITY FROM GLOWPLUG CONTROLLER HARNESS SOCKET 5 TO ENGINE GROUND?**

**TEST OPTIONS**
1. STE/ICE-R TEST 91
   [Page 2-752]
2. MULTIMETER

**REASON FOR TESTS**
The controller can't work properly without a proper ground.

---

**NO**

**REPAIR WIRE 93A OR REPLACE HARNESS**

**YES**

**REPLACE CONTROLLER**
REFERENCE INFORMATION

WARNING
Disconnect negative battery cable before disconnecting and reconnecting distribution box harness.

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

Repair wiring or replace harness, refer to (para. 4-84).

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

GLOWPLUGS CIRCUIT

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”

Repair wiring or replace harness, refer to (para. 4-85).

Replace glowplug controller, refer to (para. 4-29).
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 FO-10 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

1. WITH THE ROTARY SWITCH IN THE ENGINE "STOP" POSITION, ARE ALL THE GAUGES IN THE "OFF" POSITION AND WARNING LAMPS OFF?

   NO -> GO TO A, Page 2-330

   YES -> START

2. TURN THE ROTARY SWITCH "OFF". DISCONNECT THE GLOWPLUG CONTROLLER. WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DO ANY OF THE GAUGES AND WARNING LAMPS FUNCTION?

   NO -> GO TO B, Page 2-330

   YES -> TEST OPTIONS VISUAL

   REASON FOR QUESTION
   If any of the devices work then the master power circuit works.

3. TURN THE ROTARY SWITCH OFF. RECONNECT THE GLOWPLUG 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)].

   NO -> GO TO C, Page 2-332

   YES -> TEST OPTIONS VISUAL

   REASON FOR QUESTION
   If the wait-to-start light comes on at any time then the circuit is being powered.

4. GO TO 4, Page 2-322
None of the following instruments and accessories should work when the rotary switch is in the STOP position:

- Volts gauge
- 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, then power is available and the circuit breaker is OK.

NOTE

The wait-to-start lamp is not an accurate indication of glowplug operation. Make sure the glowplugs are operating properly BEFORE you check out the light. Go to the Glowplug Tests [page 2-304]. Return here if the light still doesn't operate properly.

The wait-t-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.
INSTRUMENTS CIRCUIT

DOES THE BRAKE WARNING LAMP OPERATE PROPERLY?

NO

SEE NOTE AT RIGHT

YES

5

DOES THE VOLT GAUGE WORK?

NO

GO TO E, Page 2-346

YES

6

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 GLOWPLUG CONTROLLER.

NO

GO TO F, Page 2-346

YES

TEST OPTIONS

VISUAL

REASON FOR QUESTION

If the brake warning lamp comes on at any time then the circuit is being powered.

If the voltmeter works then the power to the instruments is okay.

If the windshield wiper works then the power to the wiper is okay.
The brake warning lamp should come on when the engine is cranking, when the parking brake is set, or when there is a failure in the brake system. If brake warning lamp stays on, go to page 2-342. If the warning lamp does not come on, go to D, page 2-338.

The volt gauge 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 26 volts.

The volt gauge 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 awhile and watch the gauge.

If the charging system is ok, but the gauge is reading full scale one way or the other, then you may have this type of problem.

Rotary switch has to be in the RUN position for the windshield wiper or washer to operate.
WITH THE IGNITION SWITCH IN THE RUN POSITION, DOES THE FUEL GAUGE WORK PROPERLY.

DOES THE ENGINE OIL PRESSURE GAUGE WORK WITH THE ENGINE RUNNING?

DOES THE ENGINE TEMPERATURE GAUGE WORK WITH THE ENGINE WARM?
NOTE

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 at idle, 40-45 PSI at 2000 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 190°-250°F (88°-110°C).
INSTRUMENTS CIRCUIT

KNOWN INFO
- ELECTRICAL GAUGES OK

POSSIBLE PROBLEMS
- AIR RESTRICTION GAUGE VACUUM LINE

FROM 9, Page 2-324

10

DOES THE AIR FILTER RESTRICTION GAUGE WORK?

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
The restriction gauge indicates air filter condition.

NO

GO TO O, Page 2-374

YES

WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DOES THE HEATER FAN WORK?

TEST OPTIONS
- VISUAL

REASON FOR QUESTION
The heater fan should work with the rotary switch in the RUN position.

NO

GO TO P, Page 2-376

YES

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**

**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 (Page 2-750)
2. Multimeter

**REASON FOR QUESTION**
Voltage here indicates a short circuit to power.

**DIAGNOSTIC FLOWCHART**

- **A1**
  - **DISCONNECT WIRE 29B FROM CIRCUIT BREAKER 2. WITH THE ROTARY SWITCH IN THE "OFF" POSITION DO YOU HAVE 0 VOLTAGE AT W29B?**
    - **NO**
      - **A2**
        - **DISCONNECT WIRE 29D FROM CIRCUIT BREAKER "2". WITH THE ROTARY SWITCH IN THE "OFF" POSITION, DO YOU HAVE 0 VOLTAGE AT W29D?**
          - **NC**
            - **REPAIR SHORT 29D or 27F, Q, H, L, K, or 567A or REPLACE HARNESS**
          - **YES**
            - **A3**
              - **CHECK CONTINUITY FROM ALL GAUGE GROUND TERMINALS TO ENGINE GROUND (WIRES 58E-H). DO YOU HAVE CONTINUITY?**
                - **NO**
                  - **REPAIR 58E-H or REPLACE HARNESS**
                - **YES**
                  - **SEE NOTE AT RIGHT**

- **YES**
  - **GO TO J. Page 2-354**
REFERENCE INFORMATION

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.

INSTRUMENTS CIRCUIT

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.

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.

0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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 harness/or repair wiring, refer to (para 4-85). Connect the Black test lead to a good engine ground and connect the Red test lead to each gauge ground terminal (the uninsulated screw) one at a time and note each reading.

NOTE
You have checked all the wiring that is common to all the gauges and warning lamps. Reconnect wires and return to step 2 of the go-chain, page 2-320, and continue testing.
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, refer to (para 4-85).

Replace circuit breaker, refer to (para 4-9).

Replace harness/or repair wiring, refer to (para 4-85).

NOTE
You have checked all the common power wiring to all the gauges and warning lamps. Reconnect wires and return to step 3 of the go-chain, page 2-320, and continue testing.

INSTRUMENTS CIRCUIT

0-45 DC VOLTS
STEACE-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**
- POWER AVAILABLE TO GAUGES
- WAIT-TO-START LAMP DOESN’T COME ON

**POSSIBLE PROBLEMS**
- WAIT-TO-START LAMP
- PCB/DISTRIBUTION BOX
- GLOWPLUG
- CONTROLLER
- WIRING
  - NOTE: NO GLOWPLUG CONTROLLER WITH DISTRIBUTION BOX

**TEST OPTIONS**
1. STE/ICE-R TEST 89
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.

---

**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?**

**YES**
- REPAIR 27F OR REPLACE HARNESS

**NO**
- REPAIR PCB/DISTRIBUTION BOX
- PCB/DISTRIBUTION BOX 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?

**YES**
- REPAIR 571A OR REPLACE HARNESS

**NO**
- REPAIR 571A OR REPLACE HARNESS

---

**DISCONNECT PCB/DISTRIBUTION BOX 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?**

**YES**
- REPAIR 571A OR REPLACE HARNESS

**NO**
- REPAIR 571A OR REPLACE HARNESS

---

**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?**

**YES**
- REPLACE WAIT-TO-START LAMP

**NO**
- PCB, GO TO C4, PAGE 2-334
- DISTRIBUTION BOX, GO TO C7, PAGE 2-336
REFERENCE INFORMATION

WARNING

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

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

1. Set the voltmeter to an ohms scale of about 1000 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

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 ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”

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 thru STE/ICE-R. You may have to shade the lamp with your hand to see if it glows.

NOTE

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 lamp, refer to (para. 4-17).
NO

1. STE/ICE-R TEST 91 [Page 2-752]
2. MULTIMETER

**REASON FOR QUESTION**
This wire returns power for the lamp.

**TEST OPTIONS**

3. **GO TO C7, Page 2-336**
REFERENCE INFORMATION

**WARNING**

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

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

---

### INSTRUMENTS CIRCUIT

- **GLOWPLUG CONTROLLER**
- **ENGINE connector**
- **PROTECTIVE CONTROL BOX/DISTRIBUTION BOX**
- **WAIT-TO-START LAMP**

### 0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”

### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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 temperature must be below 120°F (49°C) in order to make this test, otherwise normal operation of the glowplug controller will cause the circuit to be open.

Replace harness and glowplug controller, refer to (para. 4-29).
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?

TEST OPTIONS
CONNECT THE WIRES

REASON FOR QUESTION
You may have fixed a loose or dirty connection without knowing it.
REFERENCE INFORMATION

WARNING

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

There is battery voltage at the PCB/distribution box 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, refer to (para. 4-5).
Replace distribution box (para. 4-5.1).
**INSTRUMENTS CIRCUIT**

**TEST OPTIONS**
1. **STE/ICE-R TEST 89**
   (Page 2-750)
2. **MULTIMETER**

**REASON FOR QUESTION**
This wire provides power for the lamp.

---

**DIAGNOSTIC FLOWCHART**

**D1**
**DISCONNECT WIRE 27L AT THE BRAKE WARNING LAMP.**
WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27L?

**TEST OPTIONS**
1. **STE/ICE-R TEST 89**
   (Page 2-750)
2. **MULTIMETER**

**REASON FOR QUESTION**
This wire provides power for the lamp.

---

**D2**
**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.**

**TEST OPTIONS**
1. **STE/ICE-R TEST 91**
   (Page 2-752)
2. **MULTIMETER**
   (RESISTANCE)

**REASON FOR QUESTION**
You need to know that the lamp will light.

---

**D3**
**DISCONNECT WIRE 67C AT PARKING BRAKE SWITCH.**
DO YOU HAVE CONTINUITY BETWEEN WIRE 67C AT THE SWITCH & WIRE 67D AT THE LAMP?

**TEST OPTIONS**
1. **STE/ICE-R TEST 91**
   (Page 2-752)
2. **MULTIMETER**

**REASON FOR QUESTION**
If either of these wires are open, the lamp circuit will not be grounded.

---

**GO TO D4,**

**Page 2-340**

---

**KNOWN INFO**
- BRAKE LAMP DOESN'T COME ON
- POWER AVAILABLE TO THE GAUGES

**POSSIBLE PROBLEMS**
- PARKING BRAKE SWITCH
- BRAKE LAMP WIRING

---

**KNOWN INFO**
- POWER AVAILABLE TO THE LAMP

**POSSIBLE PROBLEMS**
- PARKING BRAKE SWITCH
- BRAKE LAMP WIRING

---

**KNOWN INFO**
- BRAKE LAMP OK

**POSSIBLE PROBLEMS**
- PARKING BRAKE SWITCH WIRING

---

**REPAIR 27L OR REPLACE HARNESS**

---

**REPLACE BRAKE WARNING LAMP**

---

**REPAIR 67C,D, OR REPLACE HARNESS**
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 thru STE/ICE-R. You may have to shade the lamp with your hand to see if it glows.

NOTE

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, refer to (para. 4-85).

Replace brake warning lamp, refer to (para. 4-17).
INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

KNOWN INFO

D4

FROM D3, Page 2-338

DISCONNECT WIRE 67E AT THE PARK BRAKE SWITCH. WITH THE PARK BRAKE APPLIED, DO YOU HAVE CONTINUITY ACROSS THE SWITCH LEADS?

YES

NO

REPLACE PARK BRAKE SWITCH.

TEST OPTIONS

1. STE/ICE-R TEST 91
   (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
This wire provides power for the lamp.

KNOWN INFO

D5

PARKING BRAKE SWITCH OK

DO YOU HAVE CONTINUITY FROM WIRE 67E TO BODY (OR ENGINE) GROUND?

YES

NO

REPAIR 67E, 79A OR replace harness

TEST OPTIONS

1. STE/ICE-R TEST 91
   (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
You need to know that the lamp will light.

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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays ‘9.9.9.9.’

1. Set the voltmeter to an ohms scale of about 1000 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).

Reconnect all wiring. Connect the glowplug controller last.

Replace parking brake switch. Refer to (para. 4-19).

Replace harness/or repair wiring. Refer to (para. 4-85).
1. **KNOWN INFO**
   - BRAKE WARNING LIGHT WON'T GO OFF

2. **POSSIBLE PROBLEMS**
   - WIRING
   - PARKING BRAKE SWITCH
   - PCB/DISTRIBUTION BOX
   - BRAKE WARNING PRESSURE SWITCH

3. **TEST OPTIONS**
   - NONE

4. **REASON FOR QUESTION**
   - If the lamp stays on, it could be that the hydraulic brake system has a fault and might require bleeding.

---

1. **KNOWN INFO**
   - BRAKE WARNING LIGHT WON'T GO OFF

2. **POSSIBLE PROBLEMS**
   - WIRING
   - PARKING BRAKE SWITCH
   - PCB/DISTRIBUTION BOX
   - BRAKE WARNING PRESSURE SWITCH

3. **TEST OPTIONS**
   - 1. STE/ICE-R TEST 89 (Page 2-752)
   - 2. MULTIMETER

4. **REASON FOR QUESTION**
   - If the lamp stays on with the PCB/distribution box, valve switch and park brake switch disconnected, the problem is in the wiring.

---

1. **KNOWN INFO**
   - WIRING OK

2. **POSSIBLE PROBLEMS**
   - BRAKE WARNING PRESSURE SWITCH
   - PCB/DISTRIBUTION BOX
   - PARKING BRAKE SWITCH

3. **TEST OPTIONS**
   - 1. STE/ICE-R TEST 91 (Page 2-752)
   - 2. MULTIMETER (RESISTANCE)

4. **REASON FOR QUESTION**
   - When the protective control box/distribution box is connected, the light should not come on. If it does, the PCB/distribution box is faulty.

---

1. **BLEED BRAKE SYSTEM. DOES THE LIGHT STAY “ON”?”

2. **DISCONNECT WIRE 67A AND 67B FROM BRAKE WARNING PRESSURE SWITCH, WIRE 67C FROM PARKING BRAKE SWITCH. DISCONNECT THE PCB/DISTRIBUTION BOX BODY HARNESS CONNECTOR. CONNECT A JUMPER WIRE BETWEEN WIRES 67A AND 67B. DOES THE LIGHT GO "OUT"?

3. **CONNECT PCB/DISTRIBUTION BOX BODY HARNESS. DOES THE LIGHT STAY "OFF"?”

4. **GO TO 4, Page 2-344**
REFERENCE INFORMATION

PROTECTIVE CONTROL BOX/DISTRIBUTION BOX

BRAKE WARNING LAMP

BODY CONNECTOR

PRESSURE SWITCH

PARK BRAKE SWITCH

67A

67B

67C

67D

67

27

27L

27P

27F

27K

27D

79A

67E

REFERENCE INFORMATION

INSTRUMENTS CIRCUIT

0-45 OHMS
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 the negative.
3. Be sure to read the correct scale.

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays '9.9.9.9.'

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

Bleed brake system. Refer to (para. 7-10).
Replace parking brake switch. Refer to (para. 4-19).
Replace harness/or repair wiring.
Refer to (para. 4-85).
Replace PCB. Refer to (para. 4-5).
Replace distribution box (para. 4-5.1).

TM 9-2320-280-20-1

Change 1

2-343
CONNECT PARKING BRAKE SWITCH. MAKE SURE THE PARKING BRAKE IS DISENGAGED. DOES THE LIGHT STAY OFF?

- **NO**
  - REPLACE PARKING BRAKE SWITCH
- **YES**
  - REPLACE PROPORTIONING VALVE

**REPLACE PROPORTIONING VALVE**

**END OF TEST**

**REASON FOR QUESTION**

1. STE/ICE-R TEST 91 (PAGE 2-752)
2. MULTIMETER

**REASON FOR QUESTION**

- **NO**
  - PCB/DISTRIBUTION BOX OK
- **YES**
  - BRAKE WARNING PRESSURE SWITCH

**WIRING OK**

**PCB/DISTRIBUTION BOX OK**

**REPLACE PARKING BRAKE SWITCH**

**REPLACE BRAKE WARNING VALVE**

**PCB/DISTRIBUTION BOX OK**

**WIRING OK**

**REPLACE PARKING BRAKE SWITCH**

**END OF TEST**

**REASON FOR QUESTION**

- **NO**
  - PCB/DISTRIBUTION BOX OK
  - BRAKE WARNING PRESSURE SWITCH
- **YES**
  - PCB/DISTRIBUTION BOX OK
  - BRAKE WARNING PRESSURE SWITCH

**VISUAL**

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (PAGE 2-752)
2. MULTIMETER

**REASON FOR QUESTION**

- **NO**
  - PCB/DISTRIBUTION BOX OK
  - BRAKE WARNING PRESSURE SWITCH
- **YES**
  - PCB/DISTRIBUTION BOX OK
  - BRAKE WARNING PRESSURE SWITCH
**REFERENCE INFORMATION**

Replace parking brake switch, refer to (para. 4-19).

---

**INSTRUMENTS CIRCUIT**

| 0-4500 OHMS
<table>
<thead>
<tr>
<th>STE/ICE-R TEST 91</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Connect RED clip and BLACK clip to the terminations indicated in the question. RED to the first, BLACK to the second.</td>
</tr>
<tr>
<td>2. Start Test 91, 0-4500 ohms.</td>
</tr>
<tr>
<td>3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”</td>
</tr>
</tbody>
</table>

---

**CONTINUITY (RESISTANCE)
MULTIMETER**

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set the voltmeter to an ohms scale of about 1000 ohms.</td>
</tr>
<tr>
<td>2. Connect the RED and BLACK leads to the connections stated in the question.</td>
</tr>
<tr>
<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>
</tr>
</tbody>
</table>
DISCONNECT WIRE 567A AT THE VOLT GAUGE. WITH THE ROTARY SWITCH IN THE “RUN” POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 567A?

IF NOT:
- REPAIR 567A OR REPLACE HARTNESS
- IS THERE CONTINUITY BETWEEN WIRE 58F AND ENGINE (OR BODY) GROUND?
- REPAIR 58F,D,B,A OR REPLACE HARTNESS
- REPLACE VOLT GAUGE. RERUN INSTRUMENT TESTS TO VERIFY NO OTHER FAULTS.
**REFERENCE INFORMATION**

Replace harness/or repair wiring, refer to (para 4-85).

Replace harness/or repair wiring, refer to (para 4-85).

Be sure the charging system is functioning properly before replacing the gauge. Run the alternator tests, page 2-195, if you’re not sure. Replace voltmeter, refer to (para 4-13).

**INSTRUMENTS CIRCUIT**

### 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.

### 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.

### 0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

### CONTINUITY (RESISTANCE)

**MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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

KNOWN INFO
POWER AVAILABLE TO GAUGES
WINDSHIELD WIPERS DON'T WORK

POSSIBLE PROBLEMS
WIPER MOTOR WIRING

DIAGNOSTIC FLOWCHART

F1
DISCONNECT WIRE 27 AT WIPER MOTOR CONNECTOR. WITH ROTARY SWITCH IN THE "RUN" POSITION, DO YOU HAVE BATTERY VOLTAGE AT THE MOTOR CONNECTOR?

YES
GO TO M, Page 2-370

NO

F2
DO YOU HAVE CONTINUITY FROM WIRE 57 AT THE CONNECTOR-TO-BODY (OR ENGINE) GROUND?

YES
REPLACE WIPER MOTOR SF5576716 OR GO TO Page 2-350 FOR WIPER MOTOR P/N 12342501

NO
GO TO N, Page 2-372

TEST OPTIONS
1. STE/ICE-R TEST 89 (page 2-754)
2. MULTIMETER

REASON FOR QUESTION
This wire provides power to the wipers.

TEST OPTIONS
1. STE/ICE-R TEST 91 (page 2-752)
2. MULTIMETER

REASON FOR QUESTION
This wire provides ground for the wipers.
### REFERENCE INFORMATION

Replace wiper motor SF5578716. Refer to (para. 10-71.)

### INSTRUMENTS CIRCUIT

#### 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.

#### 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.

#### 0-4500 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 4500 ohms, STE/ICE-R displays "9.9.9.9."

#### CONTINUITY (RESISTANCE)
**MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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

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 the switch is defective.

NO
REPLACE WIPER SWITCH

TEST OPTIONS
MULTIMETER

REASON FOR QUESTION
This will determine if the switch is defective.

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.

NO
REPLACE WIPER SWITCH

YES

NO
REPLACE WIPER SWITCH

YES

F5
WITH SWITCH DEPRESSED FOR THE "PUSH-TO-WASH" OPERATION, CONTINUITY SHOULD EXIST BETWEEN THE INPUT CONNECTOR (BATTERY) AND WASH TERMINAL.

NO
REPLACE WIPER SWITCH

YES

REPLACE WIPER MOTOR
REFERENCE INFORMATION

INSTRUMENTS CIRCuits

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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 wiper switch, refer to (para. 10-72.)

WASH

INPUT CONNECTOR

BATTERY

PIN 2 (LOW SPEED)
PIN 1 (HIGH SPEED)

PIN 3 (PARK)
PIN 4 (BATTERY)

MOTOR CONNECTOR
INSTRUMENTS CIRCUIT

G1

DISCONNECT WIRE 27J FROM FUEL GAUGE. WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27J?

YES

REPAIR 27J OR REPLACE HARNESS

NO

G2

IS THERE CONTINUITY BETWEEN WIRE 58H AT THE FUEL GAUGE AND GROUND?

YES

REPAIR 58H OR REPLACE HARNESS

NO

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?

YES

GO TO L, Page 2-366

NO

GO TO G4, Page 2-354

TEST OPTIONS
1. STE/ICE-R TESTS 89 (Page 2-350)
2. MULTIMETER

REASON FOR QUESTION
This wire provides power for the gauge.

TEST OPTIONS
1. STE/ICE-R TESTS 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
If there is continuity then the ground is OK.

TEST OPTIONS
1. STE/ICE-R TESTS 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
If the resistance is OK then the sense line is OK.
REFERENCE INFORMATION

Replace harness/or repair wiring, refer to (para 4-85).

INSTRUMENTS CIRCUIT

0-45 DC 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.

0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
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?

TEST OPTIONS
TRY IT

REASON FOR QUESTION
Gauge should read at or below empty.

NO
REPLACE FUEL GAUGE

YES

G5

WITH THE ROTARY SWITCH IN THE "ON" POSITION AND WIRE 28A OPEN, DOES THE FUEL GAUGE READ OFF SCALE TO ABOVE FULL?

TEST OPTIONS
TRY IT

REASON FOR QUESTION
Gauge should read off-scale.

NO
REPLACE FUEL GAUGE

YES

NO FAULTS
Replace fuel gauge, refer to (para 4-13).

Replace fuel gauge, refer to (para 4-13).
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 2-750)
2. MULTIMETER

REASON FOR QUESTION
This is the power wire for the gauge.

KNOWN INFO
POWER AVAILABLE TO THE GAUGES OIL PRESSURE GAUGE DOESN'T WORK.

POSSIBLE PROBLEMS
GAUGE SENDING UNIT WIRING

YES

REPAIR 27H OR REPLACE HARNESS

NO

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 2-752)
2. MULTIMETER

REASON FOR QUESTION
This is the ground wire for the gauge.

KNOWN INFO
OIL PRESSURE GAUGE HAS POWER.

POSSIBLE PROBLEMS
GAUGE SENDING UNIT WIRING

YES

REPAIR 58G OR REPLACE HARNESS

NO

H3

DISCONNECT WIRE 36A AT THE GAUGE AND AT THE OIL PRESSURE SENDING UNIT. DO YOU HAVE CONTINUITY THRU WIRE 36A? RECONNECT WIRE 36A AFTER MAKING THE MEASUREMENT.

TEST OPTIONS
1. STE/ICE-R TEST 91 (PAGE 2-752)
2. MULTIMETER

REASON FOR QUESTION
If this wire is open then the gauge will always read offscale to the left.

KNOWN INFO
GAUGE GROUND OK

POSSIBLE PROBLEMS
OIL PRESSURE GAUGE SENDING UNIT WIRING

YES

REPAIR 36A OR REPLACE HARNESS

NO

GO TO H4, [Page 2-354]
### INSTRUMENTS CIRCUIT

#### 0-45 DC VOLTS
STE/CE-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.

#### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

---

### REFERENCE INFORMATION

Replace harness/or repair wiring, refer to (para 4-85).

#### 0-4500 OHMS
STE/CE-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 4500 ohms, STE/ICE displays "9.9.9.9."

Replace harness/or repair wiring, refer to (para 4-85).

---

| OIL PRESSURE SENDING UNIT |
INSTRUMENTS CIRCUIT

FROM H3, Page 2-356

DIAGNOSTIC FLOWCHART

H4

TEST OPTIONS
TRY IT

REASON FOR QUESTION
This will determine if the gauge can respond to an input signal.

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?

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 SENDING UNIT

NO

REPLACE OIL PRESSURE GAUGE

KNOWN INFO

WIRING OK

POSSIBLE PROBLEMS

GAUGE SENDING UNIT

KNOWN INFO

WIRING OK

POSSIBLE PROBLEMS

GAUGE 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, refer to (para 4-13).

Wire 36A must be connected at the gauge. Short the wire at the sending unit to ground. Replace oil pressure gauge, refer to (para 4-13).

Replace oil pressure sending unit, refer to (para 4-25).
INSTRUMENTS CIRCUIT

I1

DISCONNECT WIRE 27G AT THE TEMPERATURE GAUGE. WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27G?

TEST OPTIONS
1. STE/ICE-R TEST 89 (PAGE 2-750)
2. MULTIMETER

REASON FOR QUESTION
This is the power wire for the gauge.

KNOWLEDGE

POWER AVAILABLE TO THE GAUGES. TEMPERATURE GAUGE DOESN'T WORK.

POSSIBLE PROBLEMS
GAUGE SENDING UNIT WIRING

I2

WITH THE ROTARY SWITCH IN THE "OFF" POSITION, DO YOU HAVE CONTINUITY BETWEEN WIRE 58E AT THE GAUGE AND ENGINE (OR BODY) GROUND?

TEST OPTIONS
1. STE/ICE-R TEST 91 (PAGE 2-752)
2. MULTIMETER

REASON FOR QUESTION
This is the ground wire for the gauge.

KNOWLEDGE
TEMPERATURE GAUGE HAS POWER.

POSSIBLE PROBLEMS
GAUGE SENDING UNIT WIRING

I3

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?

TEST OPTIONS
1. STE/ICE-R TEST 91 (PAGE 2-752)
2. MULTIMETER

REASON FOR QUESTION
If either of these wires are open then the gauge will always read off scale to the left.

KNOWLEDGE
GAUGE GROUND OK

POSSIBLE PROBLEMS
TEMPERATURE GAUGE SENDING UNIT WIRING

REPAIR 27G or REPLACE HARNESS

REPAIR 58E or REPLACE HARNESS

REPAIR 33A, 33B or REPLACE HARNESS

GO TO I4, Page 2-362
REFERENCE INFORMATION

INSTRUMENTS CIRCUIT

- Replace harness/or repair wiring, refer to (para 4-85).

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.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

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.
**INSTRUMENTS CIRCUIT**

**KNOWN INFO**

| Wiring OK |

**POSSIBLE PROBLEMS**

| Gauge Sending Unit |

---

**DIAGNOSTIC FLOWCHART**

**FROM PAGE 2-360**

**I4**

**RECONNECT WIRES 27G AND 33A AT THE TEMPERATURE GAUGE. WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DOES THE GAUGE READ OFF SCALE BELOW 120°F (49 °C)?**

**TEST OPTIONS**

| TRY IT |

**REASON FOR QUESTION**

This will determine if the gauge can respond to an input signal.

**I5**

**WITH THE ROTARY SWITCH IN THE "RUN" POSITION, SHORT WIRE 33B TO ENGINE GROUND. DOES THE GAUGE READ OFF SCALE ABOVE 240°F (116 °C)?**

**TEST OPTIONS**

| TRY IT |

**REASON FOR QUESTION**

This will determine if the gauge can respond to an input signal.

**NO**

**REPLACE TEMPERATURE GAUGE**

**YES**

**REPLACE TEMPERATURE GAUGE**

**REPLACE TEMPERATURE SENDING UNIT**
REFERENCE INFORMATION

INSTRUMENTS CIRCUIT

Make sure wire 338 is not connected to the sending unit and is not touching anything metal that could cause the wire to be grounded.

Replace temperature gauge, refer to (para 4-13).

Replace temperature gauge, refer to (para 4-13).

Replace temperature sending unit, refer to (para 4-24).
**DIAGNOSTIC FLOWCHART**

**INSTRUMENTS CIRCUIT**

**KNOWN INFO**
- POWER TO GAUGES WITH ROTARY SWITCH OFF

**POSSIBLE PROBLEMS**
- ROTARY SWITCH WIRING

**J1**

DISCONNECT WIRE 11A AT THE ROTARY SWITCH. DO YOU HAVE 0 VOLTAGE AT WIRE 29B?

- NO: REPAIR 29B OR REPLACE HARNESS
- YES: J2

**KNOWN INFO**
- WIRING OK

**POSSIBLE PROBLEMS**
- ROTARY SWITCH

**J2**

WITH THE ROTARY SWITCH IN THE "OFF" POSITION, DO YOU HAVE CONTINUITY BETWEEN THE "RUN" AND "START" TERMINALS ON THE ROTARY SWITCH?

- NO: NO FAULTS
- YES: REPLACE ROTARY SWITCH

**TEST OPTIONS**

1. STE/ICE-R TEST 89 (Page 2-750)
2. MULTIMETER

**REASON FOR QUESTION**
If you disconnect the switch and still have power then the wiring is shorted.

**TEST OPTIONS**

1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

**REASON FOR QUESTION**
Continuity with the switch off indicates a shorted switch.
REFERENCE INFORMATION

INSTRUMENTS CIRCUIT

Replace harness/or repair wiring, refer to (para 4-85).

Replace rotary switch, refer to (para 4-7).

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.

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.

0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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

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?

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION
If the wire is OK then the sensing line from the sending unit to the gauge is OK.

REPAIR 28A

L2
IS THERE CONTINUITY BETWEEN WIRE 58C AT THE FUEL SENDING UNIT HARNESS AND BODY (OR ENGINE) GROUND?

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION
If the wire is OK then the sending unit ground is OK.

REPAIR WIRE 58C

L3
CHECK RESISTANCE ACROSS WIRE 28B & WIRE 58J AT THE FUEL SENDING UNIT HARNESS. IS THE RESISTANCE LESS THAN 50 OHMS?

TEST OPTIONS
1. STE/ICE-R TEST 91
2. MULTIMETER

REASON FOR QUESTION
If the fuel sending unit is OK then it could have been bad connections.

GO TO L4

NO FAULTS
The connector is located above the driveshaft toward the rear of the vehicle.

**INSTRUMENTS CIRCUIT**

### 0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

**GAUGE READING**

<table>
<thead>
<tr>
<th>OHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL 35</td>
</tr>
<tr>
<td>HALF 16</td>
</tr>
<tr>
<td>EMPTY 0</td>
</tr>
</tbody>
</table>
DISCONNECT WIRES 28B & 58J FROM SENDING UNIT IN TANK. IS THERE CONTINUITY THROUGH EACH WIRE?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-375)
2. MULTIMETER

REASON FOR QUESTION
If these wires are not open then the fuel sending unit is bad.

REPAIR WIRES 28B, 58J

YES

REPLACE FUEL LEVEL SENDING UNIT

NO

L4

FROM L3, Page 2-366
REFERENCE INFORMATION

In order to reach these wires and the sending unit you have to remove the fuel tank. 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, refer to (para 4-28 and 4-85).

INSTRUMENTS CIRCUIT

0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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**

**KNOWN INFO**
- POWER AVAILABLE TO GAUGES
- NO POWER AT WIPER MOTOR

**POSSIBLE PROBLEMS**
- WIRING

**TEST OPTIONS**
1. STE/ICE-R TEST 89
   - [Page 2-750]
2. MULTIMETER

**REASON FOR QUESTION**
These contacts provide power and ground connections to the wiper motor.

**DIAGNOSTIC FLOWCHART**

**M2**

**KNOWN INFO**
- POWER TO CONTACT

**POSSIBLE PROBLEMS**
- WIRING

**TEST OPTIONS**
1. STE/ICE-R TEST 91
   - [Page 2-752]
2. MULTIMETER

**REASON FOR QUESTION**
These contacts provide power and ground connections to the wiper motor.

**REMIND CLEVIS PINS AND TILT WINDSHIELD FORWARD. WITH ROTARY SWITCH IN THE "RUN" POSITION, IS THERE BATTERY VOLTAGE AT CONTACT P ON THE BODY?**

**YES**
- REPAIR 27K or REPLACE HARNESS

**NO**
- REPAIR 27K or REPLACE HARNESS

**NO FAULT**
Make sure these contacts are clean otherwise the wiper motor may not have power or ground.

If you experience intermittent problems with the wiper motor on your vehicle, inspect the terminals and the rubber grommet of the contact assembly. If the terminals are dirty or corroded, clean or replace as required. If the grommet shows signs of damage or deformity, replace the contact assembly (TM 9-2320-280-24P).

Replace harness or repair wiring, refer to (para 4-85).

0-45 DC VOLTS
STEACE-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.

0-4500 OHMS STEACE-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 4500 ohms, STEACE displays "9.9.9.9.9."
INSTRUMENTS CIRCUIT

KNOWN INFO
NO WIPER MOTOR GROUND

POSSIBLE PROBLEMS
WIRING

N1

DO YOU HAVE CONTINUITY FROM CONTACT G ON THE WINDSHIELD FRAME TO WIRE 57 AT THE CONNECTOR?

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
These contacts provide power and ground connections to the wiper motor.

REPAIR 57 or REPLACE HARNESS

NO FAULT

TEST OPTIONS
1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
These contacts provide power and ground connections to the wiper motor.

REPAIR 57 or REPLACE HARNESS

YES

NO

DIAGNOSTIC FLOWCHART

N FROM F2, Page 2-348

KNOWN INFO
GROUND AT CONTACT

POSSIBLE PROBLEMS
WIRING
Make sure these contacts are clean otherwise the wiper motor may not have power or ground. Replace harness/or repair wiring, refer to (para 4-85).

Replace harness/or repair wiring, refer to (para 4-85).

**0-4500 OHMS STE/CE-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 4500 ohms, STE/ICE displays "9.9.9.9."

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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

KNOWLEDGE

ELECTRICAL GAUGES OK

POSSIBLE PROBLEMS

AIR RESTRICTION GAUGE
VACUUM LINE

O1

INSPECT VACUUM TUBING
FROM AIR FILTER HOUSING TO
RESTRICTION GAUGE. IS THE
LINE INTACT?

NO

REPLACE LINE

YES

NO FAULT

DIAGNOSTIC FLOWCHART

TEST OPTIONS

VISUAL

REASON FOR QUESTION

If the line leaks then any pressure
differential won't be seen by the
gauge.

TEST OPTIONS

APPLY VACUUM TO LINE
(YOU CAN JUST SUCK ON
THE LINE TO TEST IT)

REASON FOR QUESTION

This will check gauge operation.

KNOWLEDGE

VACUUM LINE OK

POSSIBLE PROBLEMS

AIR RESTRICTION GAUGE

O2

DOES THE GAUGE READ YELLOW
WHEN VACUUM IS APPLIED TO
THE LINE AND DOES IT HOLD THE
READING?

NO

REPLACE GAUGE

YES
REFERENCE INFORMATION

You can provide enough vacuum to operate the gauge by sucking on the line. Replace vacuum line, refer to (para 3-19).

INSTRUMENTS CIRCUIT

Replace gauge, refer to (para 3-17).
INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

**P1**

**KNOWN INFO**

- AIR FILTER RESTRICTION
- GAUGE OK
- VACUUM TUBE OK

**POSSIBLE PROBLEMS**

- WIRING
- SWITCH
- MOTOR
- CIRCUIT BREAKER #1
- PCB

**TEST OPTIONS**

1. STE/ICE-R TEST 89
2. MULTIMETER

**REASON FOR QUESTION**
Voltage here indicates that wiring to the circuit breaker is OK.

**P2**

**KNOWN INFO**

- WIRE 27C OK

**POSSIBLE PROBLEMS**

- WIRING
- SWITCH
- MOTOR
- CIRCUIT BREAKER #1
- PCB

**TEST OPTIONS**

1. STE/ICE-R TEST 89
2. MULTIMETER

**REASON FOR QUESTION**
If you have voltage here, then the circuit breaker and wiring to the switch is OK.

**P3**

**KNOWN INFO**

- WIRE 27C OK
- WIRE 27D OK
- CIRCUIT BREAKER #1 OK

**POSSIBLE PROBLEMS**

- WIRING
- SWITCH
- MOTOR
- PCB

**TEST OPTIONS**

1. STE/ICE-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.

The heater motor is located directly in front of the passenger seat under the dashboard, connected to the heating ducts.

| 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. |

| 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

FROM P3, Page 2-316

DIAGNOSTIC FLOWCHART

TEST OPTIONS
1. STEACE-R TEST 91 (PAGE 2-782)
2. MULTIMETER

REASON FOR QUESTION
This wire provides the motor's connection to ground.

IS THERE CONTINUITY FROM WIRE 57E AT THE HEATER FAN MOTOR TO BODY GROUND?

KNOWN INFO
WIRE 27C OK
WIRE 27D OK
CIRCUIT BREAKER #1 OK
WIRE 4000 OK
SWITCH OK

POSSIBLE PROBLEMS
WIRING
MOTOR
PCB

P4

NO

GO TO T, Page 2-316

YES

P5

IF THE PROBLEM CONTINUES, REPLACE THE HEATER MOTOR.
RETURN TO THE INSTRUMENTS TEST CHAIN, PAGE 2-319.
0-4500 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. Lees then 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9.9.9.9.”

CONTINUITY (RESISTANCE)
mULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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

Q FROM P1, Page 2-376

TEST OPTIONS
1. STE/ICE-R TEST 89 (Page 2-750)
2. MULTIMETER

REASON FOR QUESTION
Voltage here indicates that the wiring was bad, and the problem was solved.

KNOWN INFO
NONE

POSSIBLE PROBLEMS
WIRE 27C
PCB BODY CONNECTOR

Q1
REPAIR/REPLACE WIRE 27C. WITH THE ROTARY SWITCH IN THE "RUN" POSITION, DO YOU HAVE BATTERY VOLTAGE AT WIRE 27C AT CIRCUIT BREAKER #1?

NO
REPAIR/REPLACE BODY CONNECTOR HARNESS

YES

Q2
RETURN TO P2, PAGE 2-376.
**INSTRUMENTS CIRCUIT**

### 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.

### 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.

Replace harness/or repair wiring, refer to (para 4-85).
INSTRUMENTS CIRCUIT

DIAGNOSTIC FLOWCHART

KNOWLEDGE INFO

WIRE 27C OK

POSSIBLE PROBLEMS

WIRE 27D CIRCUIT BREAKER #1

R1

R FROM P2, Page 2-376

IS THERE CONTINUITY FROM WIRE 27D AT THE HEATER FAN SWITCH TO WIRE 27D AT CIRCUIT BREAKER #1?

TEST OPTIONS

1. STE/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION

Continuity indicates that the wire is OK, and the circuit breaker must be the problem.

R3

REPAIR/REPLACE WIRE27D. RETURN TO P3, Page 2-376

YES

NO

REPLACE CIRCUIT BREAKER #1. RETURN TO P3, PAGE 2-376.
Replace harness or repair wiring, refer to (para 4-85).

### INSTRUMENTS CIRCUIT

#### 0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

#### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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

TEST OPTIONS
1. STE/ICE-R TEST 91
   (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
Continuity indicates that the wiring is OK, and the switch must be the problem.

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 2-378

REPLACE THE HEATER FAN SWITCH. RECONNECT ALL WIRES. RETURN TO P4, PAGE 2-378.

KNOWN INFO
WIRE 27C OK
WIRE 27D OK
CIRCUIT BREAKER #1 OK

POSSIBLE PROBLEMS
WIRE 400D SWITCH

Page 2-378
Repair wire or replace harness, refer to (para 4-85).

### INSTRUMENTS CIRCUIT

<table>
<thead>
<tr>
<th>0-4500 OHMS</th>
</tr>
</thead>
<tbody>
<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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
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/ICE-R TEST 91 (Page 2-752)
2. MULTIMETER

REASON FOR QUESTION
If there is continuity, the wiring is OK, and the PCB must be the problem.

REPAIR 57E OR REPLACE HARNESS. RETURN TO P5, PAGE 2-378.

REPLACE THE PCB. RETURN TO P5, PAGE 2-378.
REFERENCE INFORMATION

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.

Replace harness or repair wiring, refer to (para 4-85).

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.

Replace the PCB, refer to (para 4-5).

INSTRUMENTS CIRCUIT

0-4500 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 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
2-33. LIGHT TESTS

The Lights paragraph has 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 PCB 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.
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, P2-750) at the light socket, there may be a fault in the wiring harness.

   b) Check for continuity to ground (STE/ICE-R TEST 91, P2-752) from the light socket, there may be a missing connection to ground.

   c) Go to the wiring diagram(s) for more help.
**REFERENCE INFORMATION**

**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.

---

**LIGHTS**

**0-4500 OHMS**
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminals in the question.

2. Start Test 91, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

---

**0-45 DC 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."
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)

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.
BACKUP LAMPS AND
REAR SIDE MARKERS

CHECK FOR BATTERY VOLTAGE AT
THES POINTS
(STE/ICE-R TEST 89 OR MULTIMETER)

CHECK FOR CONTINUITY
TO BATTERY
NEGATIVE
CABLE FROM
THE STUD
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.
CAUTION

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.
FRONT LIGHTS
HEADLAMPS, BLACKOUT DRIVING LAMP, SIDE MARKERS

CHECK FOR BATTERY VOLTAGE AT THESE POINTS
(STE/ICE-R TEST 89 OR MULTIMETER)

CHECK FOR CONTINUITY TO BATTERY NEGATIVE CABLE
(STE/ICE-R TEST 91 OR MULTIMETER)

LEFT SIDE MARKER
LEFT SID HEADLIGHT

RIGHT SIDE MARKER
RIGHT SIDE HEADLIGHT

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.
CAUTION

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 &quot;C&quot;</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. &quot;B&quot;</td>
<td>325B</td>
</tr>
<tr>
<td>G</td>
<td>LIGHT SWITCH TERMINAL &quot;J&quot; (24 VOLTS)</td>
<td>467B</td>
</tr>
<tr>
<td>H</td>
<td>HAZARD/TURN SIGNAL FLASHER TERM. &quot;A&quot;</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 12339312-1), 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”.

HAZARD
2-34. TRANSMISSION SYSTEM TESTS (3L80)

These Transmission System tests may be run any time you think you have a transmission problem or if you were sent hereby another test chain. Just follow the path, answering the questions. Additional information and notes are given on the facing page when necessary. (4L80-E) Transmission system tests, refer to [para. 2-35].

Fold-out [page FO-12] may be left open for reference while testing.
TRANSMISSION SYSTEM (3L80)

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.
   - **POSSIBLE PROBLEMS**
     - FLUID
     - SHIFTER
     - MODULATOR
     - KICKDOWN SYSTEM
     - COOLING SYSTEM
     - TRANSMISSION
   - **KNOWN INFO**
     - NOTHING
   - **SEEN NOTE AT RIGHT**

2. PERFORM THE ROAD TEST PROCEDURE AT RIGHT. DID THE VEHICLE PASS THE ROAD TEST?
   - **TEST OPTIONS**
     - PROCEDURE AT RIGHT.
     - REASON FOR QUESTION: Road testing the transmission is the easiest way to check the system.
   - **POSSIBLE PROBLEMS**
     - SHIFTER
     - MODULATOR
     - KICKDOWN SYSTEM
     - COOLING SYSTEM
     - TRANSMISSION
   - **KNOWN INFO**
     - FLUID OK
   - **GO TO A, Page 2-404**

3. WITH THE VEHICLE COASTING IN 3RD 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 kickdown system.
   - **POSSIBLE PROBLEMS**
     - MODULATOR
     - COOLING SYSTEM
     - KICKDOWN SYSTEM
     - TRANSMISSION
   - **KNOWN INFO**
     - FLUID OK
     - BANDS & CLUTCHES OK
     - SHIFTER OK
   - **GO TO B, Page 2-406**

4. **GO TO 4, Page 2-407**
**REFERENCE INFORMATION**

**TRANSMISSION SYSTEM**
(3L80)

---

**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.
- Bubbles indicate an overfilled system or air leaks in the system. Drain the fluid and refill to proper level. Refer to (para 5-2).
- Milky appearance is due to water in the system. Change the fluid and filter.
- 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. Refer to (para 5-2).
- Transmission fluid coming out of dipstick filler tube indicates a restriction in the ventilation system. Check for clogged, melted, or crushed lines and/or fittings between transmission and atmosphere vent on air cleaner canister. Replace where needed. Refer to (para 5-16).

**Road Test Procedure**

1. 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 and 3-2 and 2-1 shifts should occur.
2. 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.
3. Position shift lever in “1” and accelerate the vehicle from 0 mph. No upshifts should occur in this range.
4. Position shift lever in “D” 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.
5. 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.
6. Position shift lever in “R” and check for reverse operation.
7. Hard shifting may be indicative of an underfilled or clogged system.

The kickdown system is used to shift the transmission to a lower gear under heavy acceleration. The system also disengages the engine cooling fan so as to allow maximum engine power to be used for moving the vehicle.
TRANSMISSION SYSTEM (3L80)

FROM 3, Page 2-400

KNOWLEDGE

FLUID OK
BANDS & CLUTCHES OK
SHIFTER OK
KICKDOWN OK

POSSIBLE PROBLEMS

MODULATOR
COOLING

TEST OPTIONS

VISUAL INSPECTION.

REASON FOR QUESTION
The modulator is needed for telling the transmission when to shift.

3

SHUT THE ENGINE OFF. DOES THE MODULATOR CABLE MOVE AS YOU STEP ON THE ACCELERATOR?

NO

REPLACE TRANSmission MODULATOR

5

YES

REPAIR OR REPLACE AS NECESSARY

TEST OPTIONS

VISUAL.

REASON FOR QUESTION
To see if anything is leaking

INSPECT THE TRANSmission SYSTEM FOR LEAKS. IS EVERYTHING OK?

4

NO

Yes

TEST OPTIONS

1. SEE PROCEDURE AT RIGHT. USE STE/ICE-R TEST 50 AND THE BLUE TRANSUCER. USE CONTROL FUNCTION 01 TO INTERLEAVE PRESSURE WITH RPM.

2. PRESSURE GAUGE.

REASON FOR QUESTION
There may be a problem not previously discovered in the testing.

IF YOU STILL SUSPECT A PROBLEM, YOU CAN RUN THE PRESSURE TESTS AT THE RIGHT. DOES THE TRANSMISSION PASS THE PRESSURE TESTS?

NOTIFY DS MAINTENANCE

NO FAULTS

6

2-402
NOTE
NEXT TEST MUST BE PERFORMED DURING A ROAD TEST OR WITH VEHICLE RAISED AND TIRES OFF THE GROUND. RECORD PRESSURE WITH THROTTLE CLOSED.

12. Place lever in D and take foot off brake. With engine at 2000 RPM, close throttle and read pressure between 1200 and 2000 RPM. Pressure should be 65-70 psi (448-485 kPa). If not, notify DS Maintenance.

13. Shut off engine, remove transducer and reinstall plug.
TRANSMISSION SYSTEM (3L80)

A FROM 2, Page 2-400

TEST OPTIONS
VISUAL.

A1

TEST OPTIONS
VISUAL.

REASON FOR QUESTION
The failure could be in the drive train or in the transmission if the vehicle doesn't move.

DID THE VEHICLE MOVE AT ALL DURING THE ROAD TEST?

NO

RUN THE DRIVE TRAIN TESTS. RETURN TO A2

YES

A2

WITH THE VEHICLE OFF, MOVE THE GEARSHIFT. IS THE SHIFTER WORKING PROPERLY?

NO

ADJUST OR REPAIR AS NEEDED CONTINUE WITH A3

YES

A3

WITH THE VEHICLE OFF, STEP ON THE THROTTLE. DOES THE MODULATOR CABLE MOVE AS YOU STEP ON THE THROTTLE?

NO

NOTIFY DS MAINTENANCE

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. 2-38) 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 shown in (para. 5-12).

Look for a modulator problem if the vehicle was not shifting, or was not shifting as well as it should be.

**NOTE**

Run the BRAKES and DRIVETRAIN tests in this manual. If you don’t find any faults, notify DS maintenance.
REFERENCE INFORMATION

A NO answer here means the kickdown works with the time delay module disconnected.

TRANSMISSION SYSTEM (3L80)

0-4500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the test points indicated 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 4500 ohms, STE/ICE displays "9.9.9.9."

A measurement of zero or infinity means the solenoid is no good.

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
There should be continuity when the injector pump is wide open, and an open circuit when it isn’t. Check out both positions.

Adjust or replace kickdown switch, refer to (para 4-43).

NOTE
Recheck everything in the circuit. If you don't find anything wrong, notify DS maintenance. The problem is probably in the transmission itself.
2-35. TRANSMISSION SYSTEM TESTS (4L80-E)

The 4L80-E Transmission system is equipped with a computer called the Transmission Control Module (TCM) (located left rear seat compartment; for M996A2 and M997A2 vehicles, located in the left exterior stowage 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, digital multimeter and a throttle position (TP) sensor test cable.

**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 insure 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 (4L80-E)

1. CHECK THE TRANSMISSION FLUID. IS IT OK?
   - KNOWN INFO
     - NOTHING
   - POSSIBLE PROBLEMS
     - FLUID
     - SHIFTER
     - FAN CUT-OFF SWITCH
     - TP SENSOR
     - COOLING SYSTEM
     - TRANSMISSION
   - TEST OPTIONS
     - VISUAL - SEE NOTE AT RIGHT.
   - REASON FOR QUESTION
     Transmission fluid level and appearance give a good indication of the system's condition.
   - NO
   - SEE NOTE AT RIGHT
   - YES

2. PERFORM THE ROAD TEST PROCEDURE AT RIGHT. DID THE VEHICLE PASS THE ROAD TEST?
   - KNOWN INFO
     - FLUID OK
   - POSSIBLE PROBLEMS
     - SHIFTER
     - FAN CUT-OFF SWITCH
     - TP SENSOR
     - COOLING SYSTEM
     - TRANSMISSION
   - TEST OPTIONS
     - PROCEDURE AT RIGHT.
   - REASON FOR QUESTION
     Road testing the transmission is the easiest way to check the system.
   - NO
   - GO TO A1, Page 2-416
   - YES

3. WITH THE VEHICLE COASTING IN 4TH GEAR, FLOOR THE ACCELERATOR. DOES THE TRANSMISSION DOWNSHIFT?
   - KNOWN INFO
     - FLUID OK
     - BANDS & CLUTCHES OK
     - SHIFTER OK
   - POSSIBLE PROBLEMS
     - FAN CUT-OFF SWITCH
     - COOLING SYSTEM
     - TP SENSOR
     - TRANSMISSION
   - TEST OPTIONS
     - TRY IT. BE SURE NOT TO EXCEED ANY POSTED SPEED LIMITS.
   - REASON FOR QUESTION
     You want to check out the fan cut-off switch.
   - NO
   - GO TO B1, Page 2-416
   - YES
     - GO TO 4, Page 2-414
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 small, grit, discoloration, air bubbles, or a milky appearance.

- Burnt smell, discoloration, or grit indicates worn or damaged internal components. Notify DS maintenance.
- Bubbles indicate an overfilled system or air leaks in the system. Drain the fluid and refill to proper level. Refer to (para 5-2).
- Milky appearance is due to water in the system. Change the fluid and filter.
- 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. Refer to (para. 5-2).

Road Test Procedure
1. Position shift lever in "O" (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 and 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 and 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 "4" 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 "D" 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 in "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 dogged system.

The fan cut off switch and TP sensor are used to shift the transmission to a lower gear under heavy acceleration. The system also disengages the engine cooling fan so as to allow maximum engine power to be used for moving the vehicle.
TRANSMISSION SYSTEM (4L80-E)

FROM 3, Page 2-412

SHUT THE ENGINE OFF. DOES THE FAN CUT-OFF SWITCH ROD MOVE AS YOU STEP ON THE ACCELERATOR?

TEST OPTIONS
VISUAL INSPECTION.

REASON FOR QUESTION
The fan cut-off switch is needed for telling the transmission when to shift.

NO
REPAIR OR REPLACE AS NECESSARY

YES

TEST OPTIONS
VISUAL.

REASON FOR QUESTION
To see if anything is leaking

5

INSPECT THE TRANSMISSION SYSTEM FOR LEAKS. IS EVERYTHING OK?

NO
REPAIR OR REPLACE AS NECESSARY

YES

GO TO B, Page 2-418
REFERENCE INFORMATION

Repair or replace fan cut-off switch, refer to (para 4-44).

TRANSMISSION SYSTEM
(4L80-E)
TRANSMISSION SYSTEM
(4L80-E)

KNOWN INFO
TRANSMISSION FAILS ROAD TEST

POSSIBLE PROBLEMS
SHIFTER TRANSMISSION

A1
DID THE VEHICLE MOVE AT ALL DURING THE ROAD TEST?

TEST OPTIONS
VISUAL.

REASON FOR QUESTION
The failure could be in the drive train or in the transmission if the vehicle doesn't move.

RUN THE DRIVE TRAIN TESTS. RETURN TO A2.

YES

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.

NO

YES

A3
WITH THE VEHICLE OFF, STEP ON THE THROTTLE. DOES THE FAN CUT OFF SWITCH ROD MOVE AS YOU STEP ON THE THROTTLE?

TEST OPTIONS
VISUAL INSPECTION

REASON FOR QUESTION
The fan cut-off switch tells the transmission when to shift.

REPAIR OR REPLACE AS NECESSARY

NO

YES

SEE NOTE AT RIGHT

2-416
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 Paragraph 2-33 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 shown in Paragraph 5-13.

Look for a fan cut-off switch problem if the vehicle was not shifting, or was not shifting as well as it should be.

**NOTE**
Run the BRAKES and DRIVETRAIN tests in this manual. If you don't find any faults, notify DS maintenance.
**TRANSMISSION SYSTEM (4L80-E)**

**DIAGNOSTIC FLOWCHART**

**B1**

**Known Info**
- No leaks
- Fluid ok
- Shifter ok

**Possible Problems**
- Transmission

**Connect diagnostic switch cable to the transmission control module (TCM) J2 connector. Disconnect glowplug controller. Turn vehicle ignition to the run position. Does transmission check lamp steadily illuminate?**

**Test Options**
- Visual inspection

**Reason for Question**
- Transmission check lamp may be faulty.

**B2**

**Known Info**
- No leaks
- Fluid ok
- Shifter ok

**Possible Problems**
- Transmission

**Check voltage on transmission check lamp leads. Did you get:**
- >12 V on pin 1 (Ckt 6578)?
- 0 V on pin 2 (Ckt 657A)?

**Test Options**
- Multimeter

**Reason for Question**
- Transmission check lamp or harness leads may be faulty.

**B3**

**Known Info**
- No leaks
- Fluid ok
- Shifter ok

**Possible Problems**
- Transmission

**Position switch to on. Does the transmission check lamp flash three code 12s indicating the TCM is capable of diagnostics?**

**Test Options**
- Procedure at right

**Reason for Question**
- Transmission check lamp must flash three code 12s indicating the TCM is capable of diagnostics.

**Refer to chart at right**

**Go to B4, Page 2-420**
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.)

IGNITION ON, ENGINE OFF AND GLOWPLUG CONTROLLER DISCONNECTED (PARA 4-29).

REMOVE DIAGNOSTIC SWITCH CABLE. INSTALL JUMPER CABLE BETWEEN PINS A AND E OF J2 ON TCM ASS'Y.

NO DTC 12

DTC 12 FLASHES

CHECK DIAGNOSTIC CABLE FOR OPEN AND REPAIR.

READ CODES AND REMOVE JUMPER.

• IGNITION OFF.
• DISCONNECT TCM CONNECTOR.
• IGNITION ON.

TRANS CHECK LAMP OFF.

TRANS CHECK LAMP ON.

• IGNITION OFF.
• DIAGNOSTIC TERMINAL NOT GROUNDED.
• RECONNECT TCM CONNECTOR.
• IGNITION ON AND ENGINE OFF.
• PROBE PIN E ON J2 TO GROUND.

NO DTC 12

DTC 12 FLASHES

REPLACE DEFECTIVE TCM. (REFER TO PARA 4-42).

OPEN CKT PIN A J2. REPLACE TCM. (REFER TO PARA 4-42).

NOTE: AFTER TROUBLESHOOTING, RECONNECT GLOWPLUG CONTROLLER. VEHICLE WILL HAVE TO BE OPERATED IN ORDER FOR TCM TO RECEIVE TROUBLE CODES. AFTER REPAIRS, CHECK TRANS LAMP OPERATION.
TRANSMISSION SYSTEM (4L80-E)

FROM B3, Page 2-418

B4

FOLLOWING THE CODE 12 DISPLAYS, EACH STORED CODE WILL BE FLASHER 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.

B5

RECORD THE CODES AND REFER TO THE J1 CABLE DIAGNOSTICS CHART ON PAGES 2-428 THROUGH 2-443 AND COMPLETE THE DIAGNOSTICS. REFER TO PAGE 2-421 FOR DESCRIPTION OF TROUBLE CODES.

B6

IF CODE 51 SHOWS, REPLACE TCM. REFER TO PARA. 4-42.

END OF TESTING
The following chart will help you find the code you need. The J1 cable diagnostics checks must be performed. Always correct the lower code number first. If code 51 shows up, replace TCM (para. 4-42), operate vehicle, and recheck for trouble codes.

<table>
<thead>
<tr>
<th>TROUBLE CODE</th>
<th>CIRCUIT</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Throttle Position High</td>
<td>2-422</td>
</tr>
<tr>
<td>22</td>
<td>Throttle Position Low</td>
<td>2-422</td>
</tr>
<tr>
<td>24</td>
<td>Transmission Output Speed Sensor (TOSS)</td>
<td>2-422</td>
</tr>
<tr>
<td>28</td>
<td>Transmission Range Pressure Switch</td>
<td>2-422</td>
</tr>
<tr>
<td>37</td>
<td>Torque Converter Clutch (TCC) Brake Switch Stuck “ON”</td>
<td>2-422</td>
</tr>
<tr>
<td>38</td>
<td>TCC Brake Switch Stuck “OFF”</td>
<td>2-422</td>
</tr>
<tr>
<td>39</td>
<td>TCC Stuck “OFF”</td>
<td>2-423</td>
</tr>
<tr>
<td>51</td>
<td>Transmission Control Module (TCM) Bad</td>
<td>2-423</td>
</tr>
<tr>
<td>52</td>
<td>System Voltage High Long</td>
<td>2-423</td>
</tr>
<tr>
<td>53</td>
<td>System Voltage High</td>
<td>2-423</td>
</tr>
<tr>
<td>58</td>
<td>Transmission Temperature High</td>
<td>2-423</td>
</tr>
<tr>
<td>59</td>
<td>Transmission Temperature Low</td>
<td>2-423</td>
</tr>
<tr>
<td>68</td>
<td>Transmission Component Slipping</td>
<td>2-424</td>
</tr>
<tr>
<td>69</td>
<td>Torque Converter Clutch (TCC) Stuck “ON”</td>
<td>2-424</td>
</tr>
<tr>
<td>71</td>
<td>Engine Speed Sensor Circuit Low</td>
<td>2-424</td>
</tr>
<tr>
<td>73</td>
<td>Pressure Control Solenoid (PCS) Current</td>
<td>2-424</td>
</tr>
<tr>
<td>74</td>
<td>Transmission Input Speed Sensor (TISS) Circuit</td>
<td>2-425</td>
</tr>
<tr>
<td>75</td>
<td>System Voltage Low</td>
<td>2-425</td>
</tr>
<tr>
<td>79</td>
<td>Transmission Fluid Overtemp</td>
<td>2-425</td>
</tr>
<tr>
<td>81</td>
<td>2-3 Shift Solenoid Circuit Fault</td>
<td>2-425</td>
</tr>
<tr>
<td>82</td>
<td>1-2 Shift Solenoid Circuit Fault</td>
<td>2-426</td>
</tr>
<tr>
<td>83</td>
<td>TCC Solenoid (PWM) Circuit Fault</td>
<td>2-426</td>
</tr>
<tr>
<td>85</td>
<td>Undefined Ratio</td>
<td>2-426</td>
</tr>
<tr>
<td>86</td>
<td>Low Ratio</td>
<td>2-427</td>
</tr>
<tr>
<td>87</td>
<td>High Ratio</td>
<td>2-427</td>
</tr>
</tbody>
</table>
TRANSMISSION SYSTEM
(4L80-E)

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 one second.

DTC 22 Will Set When:
- Engine is operating.
- TP sensor signal voltage is less than 0.2 volt.
- Conditions are met for one 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.
- CKT voltage is constant.
- Engine speed is greater than 3000 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) 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 volts.
- 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:
- CKT 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 seven times.

DTC 38 Will Set When:
- TCC brake switch feed CKT 810B 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 seven 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 two seconds.

DTC 51  
**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.
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 greater than 200 RPM.
- Fourth gear is indicated.
- TCC is locked.
- Not in park/neutral.
- All conditions are met for 2 seconds.

- Trans 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 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 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 pressure control solenoid. 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 amps from the commanded amperage.
• All conditions are met for 1 second.

DTC 74
Transmission Input Speed Sensor (TISS) Circuit

Circuit Description:
The TISS sensor 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:
• Trans range not in park or neutral.
• Engine speed greater than 300 rpm.
• Trans output speed greater than 200 rpm.
• Trans 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 greater than 1000 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 CKT 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:
• Trans fluid temp greater than 295°F (146°C).
• All conditions are met for 30 minutes.
TRANSMISSION SYSTEM
(4L80-E)

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 CKT 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 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 CKT 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-Drive 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 check-ball 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 apply 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.
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:
- TP 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>
<th>LESS THAN</th>
<th>MORE THAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td></td>
<td>2.38</td>
<td>2.63</td>
</tr>
<tr>
<td>2nd</td>
<td></td>
<td>1.43</td>
<td>1.58</td>
</tr>
<tr>
<td>3rd</td>
<td></td>
<td>0.95</td>
<td>1.05</td>
</tr>
<tr>
<td>REV</td>
<td></td>
<td>1.97</td>
<td>2.17</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 transmission input speed and output speed sensor readings. The control module compares the known transmission ratio to the calculated ratio for the particular gear range selected.

DTC 86 Will Set When:
- Not in park, reverse, or neutral.
- Engine speed greater than 300 rpm.
- TP greater than 25%.
- 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.

DTC 87
High Ratio Error

Circuit Description:
The control module calculates ratio based on the transmission input speed and output speed sensor readings. The control module compares the known transmission ratio to the calculated ratio for the particular gear range selected.

DTC 87 Will Set When:
- TP greater than 25%.
- Not in park, reverse, or neutral.
- Engine speed greater than 300 rpm.
- Vehicle speed greater than 7 mph (11 kph).
- 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. 4-85.
- Check connector pins before inserting probes.

### J1 Voltage Measurements With Ignition ON, Engine OFF, and Glow Plug Controller Disconnected. Refer to para 4-29.

<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>12V (Brake OFF)</td>
<td></td>
</tr>
<tr>
<td>Brake Sw</td>
<td>810B</td>
<td>W</td>
<td>a or b</td>
<td>O (Brake ON)</td>
<td></td>
</tr>
</tbody>
</table>

* Jumper wire from U to a or b.

Reconnect Glow Plug Controller; refer to para 4-29.

### J1 Voltage Measurement With Ignition ON, Engine ON, and 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>0.3 Volts min @ idle</td>
<td></td>
</tr>
<tr>
<td>Press SW A</td>
<td>765A</td>
<td>A</td>
<td>a or b</td>
<td>Open wire</td>
<td></td>
</tr>
<tr>
<td>Press SW B</td>
<td>763A</td>
<td>B</td>
<td>a or b</td>
<td>0 to 1 ohms</td>
<td></td>
</tr>
<tr>
<td>Press SW C</td>
<td>764A</td>
<td>C</td>
<td>a or b</td>
<td>Open wire</td>
<td></td>
</tr>
</tbody>
</table>
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 ohms</td>
</tr>
<tr>
<td>Battery Neg</td>
<td>599B</td>
<td>b</td>
<td>Shunt</td>
<td>0 ohms</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>TOSS</td>
<td>498A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCC SOL</td>
<td>924A</td>
<td>X</td>
<td>j</td>
<td>~ 8 to 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>FORCE MTR</td>
<td>265A</td>
<td></td>
<td></td>
<td></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 -&gt; Low Resist.)</td>
</tr>
</tbody>
</table>

Upon completion of J1 cable diagnostics, operate the vehicle and recheck for codes to insure codes have cleared. If codes have not cleared, refer to DS Maintenance.
DIAGNOSTIC FLOWCHART

BATTERY CIRCUIT

537D

Reset trans pwr CB and recheck voltage >12V.

YES END

NO

Check trans pwr CB out for >12V (wire 290A/291A/537A).

YES

Repair wire 290A/291A/537A, (para. 4-85).

NO

Check trans pwr CB In for >12V (wire 290/291/537).

YES

Repair wire 290/291/537, (para. 4-85).

NO

Replace CB, (para. 4-40).

VEHICLE GROUND CIRCUIT

599A

NO Repair wire 599A/599C.

YES END

599B

NO Repair wire 599B/599C.

YES END
TRANSMISSION SYSTEM
(4L80-E)
TRANSMISSION LIGHT CIRCUIT

657A

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.

YES

NO

Repair wire 657B, (para. 4-85).

YES

Check for continuity on wire 657A from J1 pin U to pin 2 of harness connector at trans check lamp.

NO

Repair wire 657A, (para. 4-85).

YES

Replace transfer case check lamp, (para. 4-38).

Does transfer case check lamp light?

NO

Faulty TCM ground replace TCM, (para. 4-42).

YES

Go to page 2-429.

Go to page 2-428.
DIAGNOSTIC FLOWCHART

BRAKE SWITCH CIRCUIT

Check for following resistance across brake switch leads pins 1 and 2 (wires 810A and 810B):
- $0 \Omega$ - Brakes Off
- $\infty \Omega$ - Brakes On.

Check for actuation of brake switch.

Check for $>12V$ on harness connector pin 1 (wire 810A) at brake switch.

Adjust stoplight switch, (refer to para. 4-61).

Replace stoplight switch, (refer to para. 4-61).

Repair wire 810B in harness, (para. 4-85).

Repair wire 810A, (para. 4-85).

Follow diagnostic procedure for pin j of J1 to obtain $>12V$ on wire 291D.

Go to page 2-428.
Are 125 to 175 ohms present between engine RPM sensor (located on engine front cover), pins 1 and 2?

Yes

Is continuity present from pin h wire 349A of J1 to pin 1 wire 359B of J1 to 2 wire 359J on engine harness connector to rpm sensor?

Yes

Replace engine rpm sensor, (para. 4-33).

No

Replace engine rpm sensor, (para. 4-33).

No

Repair wire 349A/349B, and/or wire 359B/359J, (para. 4-85).
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, (para. 4-85).
- NO

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/359G, (para. 4-85).
- NO

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. 4-85).
- NO

Vehicle wiring is ok. Proceed to the TPS adjustment procedure in para. 4-45 to determine whether the TPS or the adjustment is faulty.
TRANSMISSION SYSTEM
(4L80-E)

TRANSMISSION INPUT SPEED SENSOR (TISS) CIRCUIT

NOTE
If reading from J1 diagnostics chart is greater than 2, perform high resistance - less than 1 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 continuity of transmission input speed sensor and pins A and B (TISS) 1 Kohm to 2 Kohms Ω.

NO

NO

Repair pin(s) or connector, (para. 4-85).

Replace TISS, (para. 4-46).

Repair wire 495A, and/or wire 496A, (para. 4-85).

LOW RESISTANCE

Disconnect TISS and check continuity between pins M and N at J1.

YES

Repair wire 495A/496A, (para. 4-85).

NO

Replace TISS, (para. 4-46).

END
NOTE
If reading from J1 diagnostics chart is greater than 2, perform high resistance - less than 1 perform low resistance.

HIGH RESISTANCE

497A 498A
Check transmission output speed sensor connector and pins for continuity.

YES

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

Check continuity of transmission output speed sensor and pins A and B (TOSS) 1 Kohm to 2 Kohms Ω.

LOW RESISTANCE

Disconnect TOSS and check continuity between pins M and N at J1.

YES

Repair wire 497A/498A, (para. 4-85).

NO

Replace TOSS, (para. 4-46).

END

NO

END

Repair pin(s) or connector, (para. 4-85).

Repair wire 497A, and/or wire 498A, (para. 4-85).
TRANSMISSION SYSTEM
(4L80-E)
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. 4-85).

YES
Repair wire 290D/291D, (para. 4-85).

Refer to DS maintenance.

LOW RESISTANCE

Disconnect transmission connector from transmission. Check continuity from J1 pin X to J1 pin j.

YES
Refer to DS maintenance.

NO
Repair wire 924A short to ground, (para. 4-85).
DIAGNOSTIC FLOWCHART

1-2 SHIFT SOLENOID CIRCUIT SHIFT
SOLENOID A

HIGH RESISTANCE

237A
Check continuity from J1 pin S to transmission connector pin A.

NO

YES

Repair wire 237, (para. 4-85).

NO

Check continuity from J1 pin j to transmission connector pin E.

YES

Repair wire 291D/290D, (para. 4-85).

Refer to DS maintenance

LOW RESISTANCE

Disconnect transmission connector from transmission. Check continuity from J1 pin E to J1 pin j.

NO

Repair wire 237A, (para. 4-85).

YES

Refer to DS maintenance
TRANSMISSION SYSTEM
(4L80-E)
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. 4-85).

NO
Check continuity from J1 pin J to transmission connector pin E.

NO
Repair wire 291D/290D, (para. 4-85).

YES
Refer to DS maintenance.

LOW RESISTANCE

Disconnect transmission connector from transmission. Check continuity from J1 pin D to J1 pin J.

YES
Refer to DS maintenance.

NO
Repair wire 375A, (para. 4-85).
**HIGH RESISTANCE**

- **Check continuity from J1 pin g to transmission connector pin C.**
  - **YES**
    - Repair wire 264A, (para. 4-85).
  - **NO**
    - **Check continuity from J1 pin k to transmission connector pin D.**
      - **NO**
        - **Repair wire 265A, (para. 4-85).**
      - **YES**
        - Refer to DS maintenance.

**LOW RESISTANCE**

- **Disconnect transmission connector from transmission. Check continuity from J1 pin g to J1 pin k.**
  - **YES**
    - Refer to DS maintenance.
  - **NO**
    - Repair short between wire 264A and wire 265A.
TRANSMISSION SYSTEM
(4L80-E)

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.

NO

Repair short to ground in wire 765A, (para. 4-85).

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

Refer to DS maintenance.

NO

Repair short to ground in wire 763A, (para. 4-85).

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

Refer to DS maintenance.

NO

Repair short to ground in wire 764A, (para. 4-85).
The transmission temperature sensor is a thermistor. The resistance decreases as the temperature increases at 68°F (20°C) the resistance should be from 2980 to 4020 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**
  - Check continuity from J1 pin e to chassis ground.
    - **NO**
      - Repair wire 923A, (para. 4-85).
    - **YES**
      - Refer to DS maintenance.

- **NO**
  - Repair short from wire 923A to wire 359A/B/C/D, (para. 4-85).

**RESISTANCE TOO HIGH**

Disconnect transmission connector from transmission. Check continuity from J1 pin e to transmission connector pin L.

- **YES**
  - Check continuity from J1 pin c to transmission connector pin M.
    - **NO**
      - Repair wire 359A/B/C/D, (para. 4-85).
    - **YES**
      - Refer to DS maintenance.

- **NO**
  - Repair short from wire 923A, (para. 4-85).
2-36. BRAKE SYSTEM TESTS

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 page FO-13 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 2-319, for the warning lamp, or Lights, Page 2-389, for the brake lights.

- When parking brake handle is pulled, the parking brake is applied to the left and right rear service brake rotors.
BRAKES

DIAGNOSTIC FLOWCHART

START

!!

1

1. DOES THE VEHICLE REMAIN STATIONARY USING THE PROCEDURE AT THE RIGHT? (DOES THE PARKING BRAKE WORK?)

TEST OPTIONS

TEST PARKING BRAKE USING PROCEDURE AT RIGHT

REASON FOR QUESTION

A working parking brake is necessary for safety.

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

2. DO THE SERVICE BRAKES PASS THE ROAD TEST PROCEDURE AT THE RIGHT?

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.

NO

GO TO A1, Page 2-448

YES

NO

GO TO B1, Page 2-448

YES

NO FAULTS

KNOWN INFO

NONE

POSSIBLE PROBLEMS

PARKING BRAKES
SERVICE BRAKES
HYDRAULIC SYSTEM
TIRE PRESSURE

KNOWN INFO

PARKING BRAKE OK

POSSIBLE PROBLEMS

TIRE 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 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) Rear wheels lock-up before front wheels,
   6) Brake warning light comes on while braking, and
   7) A squealing, grinding, or chattering noise while braking.
**BRAKES**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**
- PARKING BRAKE INOPERATIVE

**POSSIBLE PROBLEMS**
- PADS
- CALIPER
- ROTOR
- CABLE
- BRAKE LEVER

**A1**

**HAVE YOU TRIED ADJUSTING THE PARKING BRAKE?**

- **NO**
  - TRY ADJUSTING THE PARKING BRAKE

- **YES**
  - YES
  - REPLACE/REPAIR BAD COMPONENTS

**A2**

**ARE THE PARKING BRAKE PADS, CALIPER, ROTOR, AND CABLE IN GOOD WORKING ORDER?**

- **NO**
  - REPLACE/REPAIR BAD COMPONENTS

- **YES**
  - YES
  - VISUAL INSPECTION.

**A3**

**IS THE PARKING BRAKE SHIFTING LINKAGE IN GOOD WORKING ORDER?**

- **NO**
  - REPAIR/REPLACE LINKAGE

- **YES**
  - NO FAULTS
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 drive and transfer case shift lever in high.
(4) Apply parking brake and slowly let up on service brake pedal. Vehicle should remain stationary.

Replace or repair parts, refer to (para. 7-3) for old configuration.

Replace or repair parts, refer to (para 7-20) for new configuration.

Repair or replace linkage, refer to (paras. 7-5, 7-23, and 7-24).
BRAKES

DIAGNOSTIC FLOWCHART

B1

IS THE FLUID IN THE MASTER CYLINDER FREE OF CONTAMINATION AND FILLED TO THE PROPER LEVEL?

TEST OPTIONS
VISUAL INSPECTION.

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
VISUAL INSPECTION. 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.

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.

REPLACE LEAKING LINES AND SEALS

GO TO B4, [Page 2-452]
Flush and bleed the brake system, refer to (para 7-10).

**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, refer to (para 7-13).

Check the individual lines going to each brake. Check the supply and return lines to the hydro-boost unit. Replace brake line, refer to (para 7-15).

**NOTE**

Brake hydraulic system must be bled of air whenever hydraulic lines are broken.

Bleed service brake, refer to (para 7-10).
BRAKES

**B4**

**KNOWN INFO**
- PARKING BRAKE OK
- MASTER CYLINDER OK
- NO VISIBLE LEAKS

**POSSIBLE PROBLEMS**
- BRAKE PADS
- CALIPERS
- ROTORS
- PROPORTIONING VALVE
- HYDRO-BOOSTER
- MECHANICAL COMPONENTS

**TEST OPTIONS**
- VISUAL INSPECTION.

- **REASON FOR QUESTION**
  Dirty, bent, or thin brake pads could cause problems such as noisy brakes, erratic braking, or excessive pedal pressure.

- **REPLACE PADS IN PAIRS (FRONT OR REAR)**

- **NO**

- **YES**

**B5**

**KNOWN INFO**
- PARKING BRAKE OK
- MASTER CYLINDER OK
- BRAKE PADS OK

**POSSIBLE PROBLEMS**
- ROTORS
- CALIPERS
- PROPORTIONING VALVE
- HYDRO-BOOSTER
- MECHANICAL COMPONENTS

**TEST OPTIONS**
- VISUAL INSPECTION.

- **REASON FOR QUESTION**
  Damaged rotors reduce braking ability and speed up brake failure due to excessive heat buildup.

- **REPLACE BAD ROTORS**

- **NO**

- **YES**

**B6**

**KNOWN INFO**
- PARKING BRAKE OK
- MASTER CYLINDER OK
- BRAKE PADS OK

**POSSIBLE PROBLEMS**
- ROTORS BINDING
- CALIPERS BINDING
- PROPORTIONING VALVE
- HYDRO-BOOSTER
- MECHANICAL COMPONENTS

**TEST OPTIONS**
- TRY TO ROTATE ROTORS WHILE WHEELS ARE RAISED.

- **REASON FOR QUESTION**
  Sticky rotors can cause erratic braking behavior.

- **SEE NOTE AT RIGHT**

- **NO**

- **YES**

**GO TO B7, Page 2-454**
Replace brake pad, refer to (para 7-11).

**NOTE**
The minimum brake pad thickness is 1/8 of an inch (3.2mm).

Replace service brake rotor, refer to (para 7-19).

**NOTE**
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, refer to (para 7-12).
BRAKES

FROM B6, Page 2-452

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.

REPLACE PROPORTIONING VALVE

B7

YES

NO

TEST OPTIONS
SEE INSTRUCTIONS AT RIGHT.

REASON FOR QUESTION
The hydro-booster is an integral part of the braking system.

IS THE HYDRO-BOOSTER WORKING PROPERLY?

GO TO C1, Page 2-456

B8

NO

YES

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.

LOOK AT THE BRAKE PEDAL. DOES IT MOVE THROUGH ITS FULL OPERATING RANGE?

REPAIR/REPLACE WORN PARTS

B9

NO

YES

GO TO STEERING, Page 2-459
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 46 to 40mph (72 to 69 kph) on dry concrete mad and apply sufficient pressure to lockup front brakes. If rear brakes lock up before front brakes, then the proportioning valve should be replaced.

Replace proportioning valve, refer to (para 7-18).

Method for checking hydrobooster:

Depress brake pedal several times to exhaust accumulator pedal. Depress brake pedal and start engine. Brake pedal should fall, then push back against operators foot.

Replace hydro-booster, refer to (para 7-14).

Replace service brake pedal, refer to (para 7-16).

The steering tests will check for suspension problems that will affect braking.
**BRAKES**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**
HYDRO-BOOSTER SYSTEM
NOT WORKING PROPERLY

**POSSIBLE PROBLEMS**
HYDRO-BOOSTER
POWER STEERING FLUID
BELTS LOOSE
POWER STEERING SYSTEM

**C1**
IS THE FLUID LEVEL IN THE POWER STEERING PUMP RESERVOIR OK?

**TEST OPTIONS**
VISUAL INSPECTION.

**REASON FOR QUESTION**
The hydro-booster gets its power from the power steering pump.

**YES**
FILL TO PROPER LEVEL AND BLEED IF NECESSARY

**NO**

**KNOWN INFO**
HYDRO-BOOSTER SYSTEM
NOT WORKING PROPERLY
POWER STEERING FLUID OK

**POSSIBLE PROBLEMS**
HYDRO-BOOSTER BELTS LOOSE
POWER STEERING SYSTEM

**C2**
ARE THE POWER STEERING BELTS ADJUSTED TO THE CORRECT TENSION?

**TEST OPTIONS**
USE BELT TENSION GAUGE.

**REASON FOR QUESTION**
If power steering system isn't working properly, the hydro-booster may not get enough power to work properly.

**YES**
ADJUST TO PROPER TENSION

**NO**

**KNOWN INFO**
HYDRO-BOOSTER SYSTEM
NOT WORKING PROPERLY
POWER STEERING FLUID OK
BELTS OK

**POSSIBLE PROBLEMS**
HYDRO-BOOSTER
POWER STEERING SYSTEM

**C3**
ARE ALL THE POWER STEERING HYDRAULIC COMPONENTS KNOWN TO BE OK?

**TEST OPTIONS**
CHECK COMPONENTS. YOU CAN RUN THE TESTS IN PARAGRAPH 2-37 TO TEST THE STEERING.

**REASON FOR QUESTION**
Power steering system and brake system share some of the same hydraulic components to run the hydro-booster.

**NO**
REPLACE AS REQUIRED

**YES**

**REPLACE HYDRO-BOOSTER**
Bleed power steering system, refer to (para 8-29).

Check belts using the belt tension gauge, refer to (pars 3-82) (All except "A2" vehicles).

A defective power steering pump, gear, hoses, or control valve could affect hydro-booster operation.
2-37. STEERING SYSTEM TESTS

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 FO-14 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.
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.

**WARNING**

**PRIORITY 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 9-2320-280-10].
   b. Replace my unserviceable rims (para 8-4).
2. Check steering linkage for damage.
   a. Replace any damaged steering linkage components (para 3-12).
   b. Lubricate steering linkage [TM 9-2320-280-10].
3. Check power steering fluid for contamination and level
   a. Drain and replace any fluid that appears black and smells burned.
   b. Bleed air from system where fluid appears milky white (para 8-29).
4. Check pump drive belts for fraying, cracks, damage, or misadjustment.
   a. Replace unserviceable power steering drive belts (para 3-80).
   b. Adjust loose power steering drive belts (para 3-82).

While travelling at a moderate speed (20mph) (32 kmph), 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 at which it occurs 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, then there probably isn’t a problem with the brakes (at least not one that affects the steering). If the braking action feels strange in anyway, then the brake diagnostics should be run to assure vehicle safety. TM 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, end jerking of the steering wheel when turning.
**STEERING SYSTEM**

**KNOWN INFO**
- BRAKES OK
- STRAIGHT LINE BEHAVIOR OK
- POWER STEERING SYSTEM OK

**POSSIBLE PROBLEMS**
- SUSPENSION

**DIAGNOSTIC FLOWCHART**

**4**

**IS THE VEHICLE FREE FROM RATTLING NOISES AND STRANGE VIBRATIONS WHEN TURNING OR GOING OVER ROUGH TERRAIN?**

**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.

**GO TO C, Page 2-472**

**NO FAULTS**

FROM 3
Page 2-460
Drive the vehicle until the fires 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 fires warm up.
STREETING SYSTEM

KNOWLEDGE INFO

VEHICLE EXHIBITS POOR STRAIGHT LINE STEERING

POSSIBLE PROBLEMS

TIRES ALIGNMENT SUSPENSION

A1

ARE THE TIRES AND WHEELS OK?

YES

REPAIR OR REPLACE AS NEEDED

NO

TEST OPTIONS

CHECK THE TIRES FOR PROPER INFLATION AND FOR UNEVEN OR EXCESSIVE WEAR. 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.

TEST OPTIONS

MEASURE TOE.

REASON FOR QUESTION

Poorly adjusted toe-in could have an effect on directional stability.

TEST OPTIONS

MEASURE TOE.

REASON FOR QUESTION

Poorly adjusted toe-out could have an effect on directional stability.

GO TO C.

Page 2-472
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 8-10).

For instructions on adjusting rear wheel toe-out, refer to (para 8-11). Part C will test out the suspension parts to see if they are OK.
**STEERING SYSTEM**

### KNOWN INFO
- STRAIGHT LINE BEHAVIOR OK
- BRAKES OK
- HARD STEERING EFFORT

### POSSIBLE PROBLEMS
- POWER STEERING PUMP
- POWER STEERING COMPONENTS
- SUSPENSION

### DIAGNOSTIC FLOWCHART

#### B1
- **Are the power steering belts tightened properly and in good condition?**
  - **NO:** 
    - ADJUST OR REPLACE BELTS
  - **YES:** 
    - B2

#### B2
- **Is the fluid level normal in the power steering pump?**
  - **NO:** 
    - ADD FLUID AND BLEED SYSTEM
  - **YES:** 
    - B3

#### B3
- **Are the power steering pump, pulley, and bracket firmly attached and in good working order?**
  - **NO:** 
    - REPAIR/REPLACE POWER STEERING COMPONENTS
  - **YES:** 
    - GO TO B4, Page 2-468

### TEST OPTIONS
- **LOOK AT BELTS FOR STRETCHING AND FRAYING. USE BELT TENSION GAUGE TO MEASURE BELT TENSION.**
- **REASON FOR QUESTION**
  - If the belts are loose or broken, the power steering unit may not work properly.

- **CHECK THE CAP/DIPSTICK FOR PROPER FLUID LEVEL.**
- **REASON FOR QUESTION**
  - Low fluid level may cause power steering pump to work improperly.

- **CHECK THEM.**
- **REASON FOR QUESTION**
  - Loose or broken power steering components could cause power steering assist to work improperly.
Check belts using the belt tension gauge, refer to (para 3-82) (All except "A2" Vehicles).

Do not overfill hydraulic fluid.

See TM 9-2320-280-10 for fluid replacement procedure. For bleeding procedure, refer to (para 8-29).

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.

A loose pump, pulley, or bracket could cause excess noise, slipping belts, or other malfunctions. For appropriate repair or replacement procedures, refer to (para 8-24).
Check hydraulic hoses, power steering pump, power steering cooler, hydraulic control valve, hydro-boost unit, steering gear, fan shroud, and fan clutch. See hose replacement procedures (refer to para 8-25). Check power steering cooler for bent fins or any other airflow restrictions. Straighten fins or replace power steering cooler (para. 8-28) 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 2-469)
DOES THE COOLING FAN DISENGAGE PROPERLY?

FROM Page 2-468

REASON FOR QUESTION
If the power steering pump can develop enough pressure to disengage the fan, the pump and gear are probably OK.

REMEMBER FOR END OF TEST

GO TO B7, Page 2-470

NO

YES
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. 2-43)].
12. Open analyzer valve to full open position.
13. Start engine (Refer to TM 9-2320-280-10). 
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. 3-44). 
16. Check and add power steering fluid to reach FULL COLD level in reservoir (Refer to TM 9-2320-280-10).
17. Start engine (Refer to TM 9-2320-280-10) 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. 3-44).
   - 6.2L engine: 650±25 RPM
   - 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 9-2320-280-10).
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. 8-24).
   **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. 8-24).
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. 8-24).
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. 8-21).
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. 8-21).
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. 7-14).
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. 7-14).
28. Shut off engine. Remove power steering analyzer and restore power steering system to original configuration.
29. Bleed power steering system (para. 8-29).

**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 2-25.
**STEERING SYSTEM**

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>HARD OR ABNORMAL STEERING</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POSSIBLE PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWER STEERING PUMP</td>
</tr>
<tr>
<td>POWER STEERING GEAR</td>
</tr>
<tr>
<td>FAN DRIVE</td>
</tr>
<tr>
<td>HYDRO-BOOSTER</td>
</tr>
</tbody>
</table>

**DIAGNOSTIC FLOWCHART**

**FROM B6, Page 2-468**

**B7**

**TEST OPTIONS**

**IS THE HYDRO-BOOSTER WORKING PROPERLY?**

**REASON FOR QUESTION**
The hydro-booster will affect the operation of the steering system.

<table>
<thead>
<tr>
<th>TEST OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEE INSTRUCTIONS AT RIGHT.</td>
</tr>
</tbody>
</table>

**B8**

**TEST OPTIONS**

**TRY IT**

**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.

<table>
<thead>
<tr>
<th>TEST OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRY IT</td>
</tr>
</tbody>
</table>

**B9**

**TEST OPTIONS**

**N/A**

**LOOK AT THE CHART TO THE RIGHT TO DETERMINE WHAT IS WRONG AND REPAIR IT AS DIRECTED.**

**REASON FOR TESTS**

**N/A**
Method for checking hydro-booster. Depress brake pedal several times to exhaust accumulator. Depress brake pedal and start engine. Brake pedal should fall, 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></td>
</tr>
<tr>
<td>NO     NO     NO</td>
<td>POWER STEERING PUMP</td>
</tr>
<tr>
<td>NO     NO     YES</td>
<td>SEE NOTE BELOW</td>
</tr>
<tr>
<td>NO     YES     NO</td>
<td>SEE NOTE BELOW</td>
</tr>
<tr>
<td>NO     YES     YES</td>
<td>RUN ENGINE COOLING TEST (PARA 2-19)</td>
</tr>
<tr>
<td>YES     NO     NO</td>
<td>POWER STEERING PUMP</td>
</tr>
<tr>
<td>YES     NO     YES</td>
<td>HYDRO-BOOSTER</td>
</tr>
<tr>
<td>YES     YES     NO</td>
<td>DS LEVEL 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**

**Known Info**
- Wheels and tires OK
- Brakes OK
- Alignment OK

**Possible Problems**
- Steering components
- Suspension components

**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?**

**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.

**Test Options**
- Replace as needed

**C2**

**Check Power Steering Drivebelt Pulley for Grooves and Scoring, and Make Sure Belt Tension is OK. Are These OK?**

**Test Options**
1. Visual inspection.
2. Belt tension gauge.

**Reason for Question**
A damaged pulley will ruin the drivebelt. A loose belt will slip, causing the power steering to loose power or fail.

**Test Options**
- Replace damaged/worn belt or pulley

**C3**

**Are the Ball Joints OK (Not Worn)?**

**Test Options**
- Procedure at right

**Reason for Question**
Worn ball joints can result in difficult or noisy steering.

**Test Options**
- Replace ball joints

**Go to C4, Page 2-474**
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:
- (i) Chock rear wheels front and back.
- (ii) Raise front wheels about two inches off the ground and support on a jack stand.
  - (a) Lower ball joints.
- (iii) 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.
- (iv) Put a prybar between the cover control arm and geared hub.
- (v) Set a 6-inch ruler upright between the lower control arm and the marked screw.
- (vi) Push down the prybar to try to move the hub.
- (vii) 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.
- (viii) Grasp top of tire and attempt to move it in and out.
- (ix) Measure any movement at top outer edge of tire. Replace upper ball joints if tire movement is 3/8 inch (10 mm) or more (refer to para. 6-26).
STEERING SYSTEM

FROM C3, Page 2-472

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.

NO
REPLACE CONTROL ARMS/BUSHINGS

YES

C5

ARE THE SHOCK ABSORBERS AND COIL SPRINGS OPERATING EFFECTIVELY?

TEST OPTIONS
PROCEDURE AT RIGHT

REASON FOR QUESTION
Broken or fatigued shock absorbers and coils can lead to loss of steering control on rough surfaces.

NO
REPLACE SHOCKS/COIL SPRINGS

YES

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
REPLACE RADIUS ROD

YES

GO TO C7, Page 2-476
For upper and lower control arm and bushing replacement instructions, refer to (para 6-28 and 6-29).

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 maybe 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 6-30 and 6-31).

For instructions on replacing the radius rod, refer to (para 6-25).
STEERING SYSTEM

FROM C6, Page 3-474

KNOWLEDGE INFORMATION

MOST STEERING AND SUSPENSION PARTS ARE OK

POSSIBLE PROBLEMS

STEERING SHAFTS CAPSCREWS STABILIZER BAR

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.

TEST OPTIONS

VISUAL INSPECTION.

REASON FOR QUESTION

If the bar is broken or loose, the vehicle could be hard to control at moderate to high speeds during turns.

TEST OPTIONS

1. VISUAL INSPECTION.
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.

NO FAULTS
NOTE
Inspect intermediate shaft U-joints for wear, binding, or missing/damaged grease fittings. Replace or lubricate as necessary. Refer to (para. 8-22) for replacement and TM 9-2320-280-10 Appendix G, for lubrication instructions.

Replace the stabilizer bar, refer to (para 6-23).

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.
2-38. DRIVETRAIN TESTS

These Drivetrain tests maybe run anytime 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 FO-15 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 Paragraph 2-34 or 2-35.
START

1. IS THE TRANSMISSION FLUID OK?
   - NO: SEE NOTE AT RIGHT
   - YES: VISUAL - SEE NOTE AT RIGHT

   **POSSIBLE PROBLEMS:**
   - TRANSFER CASE
   - DIFFERENTIALS
   - HALF AND PROPELLER SHAFTS
   - CV & U-JOINTS
   - GEARED HUBS

2. ROAD TEST THE VEHICLE. DOES IT PASS?
   - NO: GO TO A, Page 2-486
   - YES: TRY ALL TRANSFER CASE OPTIONS AND NOTE UNUSUAL BEHAVIOR

   **POSSIBLE PROBLEMS:**
   - TRANSFER CASE
   - DIFFERENTIALS
   - HALF AND PROPELLER SHAFTS
   - CV & U-JOINTS
   - GEARED HUBS

3. DOES THE SPEEDOMETER WORK?
   - NO: GO TO C, Page 2-494
   - YES: VISUAL INSPECTION

   **POSSIBLE PROBLEMS:**
   - TRANSFER CASE
   - DIFFERENTIALS
   - HALF AND PROPELLER SHAFTS
   - CV & U-JOINTS
   - GEARED HUBS

4. VEHICLE PASSES ROAD TEST
   - GO TO 4, Page 2-482
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.
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.

- Bubbles indicate an overfilled system or air leaks in the system. Drain the fluid and refill to proper level, refer to (para 5-2).

- Milky appearance is due to water in the system. Replace fluid, and replace filter.

If the speedometer works, but the vehicle doesn't move, the transmission is OK and the problem is in the final drive. Most likely the fault is in the splined output shafts of the transfer case. Listen for unusual noise.
DRIVETRAIN

FROM 3,
Page 2-480

4

INSPECT THE HALFSHAFTS AND THE CONSTANT VELOCITY (CV) JOINTS. ARE THEY OK?

TEST OPTIONS
VISUAL INSPECTION.

REASON FOR QUESTION
The halfshafts transmit power from the differentials to the geared hubs.

NO
REPAIR OR REPLACE AS NEEDED

YES

TEST OPTIONS
VISUAL INSPECTION.

REASON FOR QUESTION
The propeller shafts transmit power from the transfer case to the differentials.

NO
REPAIR OR REPLACE AS NEEDED

YES

TEST OPTIONS
VISUAL INSPECTION.

REASON FOR QUESTION
The geared hubs transmit power from the drivetrain to the wheels.

NO
REPAIR OR REPLACE AS NEEDED

YES

GO TO 7,
Page 2-484

TM 8-2320-280-20-1

2-482
Check for torn boots on the CV joints, stripped splines, smooth joint operation, and proper mounting torques. Replace halfshafts and CV joints, refer to (para 6-9).

Lube in accordance with TM 9-2320-280-10.

Check for smooth operation of U-joints, stripped splines, bent yokes, or other problems. Also check to see if the shaft itself is bent. Replace propeller shafts or U-joints, refer to (para 6-2 through 6-7).

Lube in accordance with TM 9-2320-280-10.

Make sure the geared hubs turn freely. Check mounting hardware for proper installation.

Lube in accordance with TM 9-2320-280-10.

Replace geared hubs, refer to (para 6-11).
DRIVETRAIN

KNOWN INFO
- Propeller Shafts OK
- U-Joints OK
- Shifter OK
- Transfer Case OK
- Halfshafts and CV Joints OK

POSSIBLE PROBLEMS
- Differentials

DIAGNOSTIC FLOWCHART

TEST OPTIONS
- Visual Inspection.

REASON FOR QUESTION
- The only thing left is the differentials.

INSPECT THE FRONT AND REAR DIFFERENTIALS. ARE THEY OK?

NOTIFY DS, EXCEPT FOR LUBRICATION

YES

NO

NO FAULTS FOUND IF YOU WERE SENT HERE FROM ANOTHER TEST CHAIN RETURN THERE

FROM 6, Page 2-482
Check for loose mounting and broken parts.

Check fluid in accordance with [TM 9-2320-280-10].

Notify DS maintenance for other faults.

DRIVETRAIN
**DRIVETRAIN**

**KNOWN INFO**

- VEHICLE FAILS
- ROAD TEST
- FLUID OK

**POSSIBLE PROBLEMS**

- SHIFTER
- PROPELLER SHAFTS
- HALFSHAFTS
- GEARED HUBS
- TRANSFER CASE

**TEST OPTIONS**

- VISUAL INSPECTION.

**REASON FOR QUESTION**

To make sure the shifter works.

---

**A1**

WITH THE VEHICLE OFF, HAVE AN ASSISTANT MOVE THE SELECTOR LEVER. DOES THE LINKAGE AT THE TRANSFER CASE WORK PROPERLY?

- **NO**
  - REPAIR SHIFTER AS NEEDED

- **YES**
  - GO TO A2, Page 2-489

---

**A2**

DOES THE VEHICLE MOVE AT ALL?

- **NO**
  - GO TO B, Page 2-489

- **YES**
  - GO TO A3, Page 2-489

---

**A3**

DOES THE TRANSMISSION WORK PROPERLY?

- **NO**
  - GO TO TRANSMISSION [Page 2-399] or 2-411

- **YES**
  - GO TO A4, Page 2-489

---

**TEST OPTIONS**

- VISUAL.

**REASON FOR QUESTION**

If the vehicle doesn't move, it means the transmission or transfer case are probably at fault.

---

**A4**

TRY TO FEEL IF THE TRANSMISSION IS SHIFTING PROPERLY, OR GO TO TRANSMISSION, PAGE 2-399 or 2-411.

**REASON FOR QUESTION**

A road test failure could be due to the transmission.
Adjust and repair linkage, refer to (para 5-8 or 5-11). 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.

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.

Lube in accordance with Table 2-1.
DRIVETRAIN

KNOWN INFO
VEHICLE FAILS
ROAD TEST
FLUID OK
SHIFTER OK
VEHICLE MOVES

POSSIBLE PROBLEMS
DIFFERENTIALS
SHAFTS
GEARED HUBS
TRANSFER CASE

A4

ARE BOTH PROPELLER SHAFTS AND U-JOINTS OK?

NO

REPLACE AS NEEDED

YES

A5

ARE ALL 4 HALFSHAFTS AND CONSTANT VELOCITY JOINTS OK?

NO

REPLACE AS NEEDED

YES

TEST OPTIONS
VISUAL INSPECTION.

REASON FOR QUESTION
The propeller shafts transmit power to the differentials.

TEST OPTIONS
VISUAL.

REASON FOR QUESTION
Halfshafts transmit power from the differentials to the geared hubs.

A6

INSPECT THE GEARED HUBS. ARE THEY OK?

NO

REPLACE AS NEEDED

YES

TEST OPTIONS
VISUAL INSPECTION.

REASON FOR QUESTION
The geared hubs transmit power from the drive train to the wheels.

SEE NOTE AT RIGHT
Lube in accordance with TM 9-2320-280-10.

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, refer to (para 6-4 thru 6-7).

Check for torn boots on the CV joints, stripped splines, smooth joint operation, and proper mounting torques.

For halfshaft maintenance procedures, refer to (para 6-9).

Lube in accordance with TM 9-2320-280-10.

Make sure the geared hubs turn freely. Check mounting hardware for proper installation.

Lube in accordance with TM 9-2320-280-10.

NOTE
If you haven’t found any faults, check the differential fluid in accordance with TM 9-2320-280-10. Otherwise notify DS maintenance.
DRIVETRAIN

**KNOWN INFO**
- Vehicle doesn't move
- Shifter OK
- Fluid OK

**POSSIBLE PROBLEMS**
- Transfer case
- Transmission
- Half and propeller shafts
- Geared hubs

---

**B1**

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.

---

**B2**

INSPECT THE FRONT AND REAR PROPELLER SHAFTS AND U-JOINTS. ARE THEY OK?

**TEST OPTIONS**
- Visual inspection.

**REASON FOR QUESTION**
The propeller shafts transmit power from the transfer case to the differentials.

---

**B3**

INSPECT THE HALFSHAFTS AND THE CONSTANT VELOCITY JOINTS. ARE THEY O.K.?

**TEST OPTIONS**
- Visual inspection.

**REASON FOR QUESTION**
The halfshafts transmit power from the differentials to the geared hubs.

---

**GO TO B4, [Page 2-492]**
If the vehicle doesn't work, then 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, refer to (para 6-2 thru 6-6).

Lube in accordance with TM 9-2320-280-10.

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 6-9).

Lube in accordance with TM 9-2320-280-10.
DRIVETRAIN

KNOWN INFO
SHIFTER OK
TRANSFER CASE OK
TRANSMISSION OK
PROPELLER SHAFTS
U-JOINTS
HALFSHAFTS AND
CV JOINTS OK

POSSIBLE PROBLEMS
GEARED HUBS
DIFFERENTIALS

B4

FROM B3,
Page 2-490

INSPECT THE GEARED HUBS.
ARE THEY OK?

YES

NO

REPLACE AS
NEEDED

TEST OPTIONS
VISUAL INSPECTION.

REASON FOR QUESTION
The geared hubs transmit
power from the drive
train to the wheels.

KNOWN INFO
SHIFTER OK
TRANSFER CASE OK
TRANSMISSION OK
SHAFTS AND JOINTS OK
GEARED HUBS OK

POSSIBLE PROBLEMS
DIFFERENTIALS

B5

CHECK THE FLUID LEVEL AND
CONDITION IN EACH
DIFFERENTIAL. IS IT OK?

YES

CHANGE AS
NEEDED

NO

TEST OPTIONS
VISUAL

REASON FOR QUESTION
To make sure the
differentials are OK.

B6

IF YOU STILL HAVE A PROBLEM,
RUN TRANSMISSION TESTS
(PARA. 2-34 or 2-35) IF YOU
HAVEN'T ALREADY. OTHERWISE,
NOTIFY DS MAINTENANCE.
Make sure the geared hubs turn freely. For geared hub replacement procedure, refer to (para 6-11). Check mounting hardware for proper installation. Lube in accordance with TM 9-2320-280-10.

Check for loose mounting and broken parts. Notify DS maintenance.

Check fluid level in accordance with TM 9-2320-280-10.

Notify DS maintenance for other faults.
**Drivetrain Diagnostic Flowchart**

**Known Info**
- Speedometer doesn't work

**Possible Problems**
- Driven gear
- Cable
- Speedometer head

**C1**
- Disconnect the speedometer cable from the transfer case. Turn the cable by hand. Does the speedometer respond to the cable?

**Test Options**
- Test Options: Have an assistant turn one end while you watch the other.

**Reason for Question**
- This will tell you if the cable is OK.

**Test Options**
- Test Options: Turn the cable and have an assistant see if the needle moves. It will only move a little, so watch closely.

**Reason for Question**
- If the speedometer moves in response to the cable, it means the driven gear or the drive gear is no good.

**C2**
- Disconnect the speedometer cable from the speedometer again. Turn the cable by hand at the transfer case. Did the speedometer end of the cable turn?

**Test Options**
- Yes → Replace cable
- No → Replace speedometer
REFERENCE INFORMATION

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.

Replace the driven gear, refer to (para 5-24).

Replace the cable, refer to (para 4-15).

Replace speedometer, refer to (para 4-14).
2-39. AMBULANCE ELECTRICAL SYSTEM TESTS

This section provides information to diagnose and correct malfunctions of the ambulance electrical system.

Each malfunction symptom given for an individual component or system is followed by step(s) that you should take to determine the cause and corrective action necessary to remedy the problem.

Before taking any action to correct a possible malfunction, the following rules should be followed:

(1) Question the operator to obtain any information that might help you determine the cause of the problem.

(2) Never overlook the chance that the problem could be of simple origin because it could be corrected with minor adjustment.

(3) Use all senses to observe and locate trouble spots.

(4) Use test instruments or gauges to help you 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.

(7) Functional Schematics for ambulance electrical systems are located on pages 2-685 thru 2-691.
AMBULANCE
(All Dome Lamps)
With Ambulance Compartment
Front Door, Rear Door, and Rear
Step closed (Refer to Fig. 11)

START

1

REPLACE OLD BULBS WITH
NEW ONES. IS LIGHT SWITCH ON
CONTROL BOX IN NORMAL
OPERATING POSITION?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Improper switch position would
cause dome lights not to
illuminate.

NO

PLACE LIGHT SWITCH
TO NORMAL POSITION

YES

TEST OPTIONS
1. STE/ICE-R TEST 89,
   Page 2-750
   2. MULTIMETER

REASON FOR QUESTION
Battery malfunction will cause
any dependent circuit to
malfunction.

NO

GO TO 1,
Page 2-292

YES

2

IS BATTERY IN PROPER
WORKING ORDER?

KOWN INFO
LIGHT SWITCH
POSITION OK

TEST OPTIONS
1. STE/ICE-R TEST 89,
   Page 2-750
   2. MULTIMETER

REASON FOR QUESTION
No power at power stud would
indicate a damaged cable from
power source.

NO

GO TO 4,
Page 2-300

YES

3

IS THERE BATTERY VOLTAGE IN
CONTROL BOX AT POWER STUD?

TEST OPTIONS
1. STE/ICE-R TEST 89,
   Page 2-750
   2. MULTIMETER

REASON FOR QUESTION
No power at power stud would
indicate a damaged cable from
power source.

NO

REPAIR CABLE 660

YES

4

FINAL DIAGNOSIS
FURTHER SERVICE
ACCORDING TO OR
INSTRUCTIONS

GO TO 1,
Page 2-292
REFERENCE INFORMATION

AMBULANCE

BLACKOUT REAR STEP SWITCH (SWITCH CLOSED WHEN STEPS UP)

LEFT INTERIOR BLACKOUT LAMP

BLACKOUT REAR DOOR SWITCH (SWITCH CLOSED WHEN DOOR IS CLOSED)

FRONT DOOR SWITCH (SWITCH CLOSED WHEN DOOR IS CLOSED)

TERMINAL BOARD

CONTROL BOX

NEGATIVE BUS

FUSE BLOCK

RELAY NO. 1

LIGHT SWITCH

RELAY NO. 2

POSITIVE POWER

0-45 DC VOLTS
STEACE-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.

Repair cable, refer to DS Maintenance.

2-499
AMBULANCE
(All Dome Lamps)
With Ambulance
Compartment Front Door,
Rear Door, and Rear Step
closed (Refer to Fig. 11.)

FROM 3,
Page 2-408

DIAGNOSTIC FLOWCHART

TEST OPTIONS
1. STE/CE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
If you have battery voltage here, then light switch is ok.

IS THERE BATTERY VOLTAGE IN
CONTROL BOX AT RELAY 1,
TERMINAL 86?

4

YES
REPLACE LIGHT SWITCH

NO

REPLACE RELAY 1

KNOWN INFO

LIGHT SWITCH
POSITION OK
BATTERY OK
CABLE 600 OK

POSSIBLE PROBLEMS
LIGHT SWITCH
RELAY 1

5

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If dome lights operate, then relay 1 is malfunctioning.

PLACE JUMPER WIRE FROM
TERMINAL 87 TO TERMINAL 30 OF
RELAY 1. DO DOME LAMPS
ILLUMINATE?

YES
GO TO 6,
Page 2-502

NO

KNOWN INFO

LIGHT SWITCH POSITION
OK
BATTERY OK
CABLE 600 OK
LIGHT SWITCH OK

POSSIBLE PROBLEMS
RELAY 1
Replace light switch, refer to (para. 4-118).

Replace relay 1, refer to (para. 4-120).

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.

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.
AMBULANCE (All Dome Lamps)  
With Ambulance Compartment Front Door, Rear Door, and Rear Step closed (Refer to Fig. 11)

**DIAGNOSTIC FLOWCHART**

1. **KNOWN INFO**
   - PREVIOUSLY CORRECTED INFORMATION

2. **POSSIBLE PROBLEMS**
   - LEAD 791 E
   - LEAD 791 D
   - BLACKOUT REAR STEP SWITCH LEAD 791 A
   - BLACKOUT REAR DOOR SWITCH LEAD 791 B
   - LEAD 791 A
   - FRONT DOOR SWITCH LEAD 791

3. **TEST OPTIONS**
   - 1. STE/ICE-R TEST 91, PAGE 2-752
   - 2. MULTIMETER

4. **REASON FOR QUESTION**
   - No continuity would indicate a damaged lead.

5. **FROM 5, Page 2-500**

6. **IS THERE CONTINUITY IN THE CONTROL BOX BETWEEN TERMINAL 85 OF RELAY 1 AND TERMINAL BOARD (TB) TERMINAL 5?**

   - NO
   - REPLACE LEAD 791 E

   - YES
   - LEAD 791 E

7. **KNOWN INFO**

8. **POSSIBLE PROBLEMS**
   - LEAD 791 D
   - BLACKOUT REAR STEP SWITCH LEAD 791 C
   - BLACKOUT REAR DOOR SWITCH LEAD 791 A
   - BLACKOUT REAR DOOR SWITCH LEAD 791 B
   - LEAD 791 A
   - FRONT DOOR SWITCH LEAD 791

9. **TEST OPTIONS**
   - 1. STE/ICE-R TEST 91, PAGE 2-752
   - 2. MULTIMETER

10. **REASON FOR QUESTION**
    - No continuity would indicate a damaged lead.

11. **YES**
    - REPAIR LEAD 791 D

12. **IS THERE CONTINUITY BETWEEN TB TERMINAL 5 AND BLACKOUT REAR STEP SWITCH?**

13. **YES**
    - LEAD 791 D

14. **IS THERE CONTINUITY ACROSS BLACKOUT REAR STEP SWITCH?**

15. **NO**
    - ADJUST AND/OR REPLACE BLACKOUT REAR STEP SWITCH

16. **YES**
    - LEAD 791 C

17. **GO TO 9, Page 2-504**
**REFERENCE INFORMATION**

**AMBULANCE**

- **LEFT INTEIOR BLACKOUT LAMP**
- **BLACKOUT REAR STEP SWITCH (SWITCH CLOSED WHEN STEPS UP)**
- **BLACKOUT REAR DOOR SWITCH (SWITCH CLOSED WHEN DOOR IS CLOSED)**
- **FRONT DOOR SWITCH (SWITCH CLOSED WHEN DOOR IS CLOSED)**
- **TERMINAL BOARD**
- **CONTROL BOX**

Repair lead, refer to para. 4-85.
Repair lead connector, refer to para. 4-85.

Replace blackout rear step switch, refer to para. 4-82.

---

**0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9.9."

---

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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 blackout rear door switch, refer to (para. 4-93).

0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
AMBULANCE (All Dome Lamps) With Ambulance Compartment Front Door, Rear Door, and Rear Step Closed (Refer to Fig. 11.)

**Diagnostic Flowchart**

**Known Info**

- Lead 791 E OK
- Lead 791 D OK
- Blackout Rear Step Switch OK
- Blackout Rear Door Switch OK

**Possible Problems**

- Blackout Rear Door Switch Lead 791 B
- Lead 791 A
- Front Door Switch Lead 791

**Separate Block Diagram Flow**

11. **Is there continuity across second black-out rear door switch?**
   - Yes: Adjust and/or replace blackout rear door switch
   - No: Go to 12, Page 2-190

12. **Is there continuity of lead 791 B?**
   - Test Options:
     -ステーションテスト 91, Page 2-732
   - Reason for Question:
     - No continuity would indicate a malfunction of the switch.
   - Yes: Go to 1, Page 2-190
   - No: Go to 13, Page 2-504

13. **Is there continuity between front door switch and lead 791 B?**
   - Test Options:
     -ステーションテスト 91, Page 2-732
   - Reason for Question:
     - No continuity would indicate a damaged lead.
   - Yes: Repair lead 791 A
   - No: Go to 14, Page 2-504
0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays “9999.”

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

---

REFERENCE INFORMATION

Replace blackout rear door switch, refer to (para. 4-85).

Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).

Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).
REFERENCE INFORMATION

Replace front door switch, refer to (para. 4-94).

Repair lead, refer to (para. 4-85).

0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms. STE/ICE displays “9.9.9.9.”

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
AMBULANCE
(All Dome Lamps)
With Ambulance
Compartment Front Door,
Rear Door, and Rear Step
Closed (Refer to Fig. 11)

FROM 16,
Page 2-508

17

IS THERE BATTERY VOLTAGE IN
CONTROL BOX AT FUSE BLOCK?

NO

REPLACE LEAD 660 D

YES

18

CHECK FUSE BLOCK IN CONTROL
BOX. ARE FUSES OK?

NO

REPLACE BLOWN FUSES

YES

19

IS THERE BATTERY VOLTAGE IN
CONTROL BOX AT:
TB TERMINAL 1?
TB TERMINAL 2?

NO

REPLACE LEAD 712
AND/OR LEAD 711

YES

GO TO 20,
Page 2-512

TEST OPTIONS
1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No voltage would indicate a
damaged power supply lead,
thus no power.

TEST OPTIONS
1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate
damaged leads.

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Damaged fuses causes the
power circuit to be incomplete.
REFERENCE INFORMATION

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.

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.
AMBULANCE
(All Dome Lamps)
With Ambulance
Compartment Front Door, Rear Door, and Rear Step
Closed (Refer to Fig. 11.)
Replace dome lamp assembly, refer to (para. 4-67).
Repair lead connector, refer to (para. 4-85).

---

**D-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.

---

**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.
AMBULANCE
(All Dome Lamps)
With Ambulance
Compartment Front Door, Rear Door, and Rear Step
Closed (Refer to Fig. 11.)

FROM 21, Page 2-512

TEST OPTIONS
STE/ICE-R TEST 91, Page 2-512

REASON FOR QUESTION
No continuity would indicate a damaged lead.

IS THERE CONTINUITY IN CONTROL BOX BETWEEN NEGATIVE BUSS AND LIGHT SWITCH?

REPAIR LEAD 797

YES

NO

TEST OPTIONS
1. STE/ICE-R TEST 91, Page 2-512
2. MULTIMETER

REASON FOR QUESTION
No continuity would indicate a damaged switch.

IS THERE CONTINUITY IN CONTROL BOX ACROSS LIGHT SWITCH?

REPLACE LIGHT SWITCH

YES

NO

TEST OPTIONS
STE/ICE-R TEST 91, Page 2-512

REASON FOR QUESTION
No continuity would indicate a damaged lead.

IS THERE CONTINUITY IN CONTROL BOX, AT LIGHT SWITCH, OF LEAD 718?

REPLACE LEAD 718

YES

NO

GO TO 25, Page 2-518
Repair lead, refer to (para. 4-85).

Replace light switch, refer to (para. 4-118).

0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
AMBULANCE
(All Dome Lamps)
With Ambulance
Compartment Front Door,
Rear Door, and Rear Step
Closed (Refer to Fig. 11.)

FROM 24,
Page 2-514

DIAGNOSTIC FLOWCHART

TEST OPTIONS
STE/ICE-R TEST 91, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a
damaged lead.

KNOWN INFO
LEAD 797 OK
LIGHT SWITCH OK
LEAD 718 OK

POSSIBLE PROBLEMS
LEAD 718 A
LEAD 719
DAMAGED LEADS
DOME LAMP SOCKETS

25
IS THERE CONTINUITY IN
CONTROL BOX BETWEEN RELAY 1,
TERMINAL 30, AND LIGHT SWITCH?

YES
REPLACE LEAD 718 A

NO

REPLACE LEAD 719

KNOWN INFO
LEAD 797 OK
LIGHT SWITCH OK
LEAD 718 OK
LEAD 718A OK

POSSIBLE PROBLEMS
LEAD 719
DAMAGED LEADS
DOME LAMP SOCKETS

26
IS THERE CONTINUITY IN
CONTROL BOX BETWEEN TB
TERMINAL 3, RELAY 1, AND
TERMINAL 87?

YES

NO

REPAIR DAMAGED LEADS

TEST OPTIONS
1. STE/ICE-R TEST 91, PAGE 2-752
2. MULTIMETER

REASON FOR QUESTION
No continuity would indicate
damaged leads.

KNOWN INFO
LEAD 797 OK
LIGHT SWITCH OK
LEAD 718 OK
LEAD 718 A OK
LEAD 719 OK

POSSIBLE PROBLEMS
DAMAGED LEADS
DOME LAMP SOCKETS

27
IS THERE CONTINUITY IN
CONTROL BOX BETWEEN TB
TERMINAL 3 AND DOME LAMPS
THROUGH:
LEADS 719 A, 719 B, AND719 E?
LEADS 719 A, 719 F, 719 K, AND
719 G?

YES

NO

GO TO 28,
Page 2-518

TM 9-2320-280-20-1

2-516
REFERENCE INFORMATION

AMBULANCE

0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 10000 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 lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).
AMBULANCE (All Dome Lamps)
With Ambulance Compartment Front Door, Rear Door, and Rear Step Closed (Refer to Fig. 11.)

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**
- LEAD 797 OK
- LIGHT SWITCH OK
- LEAD 718 OK
- LEAD 718 A OK
- LEAD 719 OK
- DAMAGED LEADS OK

**POSSIBLE PROBLEMS**
- DAMAGED LAMPS

**TEST OPTIONS**
1. STE/ICE-R TEST 91, [Page 2-752]
2. MULTIMETER

**REASON FOR QUESTION**
No continuity would indicate damaged lamp sockets.

**FLOWCHART: 28**

- **IS THERE CONTINUITY THROUGH DOME LAMPS?**
  - **YES**
    - REPLACE DAMAGED DOME LAMPS
  - **NO**
    - **TEST OPTIONS**
      - TRY IT
    - **REASON FOR QUESTION**
      - If lamps do not illuminate, that would indicate a malfunction not handled at this level.

**FLOWCHART: 29**

- **DO DOME LAMPS ILLUMINATE?**
  - **YES**
    - NOTIFY DS MAINTENANCE
  - **NO**
    - END OF TESTING
Refer to para. 4-87.

**0-4500 DC 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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).
AMBULANCE
(All Dome Lamps)
With Ambulance compartment front door, rear door, and rear step open and vehicle light switch in service position. (Refer to Fig. 11.)

1. REPLACE OLD BULBS WITH NEW ONES. IS VEHICLE LIGHT SWITCH OK?

   NO
   REPAIR/REPLACE VEHICLE LIGHT SWITCH

   YES
2. IS VEHICLE LIGHT SWITCH IN PROPER OPERATING POSITION?

   NO
   PLACE VEHICLE LIGHT SWITCH TO SERVICE DRIVE POSITION

   YES
3. PERFORM STEPS 1-3, PAGE 2-498 AND STEP 4, PAGE 2-500 AND GO TO 4, PAGE 2-522

   NO

   REASON FOR QUESTION
   Loose connection can be the cause of a malfunction.

   REASON FOR QUESTION
   Improper switch position would cause dome lamps to illuminate.

   REASON FOR QUESTION
   No power would indicate a relay 2 malfunction.

   TEST OPTIONS
   VISUAL

   KNOWN INFO
   VEHICLE LIGHT SWITCH OK
   VEHICLE LIGHT SWITCH POSITION OK
   RELAY 2

   POSSIBLE PROBLEMS
   VEHICLE LIGHT SWITCH POSITION RELAY 2

   KNOWN INFO
   NOTHING

   POSSIBLE PROBLEMS
   VEHICLE LIGHT SWITCH
   VEHICLE LIGHT SWITCH POSITION
   RELAY 2

   TEST OPTIONS
   VISUAL

   KNOWN INFO
   RELAY 2

   POSSIBLE PROBLEMS
   VEHICLE LIGHT SWITCH
   VEHICLE LIGHT SWITCH POSITION
   RELAY 2

   TEST OPTIONS
   TRY IT

   GO TO 4, PAGE 2-522
Replace main light switch, refer to (para. 4-59).
AMBULANCE (All Dome Lamps)

With Ambulance compartment front door, rear door, or rear step open and vehicle light switch in service position (Refer to Fig. 11.)

**Diagnostic Flowchart**

**Known Info**

<table>
<thead>
<tr>
<th>Vehicle Light Switch OK</th>
<th>Vehicle Light Switch Position OK</th>
<th>Battery OK</th>
<th>Cable 660 OK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Possible Problems</strong></td>
<td>RELAY 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Test Options**

1. Ste/ce-r Test 89, Page 2-750
2. Multimeter

**Reason for Question**

No power would indicate a vehicle light switch malfunction.

**Question 4**

**Is there battery voltage in control box at relay 2, terminal 86?**

**Yes**

Replace Vehicle Light Switch

**No**

Replace Relay 2

**Question 5**

**Place jumper wire from terminal 87 to terminal 30 of relay. Do dome lamps illuminate?**

**Yes**

Go to 6, Page 2-524

**No**

Replace Relay 2
Replace main light switch, refer to (para. 4-50).

Replace relay 2, refer to (para. 4-120).

---

**0-45DC 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 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.
(All Dome Lamps)
With Ambulance compartment front door, rear door, or rear step open and vehicle light switch in service position
(Refer to Fig. 4)

FROM 5, Page 2-522

PERFORM STEPS 18-22 ON PAGES 2-510 THROUGH 2-514. GO TO 7 BELOW IF THE ANSWER TO 21, PAGE 2-512, IS NO.

TEST OPTIONS
TRY IT

REASON FOR QUESTION
No power would indicate damaged leads.

7
IS THERE CONTINUITY IN CONTROL BOX BETWEEN NEGATIVE BUSS AND TERMINAL 85 OF RELAY 2?

TEST OPTIONS
STE-ICE-R TEST 91, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

YES NO
REPLACE LEAD 797 A

8
IS THERE CONTINUITY BETWEEN TERMINALS 85 AND 30 OF RELAY 2?

TEST OPTIONS
STE-ICE-R TEST 91, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

YES NO
REPLACE LEAD 797 B

GO TO 9, Page 2-522

TM 9-2320-280-20-1

2-524
0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."
AMBULANCE (All Dome Lamps)

With Ambulance compartment front door, rear door, or rear step open and vehicle light switch in service position.
(Refer to Fig. 11.)

FROM 8, Page 3-524

DIAGNOSTIC FLOWCHART

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
<th>LEAD 797 A OK</th>
<th>LEAD 797 B OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSSIBLE PROBLEMS</td>
<td>LEAD 791 F</td>
<td></td>
</tr>
</tbody>
</table>

9

IS THERE CONTINUITY IN CONTROL BOX BETWEEN TERMINAL 87 OF RELAY 2 AND TERMINAL 85 OF RELAY 1?

FROM 8, Page 3-524

TEST OPTIONS
STE-ICE-R TEST 91, Page 2-732

REASON FOR QUESTION
No continuity would indicate a damaged lead.

NO

REPLACE LEAD 791 F

YES

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
<th>LEAD 797 A OK</th>
<th>LEAD 797 B OK</th>
<th>LEAD 791 F OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSSIBLE PROBLEMS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10

PERFORM STEPS 22 THROUGH 29 ON PAGES 2-514 THROUGH 2-518

TEST OPTIONS
TRY IT

REASON FOR QUESTION
No continuity would indicate a damaged lead.
0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.999.9."
AMBULANCE (Left Side Dome Lamps) (Refer to Fig. 11)

1. REPLACE OLD BULBS WITH NEW ONES.
   IS THE FUSE IN FUSE BLOCK IN CONTROL BOX OK?

   YES → REPLACE BLOWN FUSE

   NO →

   2. IS THERE BATTERY VOLTAGE IN CONTROL BOX AT TB TERMINAL 1?

   YES → REPLACE LEAD 712

   NO

   3. IS THERE BATTERY VOLTAGE AT LEFT SIDE DOMES LAMPS THROUGH:
   LEADS 712 A, 712 E, AND 712 B?

   YES

   NO → REPAIR DAMAGED LEADS AND/OR REPLACE DOME LAMP ASSEMBLY

   GO TO 4, Page 2-530
Replace dome lamp assembly, refer to (para. 4-87).
Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-86).

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.

BATTERY VOLTAGE
MULTIMETER

1. Set the voltmeter to a 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

AMBULANCE
(Left Side Dome Lamps)
(Refer to Fig. 11.)

KNOWN INFO
RIGHT SIDE DOME LAMPS
AND RELATED CIRCUITS
OK
FUSE OK
LEAD 712 OK
LEAD 712 A OK
LEAD 712 E OK
LEAD 712 B OK
DOME LAMPS OK

POSSIBLE PROBLEMS

DO LEFT SIDE DOME LAMPS
ILLUMINATE?

TEST OPTIONS
TRY IT

REASON FOR QUESTION
No power would indicate
damaged leads.

GO TO 5,
Page 3-532

FROM 3,
Page 3-528

END OF TESTING

YES

NO
AMBULANCE
(Left Side Dome Lamps)
(Refer to Fig. 11.)

Known Info
Previously Corrected Information

Possible Problems
Lead 719 F
Lead 719 K
Lead 719 G
Dome Lamps

Test Options
Step/CE-R Test 91, Page 2-752

Reason for Question
No continuity would indicate a damaged lead.

5

Is there continuity at lead 719 F?

Yes
Repair Lead 719 F

No

6

Is there continuity of leads 719 K and 719 G through to left side dome lamps leads?

Yes
Repair Damaged Leads and/or Dome Lamp Assembly

No

7

Do left side dome lamps illuminate?

Yes
Notify DS Maintenance

No

Test Options
Try It

Reason for Question
If left side dome lamps do not illuminate, that would indicate a malfunction not handled at this level.

END OF TESTING
REFERENCE INFORMATION

AMBULANCE

Repair lead, refer to (para. 4-85).

Replace dome lamp assembly, refer to (para. 4-87). Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).

---

0-4500 DC 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

---

TM 9-2320-280-20-1
2-533
AMBULANCE
(Right Side Dome Lamps)
(Refer to Fig. 11.)

START

1

REPLACE OLD BULBS WITH NEW ONES.
IS THE FUSE IN FUSE BLOCK IN CONTROL BOX OK?

NO
REPLACE BLOWN FUSE

YES

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Damaged fuse causes the power circuit to be incomplete.

2

IS THERE BATTERY VOLTAGE IN CONTROL BOX AT TB TERMINAL 2?

NO
REPLACE LEAD 711

YES

TEST OPTIONS
1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate damaged leads.

3

IS THERE BATTERY VOLTAGE AT RIGHT SIDE DOME LAMPS THROUGH:
LEADS 711 A, 711 F, AND 711 C?

NO
REPAIR DAMAGED LEADS AND/OR REPLACE DOME LAMP ASSEMBLY

YES

TEST OPTIONS
1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate damaged leads.

GO TO 4,
Page 2-538
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.

BATTERY VOLTAGE
MULTIMETER

1. Set the voltmeter to voltmeter 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.

Replace dome lamp assembly, refer to (para. 4-87).
Repair lead, refer to (para. 4-87).
Repair lead connector, refer to (para. 4-85).
AMBULANCE
(Right Side Dome Lamps)
(Refer to Fig. 11.)

DIAGNOSTIC FLOWCHART

KNOWN INFO
FUSE OK
LEAD 711 OK
LEAD 711 A OK
LEAD 711 F OK
LEAD 711 C OK
DOME LAMPS OK

POSSIBLE PROBLEMS

DO RIGHT SIDE DOME LAMPS ILLUMINATE?

END OF TESTING

FROM 3,
Page 2-534

TEST OPTIONS
TRY IT

REASON FOR QUESTION
No power would indicate damaged leads.

GO TO 5,
Page 3-638

YES
NO
AMBULANCE
(Right Side Dome Lamps)
(Refer to Fig. 11.)

FROM 4,
Page 2-336

DIAGNOSTIC FLOWCHART

TEST OPTIONS
STE/ICE-R TEST 91,
PAGE 2-762

IS THERE CONTINUITY OF LEAD
719 F?

NO
REPAIR LEAD 719 F

YES

REASON FOR QUESTION
No continuity would indicate a
damaged lead.

TEST OPTIONS
STE/ICE-R TEST 91,
PAGE 2-762

IS THERE CONTINUITY AT LEADS
719 B AND 719 E THROUGH TO
RIGHT SIDE DOME LAMPS LEADS?

NO
REPAIR DAMAGED
LEADS AND/OR DOME
LAMP ASSEMBLY

YES

REASON FOR QUESTION
No continuity would indicate
damaged leads.

TEST OPTIONS
TRY IT

DO RIGHT SIDE DOME LAMPS
ILLUMINATE?

NO
NOTIFY DS
MAINTENANCE

YES

END OF TESTING
Reference Information

AMBULANCE

0-4500 DC OHMS
STE/ACE-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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ACE displays "9.9.9.9."

Replace dome lamp assembly, refer to (para. 4-87).

Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).
DAMOBULE (Single Dome Lamp)
(Refer to Fig. 11.)

DIAGNOSTIC FLOWCHART

START

1

REPLACE OLD BULB WITH A NEW BULB.

IS THERE BATTERY VOLTAGE AT DOME LAMP?

NO

REPAIR/REPLACE DAMAGED COMPONENTS

YES

2

DOES DOME LAMP ILLUMINATE?

TEST OPTIONS
1. STE/ICE-R TEST 89, PAGE 2-760
2. MULTIMETER

REASON FOR QUESTION
No power would indicate damaged components to dome lamp.

YES

REPLACE DOME LAMP

END OF TESTING

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If dome lamp does not illuminate, that would indicate a dome lamp malfunction.
REFERENCE INFORMATION

AMBULANCE

<table>
<thead>
<tr>
<th>9-45 DC VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEAKER 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>BATTERY VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIMETER</td>
</tr>
<tr>
<td>1. Set the voltmeter to 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>

Repair leads, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

Replace dome lamp assembly, refer to (para. 4-87).
AMBULANCE (SPOTLIGHT) (Refer to Fig. 11)

START

1

REPLACE OLD BULB WITH A NEW ONE. IS LIGHT SWITCH ON CONTROL BOX IN NORMAL OPERATING POSITION?

TEST OPTIONS
VISUAL

NO

PLACE LIGHT SWITCH TO NORMAL POSITION

YES

TEST OPTIONS
TRY IT

REASON FOR QUESTION
Spotlight will not illuminate if light switch is not in correct position.

2

DO DOME LAMPS ILLUMINATE?

TEST OPTIONS
VISUAL

NO

GO TO 6,
Page 2-546

YES

3

IS SPOTLIGHT SWITCH IN PROPER POSITION?

TEST OPTIONS
VISUAL

NO

PLACE SPOTLIGHT SWITCH TO PROPER POSITION

YES

GO TO 4,
Page 2-544
AMBULANCE (Spotlight)  
(Refer to Fig. 11.)

**KNOWN INFO**
- Light Switch Position OK
- Dome Lamps OK
- Spotlight Switch Position OK

**POSSIBLE PROBLEMS**
- Corroded Connections
- Loose Lamp Socket
- Damaged Wire
- Terminals
- Spotlight

**DIAGNOSTIC FLOWCHART**

1. **FROM 3, Page 2-542**
2. **TEST OPTIONS**
   1. STE/CE-R TEST 89, PAGE 2-750
   2. MULTIMETER

3. **REASON FOR QUESTION**
   No power to spotlight would indicate damaged leads and/or spotlight.

4. **REPAIR/REPLACE DAMAGED COMPONENTS AND/OR REPLACE SPOTLIGHT**

5. **KNOWN INFO**
   - Light Switch Position OK
   - Dome Lamps OK
   - Spotlight Switch Position OK
   - Connections OK
   - Lamp Socket Tight
   - Wire Terminals OK
   - Spotlight OK

6. **POSSIBLE PROBLEMS**

7. **TEST OPTIONS**
   - TRY IT

8. **REASON FOR QUESTION**
   If lamps do not illuminate, that would indicate a malfunction not handled at this level.

9. **NOTIFY DS MAINTENANCE**

10. **END OF TESTING**

---

2-544
Replace spotlight assembly, refer to (para. 4-86).
Repair leads, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

<table>
<thead>
<tr>
<th>0-45 DC VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/CE-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>

| 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. |
AMBULANCE (Spotlight) (Refer to Fig. 11.)

FROM 2, Page 2-542

PERFORM STEPS 1 THROUGH 29, PAGES 2-498 THROUGH 2-518 IF VEHICLE LIGHT SWITCH IS IN THE BLACKOUT DRIVE POSITION. IF VEHICLE LIGHT SWITCH IS IN THE SERVICE DRIVE POSITION, PERFORM STEPS 1 THROUGH 10, PAGES 2-520 THROUGH 2-526, AND RETURN TO 3, PAGE 2-542.

TEST OPTIONS
TRY IT

REASON FOR QUESTION
No power would indicate damage in electrical system.
AMBULANCE
(Interior Blackout Lamps)
(Refer to Fig. 11)

START

1

REPLACE OLD BULBS WITH NEW ONES. IS LIGHT SWITCH ON CONTROL IN BLACKOUT POSITION?

NO

PLACE LIGHT SWITCH TO BLACKOUT POSITION

YES

TEST OPTIONS

VISUAL

REASON FOR QUESTION
Improper switch position would cause interior blackout lamps not to illuminate.

TEST OPTIONS

TRY IT

REASON FOR QUESTION
Interior blackout lamps are powered off of the dome lamp circuit.

3

PLACE JUMPER WIRE FROM TERMINAL 87A TO TERMINAL 30 OF RELAY 1 IN CONTROL BOX. DO BLACKOUT LAMPS ILLUMINATE?

NO

NOTIFY DS MAINTENANCE

YES

REPLACE RELAY 1

TEST OPTIONS

TRY IT

REASON FOR QUESTION
If interior blackout lamps illuminate, that would indicate a relay malfunction.

KNOWN INFO

LIGHT SWITCH POSITION OK

POSSIBLE PROBLEMS

DOME LAMPS

KNOWN INFO

LIGHT SWITCH POSITION OK

POSSIBLE PROBLEMS

DOME LAMPS

GO TO 8, Page 3-543, THEN RETURN TO STEP 3 BELOW

2

PLACE LIGHT SWITCH ON CONTROL BOX TO NORMAL OPERATING POSITION. DO DOME LAMPS ILLUMINATE?
AMBULANCE
(Aspirator)
(Refer to Fig. 12)

KNOWN INFO

NOTHING

POSSIBLE PROBLEMS

ASPIRATOR CABLES
ASPIRATOR
BATTERY

TEST OPTIONS

1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate a damaged lead.

DISCONNECT CABLE NUMBER 781 FROM ASPIRATOR/RESCUATOR. IS THERE BATTERY VOLTAGE AT CABLE 781?

GO TO 3.
Page 2-552

2

KNOWN INFO

BATTERY OK

POSSIBLE PROBLEMS

ASPIRATOR CABLES
ASPIRATOR

TEST OPTIONS

STE/ICE-R TEST 91, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

DISCONNECT CABLE NUMBER 792 FROM ASPIRATOR/RESCUATOR. IS THERE CONTINUITY BETWEEN CABLE 792 AND BODY GROUND?

REPAIR/REPLACE ASPIRATOR/RESCUATOR CABLE

REPLACE ASPIRATOR/RESCUATOR

START

YES

NO
**REFERENCE INFORMATION**

---

**AMBULANCE**

---

**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.

---

**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.

---

**0-4500 DC 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

---

Replace Aspirator/Resuscitator cable, refer to (para. 4-104). Repair cable, refer to DS Maintenance.
AMBULANCE
(Aspirator)
(Refer to Fig. 12.)

DIAGNOSTIC FLOWCHART

FROM 1, Page 2-550

TEST OPTIONS
1. ST/E/ICE-R TEST 89, Page 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate a battery malfunction.

KNOWN INFO
NOTHING

POSSIBLE PROBLEMS
ASPIRATOR CABLES
ASPIRATOR
BATTERY

IS THERE BATTERY VOLTAGE AT
POWER STUD ON VEHICLE
BATTERY BOX?

GO TO 1, Page 2-552

REPAIR/REPLACE
ASPIRATOR/
RESUSCITATOR
CABLE

YES

NO
0-45 DC VOLTS
STEACE-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.
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.

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.

0-4500 DC 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).
**Diagnostic Flowchart**

**Amulance (Front DC Outlet)**
(Refer to Fig. 13.)

**Known Info**
- Fuse OK
- Battery OK
- Lead 660 D OK

**Possible Problems**
- Lead 714
- Lead 790

**Test Options**
1. Ste/ice-r Test 89, Page 2-750
2. Multimeter

**Reason for Question**
- No power would indicate a damaged lead.

**Diagram:**

1. **Step 4:**
   - **Question:** Is there battery voltage at positive terminal of front DC outlet?
   - **Flow Options:**
     - **Yes:** Repair Lead 714
     - **No:**
       - **Flow Options:**
         - **Yes:** Repair Lead 790
         - **No:** Replace Front DC Outlet

2. **Step 5:**
   - **Question:** Is there continuity between front DC outlet negative terminal and body ground?
   - **Flow Options:**
     - **Yes:** Repair Lead 790
     - **No:** Replace Front DC Outlet

**Other Notes:**
- Test Options:
  1. Ste/ice-r Test 91, Page 2-752
  2. Multimeter

**Reason for Question**
- No continuity would indicate a damaged lead.
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.

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.

0-4500 DC 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

CONTINUITY (RESISTANCE)
MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
AMBULANCE
(Rear DC Outlet)
(Refer to Fig. 13.)

DIAGNOSTIC FLOWCHART

1

PERFORM STEPS 1 AND 2 OF PAGE 2-554, AND RETURN TO 2 BELOW.

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If fuse is blown, circuit is incomplete.

KNOWLEDGE

NOTHING

POSSIBLE PROBLEMS
FUSE
BATTERY
LEAD 660 C
LEAD 714 A
LEAD 714 B
REAR DC OUTLET
LEAD 790 A

2

DISCONNECT BOTH ENDS OF LEAD 660 C. IS THERE CONTINUITY?

TEST OPTIONS
1. TEST/ICE-R TEST 91, PAGE 2-752
2. MULTIMETER

REASON FOR QUESTION
No continuity would indicate a damaged lead.

KNOWLEDGE

FUSE OK
BATTERY OK

POSSIBLE PROBLEMS
LEAD 660 C
LEAD 714 A
LEAD 714 B
REAR DC OUTLET
LEAD 790 A

3

IS THERE BATTERY VOLTAGE IN CONTROL BOX TB TERMINAL 7?

TEST OPTIONS
1. TEST/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate damaged lead.

KNOWLEDGE

FUSE OK
BATTERY OK
LEAD 660 C OK

POSSIBLE PROBLEMS
LEAD 714 A
LEAD 714 B
REAR DC OUTLET
LEAD 790 A

YES

REPAIR LEAD 660 C

NO

YES

REPAIR LEAD 714 A

GO TO 4,
Page 2-550
REFERENCE INFORMATION

AMBULANCE

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9.9."

CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).

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.

BATTERY VOLTAGE MULTIMETER

1. Set the voltmeter to a 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.

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).
AMBULANCE
(Rear DC Outlet)

FROM 3,
Page 2-558

IS THERE BATTERY VOLTAGE AT
POSITIVE TERMINAL OF REAR DC
OUTLET?

1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate a
damaged lead.

REPAIR LEAD 714 B

IS THERE CONTINUITY BETWEEN
REAR DC OUTLET NEGATIVE
TERMINAL AND BODY GROUND?

1. STE/ICE-R TEST 91, PAGE 2-752
2. MULTIMETER

REASON FOR QUESTION
No continuity would indicate a
damaged lead.

REPAIR LEAD 790 A

REPLACE REAR
DC OUTLET
0-45 DC VOLTS
STEACE-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.

0-4500 DC OHMS
STEACE-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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STEACE displays "9.9.9.9."

CONTINUITY (RESISTANCE)
MULTIMETER
1. Set the voltmeter to an ohms scale of about 1000 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).
AMBULANCE (Compressor Clutch) (M997 Only) (Refer to Fig. 14.)

**DIAGNOSTIC FLOWCHART**

**START**

1. **KNOWN INFO**
   - NOTHING

   **POSSIBLE PROBLEMS**
   - A/C CONTROL SETTING FUSE
   - CABLE 660
   - LEAD 660 B
   - LEAD 720
   - LEAD 720 A
   - DOOR SWITCH

   **TEST OPTIONS**
   - VISUAL

   **REASON FOR QUESTION**
   Controls must be in correct position for clutch to engage.

   **IS AIR-CONDITIONER ON AND THE CONTROLS SET TO MAXIMUM COOLING AND BLOWER SPEED SETTINGS?**

   - **NO**
     - TURN AIR CONDITIONER ON AND SET CONTROLS TO MAXIMUM COOLING AND BLOWER SPEED SETTINGS
   - **YES**
     - CHECK FUSE BLOCK ON CONTROL BOX COVER. IS FUSE OK?

2. **KNOWN INFO**
   - A/C CONTROL SETTINGS OK

   **POSSIBLE PROBLEMS**
   - FUSE
   - CABLE 660
   - LEAD 660 B
   - LEAD 720
   - LEAD 720 A
   - DOOR SWITCH

   **TEST OPTIONS**
   - VISUAL

   **REASON FOR QUESTION**
   If fuse is blown, circuit to A/C is incomplete.

   **NO**
   - REPLACE BLOWN FUSE
   - **YES**
     - DISCONNECT LEAD 436 E AT COMPRESSOR. IS THERE BATTERY VOLTAGE AT LEAD 436 E?

3. **KNOWN INFO**
   - A/C CONTROL SETTINGS OK FUSE OK

   **POSSIBLE PROBLEMS**
   - CABLE 660
   - LEAD 660 B
   - LEAD 720
   - LEAD 720 A
   - DOOR SWITCH

   **TEST OPTIONS**
   - STE/ICE-R TEST 89 [PAGE 2-750]

   **REASON FOR QUESTION**
   The presence of voltage would indicate a malfunction of compressor or related components.

   - **NO**
     - **GO TO 4, PAGE 2-564**
   - **YES**
     - **GO TO 22, PAGE 2-576**
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.
**AMBULANCE (Compressor Clutch) (M997 Only) (Refer to Fig. 14.)**

**KNOWN INFO**

- A/C CONTROL SETTINGS OK
- FUSE OK

**POSSIBLE PROBLEMS**

- CABLE 660
- LEAD 660 B
- LEAD 720
- LEAD 720 A
- DOOR SWITCH

---

**DIAGNOSTIC FLOWCHART**

1. **IS BATTERY IN PROPER WORKING ORDER?**
   - **TEST OPTIONS**
     - 1. STE/ICE-R TEST 89, PAGE 2-750
     - 2. MULTIMETER
   - **REASON FOR QUESTION**
     - Battery malfunction will cause any dependent circuit to malfunction.

2. **GO TO 1, PAGE 2-252**

---

3. **IS THERE BATTERY VOLTAGE IN CONTROL BOX AT POWER STUD?**
   - **TEST OPTIONS**
     - 1. STE/ICE-R TEST 89, PAGE 2-750
     - 2. MULTIMETER
   - **REASON FOR QUESTION**
     - No voltage at power stud would indicate a damaged cable.

4. **REPAIR CABLE 660**

5. **IS THERE BATTERY VOLTAGE IN CONTROL BOX LEAD 660 B AT FUSE BLOCK?**
   - **TEST OPTIONS**
     - STE/ICE-R TEST 89, PAGE 2-750
   - **REASON FOR QUESTION**
     - No power would indicate a damaged lead.

6. **REPAIR LEAD 660 B**

---

2-564
Reference Information

Amulance

0-45 DC Volts
STEACE-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.

Repair cable, refer to DS Maintenance.

Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).
AMBULANCE
(Compressor Clutch)
(M997 Only)
(Refer to Fig. 14)

### KNOWN INFO
- A/C CONTROL SETTINGS OK
- FUSE OK
- BATTERY OK
- CABLE 660 OK
- LEAD 660 B OK

### POSSIBLE PROBLEMS
- LEAD 720
- LEAD 720 A
- DOOR SWITCH

---

### DIAGNOSTIC FLOWCHART

**7**

**IS THERE BATTERY VOLTAGE IN CONTROL BOX AT TB TERMINAL 9?**

- **YES**
  - REPLACE LEAD 720

- **NO**
  - TEST OPTIONS
    - STE/ICE-R TEST 89, PAGE 2-750

  - **REASON FOR QUESTION**
    - No power would indicate a damaged lead.

**8**

**IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT DOOR SWITCH?**

- **YES**
  - REPLACE LEAD 720

- **NO**
  - TEST OPTIONS
    - STE/ICE-R TEST 89, PAGE 2-750

  - **REASON FOR QUESTION**
    - No power would indicate a damaged lead.

**9**

**PLACE JUMPER WIRE BETWEEN LEAD 720 A AND LEAD 720 B AT DOOR SWITCH IN ENVIRONMENTAL CONTROL BOX. DOES COMPRESSOR CLUTCH ENGAGE?**

- **YES**
  - TEST OPTIONS
    - TRY IT

  - **REASON FOR QUESTION**
    - If compressor clutch engages, that would indicate a damaged switch.

- **NO**
  - GO TO 10, PAGE 2-568

**10**

**REPLACE DOOR SWITCH**
REFERENCE INFORMATION

AMBULANCE

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.

---

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

Replace door switch, refer to DS Maintenance.
AMBULANCE (Compressor Clutch) (M997 Only) 
(Refer to Fig. 14.)

DIAGNOSTIC FLOWCHART

FROM 9, Page 2-566

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power at switch would indicate a damaged lead.

10

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT A/C ON/OFF SWITCH?

YES

NO

REPAIR LEAD 720 B

11

PLACE JUMPER WIRE BETWEEN LEAD 720 C AND LEAD 720 D AT A/C ON/OFF SWITCH IN ENVIRONMENTAL CONTROL BOX. DOES COMPRESSOR CLUTCH ENGAGE?

YES

NO

GO TO 12, Page 2-570

REPLACE A/C ON/OFF SWITCH

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If compressor engages, that would indicate a damaged switch.

KNOWN INFO
PREVIOUSLY CORRECTED INFORMATION

POSSIBLE PROBLEMS
LEAD 720 B A/C ON/OFF SWITCH

KNOWN INFO
LEAD 720 B OK

POSSIBLE PROBLEMS
A/C ON/OFF SWITCH
REFERENCE INFORMATION

Repair lead, refer to (para. 4-85).

Replace A/C ON/OFF switch, refer to (para. 4-127).

AMBULANCE

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.

TM 9-2320-280-20-1
AMBULANCE (Compressor Clutch) (M997 Only) (Refer to Fig. 14)

12

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT COLD CONTROL?

13

PLACE JUMPER WIRE BETWEEN TERMINALS OF COLD CONTROL. DOES COMPRESSOR CLUTCH ENGAGE?

YES

REPLACE COLD CONTROL

NO

REPLACE LEAD 720 D

TEST OPTIONS

STE/ICE-R TEST 89, PAGE 2-570

REASON FOR QUESTION

No power would indicate a damaged lead.

YES

GO TO 14, PAGE 2-572

NO

TEST OPTIONS

TRY IT

REASON FOR QUESTION

If compressor clutch engages, that would indicate a damaged cold control.
REFERENCE INFORMATION

AMBULANCE

0-45 DC 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.

Replace cold control, refer to DS Maintenance.
Replace LO pressure switch, refer to DS Maintenance.

**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.

**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.
AMBULANCE (Compressor Clutch) (M997 Only) (Refer to Fig. 14.)

**KNOWN INFO**
- LEAD 436 A OK
- LO PRESSURE SWITCH OK
- LEAD 436 B OK

**POSSIBLE PROBLEMS**
- HI PRESSURE SWITCH
- LEAD 436 C
- LEAD 436 D
- LEAD 436 E
- COMPRESSOR WIRING HARNESS
- LEAD 798 A
- COMPRESSOR

**DIAGNOSTIC FLOWCHART**

**TEST OPTIONS**
1. STE/ICE-R TEST 89, PAGE 2-760
2. MULTIMETER

**REASON FOR QUESTION**
No power would indicate a damaged switch.

**FROM 16, PAGE 2-572**

17

**DISCONNECT LEAD 436 C FROM LEAD 436 OF HI PRESSURE SWITCH. IS THERE BATTERY VOLTAGE AT LEAD 436?**

**YES**

**REPLACE HI PRESSURE SWITCH**

**NO**

**18**

**DISCONNECT LEAD 436 C FROM LEAD 436 D. IS THERE BATTERY VOLTAGE AT LEAD 436 C?**

**YES**

**REPLACE LEAD 436 C**

**NO**

**TEST OPTIONS**
- STE/ICE-R TEST 89, PAGE 2-760

**REASON FOR QUESTION**
No power would indicate a damaged lead.

**19**

**DISCONNECT LEAD 436 D FROM LEAD 436 E. IS THERE BATTERY VOLTAGE AT LEAD 436 D?**

**YES**

**REPLACE LEAD 436 D**

**NO**

**TEST OPTIONS**
- STE/ICE-R TEST 89, PAGE 2-760

**REASON FOR QUESTION**
No power would indicate a damaged lead.

**GO TO 20, PAGE 2-579**
Replace high pressure switch, refer to DS Maintenance.

---

**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.

**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.
DIAGNOSTIC FLOWCHART

20

IS THERE NOW BATTERY VOLTAGE THROUGH LEAD 436 E?

FROM 19, Page 2-574

TEST OPTIONS
STE/ICE-R TEST 89, Page 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

21

REPAIR LEAD 436 E OR REPLACE COMpressor WIRING HARNESS

YES

DOES COMPRESSOR CLUTCH ENGAGE?

NO

TEST OPTIONS
TRY IT

REASON FOR QUESTION
Compressor clutch should engage now that power is supplied if properly grounded.

NO

GO TO 22, Page 2-572

YES

END OF TESTING
Replace compressor wiring harness, refer to (para. 4-122).

Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).
AMBULANCE
(Compressor Clutch)
(M997 Only)
(Refer to Fig. 14.)

FROM 3, 2-562 AND 21,
Page 2-576

DISCONNECT LEAD 798 A AT
COMPRESSOR. IS THERE
CONTINUITY OF LEAD 798 A TO
GROUND?

TEST OPTIONS
STORE TEST 01, PAGE 2-576

REASON FOR QUESTION
No continuity would indicate a
damaged lead.

YES

REPAIR LEAD 798 A

NO

22

23

KNOWLEDGE INFO
LEAD 798 A OK

KNOWLEDGE INFO
PREVIOUSLY CORRECTED INFORMATION

POSSIBLE PROBLEMS
LEAD 798 A
COMPRESSOR

POSSIBLE PROBLEMS
COMPRESSOR

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If compressor clutch does not
engage, that would indicate a
malfunction not handled at this
level.

YES

NO

COMPRESSOR FAULTY:
NOTIFY DS MAINTENANCE

END OF TESTING
0-4500 DC OHMS
STE/ACE-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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."
**DIAGNOSTIC FLOWCHART**

1. **IS AIR-CONDITIONING CONTROL LEVER IN PROPER POSITION?**
   - **KNOWN INFO:** NO
   - **POSSIBLE PROBLEMS:** A/C CONTROL LEVER POSITION, FAN SWITCH POSITION, FUSE, EVAPORATOR FANS
   - **TEST OPTIONS:** VISUAL
   - **REASON FOR QUESTION:** Control lever must be in correct position for fan to operate.
   - **PLACE CONTROL LEVER TO A/C NORMAL OR A/C MAX POSITION**

2. **IS THE FAN SWITCH IN PROPER POSITION?**
   - **KNOWN INFO:** A/C CONTROL LEVER POSITION OK
   - **POSSIBLE PROBLEMS:** FAN SWITCH POSITION, FUSE, EVAPORATOR FANS
   - **TEST OPTIONS:** VISUAL
   - **REASON FOR QUESTION:** Fan switch must be in correct position for fan to operate.
   - **PLACE FAN SWITCH TO HIGH POSITION**

3. **CHECK FUSE BLOCK ON CONTROL BOX COVER. IS FUSE OK?**
   - **KNOWN INFO:** A/C CONTROL LEVER POSITION OK, FAN SWITCH POSITION OK
   - **POSSIBLE PROBLEMS:** FUSE, EVAPORATOR FANS
   - **TEST OPTIONS:** VISUAL
   - **REASON FOR QUESTION:** If fuse is blown, circuit is incomplete.
   - **REPLACE BLOWN FUSE
   - **GO TO 4.**

*Page 2-582*
AMBULANCE (Evaporator Fans) (M997 Only) (Refer to Fig. 14)

**Known Info**
- A/C Control Lever Position OK
- Fan Switch Position OK
- Fuse OK

**Possible Problems**
- Evaporator Fans

**Test Options**
- STE/ICE-R Test 89, Page 2-750

**Reason For Question**
The presence of voltage would indicate a malfunction of evaporator fan or related components.

**Diagram**

1. **Flowchart**
   - **From:** Page 2-580
   - **To:** Page 2-581

2. **Test Options**
   - STE/ICE-R Test 91, Page 2-752
   - **Reason For Question**
     - No continuity would indicate damaged leads.

3. **Diagram Steps**
   - **Yes**
     - **Go To:** Page 2-582
   - **No**
     - **Replace Evaporator Fans**

4. **Additional Info**
   - **Disconnect Leads 770 C and 770 E at Evaporator Fans. Is there battery voltage at leads 770 C and 770 E?**
   - **Disconnect Leads 799 E and 799 F at Evaporator Fans. Is there continuity at leads 799 E and 799 F to ground?**
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.

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

REFERENCE INFORMATION

AMBULANCE

Replace evaporator fans, refer to (para. 11-198).
AMBULANCE (Evaporator Fans) (M997 Only)
(Refer to Fig. 14.)

FROM 4, Page 2-582

6

PERFORM STEPS 4 AND 5 ON PAGE 2-564, THEN RETURN TO 7 BELOW.

KNOWLEDGED INFO
PREVIOUSLY CORRECTED INFORMATION

POSSIBLE PROBLEMS
BATTERY
CABLE 660
LEAD 660 C
LEAD 721
LEAD 721 A
DOOR SWITCH

7

IS THERE BATTERY VOLTAGE IN CONTROL BOX LEAD 660 C AT FUSE BLOCK?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

KNOWLEDGED INFO
BATTERY OK
CABLE 660 OK

POSSIBLE PROBLEMS
LEAD 660 C
LEAD 721
LEAD 721 A
DOOR SWITCH

8

IS THERE BATTERY VOLTAGE IN CONTROL BOX AT TB TERMINAL 8?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

KNOWLEDGED INFO
BATTERY OK
CABLE 660 OK
LEAD 660 C OK

POSSIBLE PROBLEMS
LEAD 721
LEAD 721 A
DOOR SWITCH

YES
REPAIR LEAD 660 C

NO

YES
REPLACE LEAD 721

NO

GO TO 9, Page 2-586
**REFERENCE INFORMATION**

**AMBULANCE**

---

**TERMINAL BOARD**

- 6
- 7
- 8
- 10
- 720
- 721
- 722
- 720A AC
- 721A AC

**CONTROL BOX**

- 660C
- 660R
- 060

---

**POSITIVE POWER STUD**

- 12 AWG

---

**NEGATIVE BUSS**

---

**0-45 DC VOLTS STE/CE-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 lead**, refer to (para. 4-85).

**Repair lead connector**, refer to (para. 4-85).
AMBULANCE (Evaporator Fans) (M997 Only) (Refer to Fig. 14.)

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
<th>POSSIBLE PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BATTERY OK</td>
<td>LEAD 721 A</td>
</tr>
<tr>
<td>CABLE 660 OK</td>
<td>DOOR SWITCH</td>
</tr>
<tr>
<td>LEAD 660 C OK</td>
<td></td>
</tr>
<tr>
<td>LEAD 721 OK</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
<th>POSSIBLE PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BATTERY OK</td>
<td>DOOR SWITCH</td>
</tr>
<tr>
<td>CABLE 660 OK</td>
<td></td>
</tr>
<tr>
<td>LEAD 660 C OK</td>
<td></td>
</tr>
<tr>
<td>LEAD 721 OK</td>
<td></td>
</tr>
<tr>
<td>LEAD 721 A OK</td>
<td></td>
</tr>
</tbody>
</table>

FROM 8, Page 2-584

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT DOOR SWITCH?

TEST OPTIONS
STEICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

YES
NO
REPAIR LEAD 721 A

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If evaporator fans operate, that would indicate a malfunction of the door switch.

YES
NO
GO TO 11, Page 2-588

REPLACE DOOR SWITCH
Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).

Replace door switch, refer to DS Maintenance.
AMBULANCE (Evaporator Fans) (M997 Only)  
(Refer to Fig. 14)

**DIAGNOSTIC FLOWCHART**

**11**

**IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT LEAD 721 B AT FAN SWITCH?**

- **YES**: REPAIR LEAD 721 B
- **NO**: FROM 10, Page 2-586

**TEST OPTIONS**
- STE/ICE-R TEST 89, Page 2-750

**REASON FOR QUESTION**
No power would indicate a damaged lead.

**12**

**DISCONNECT FAN SWITCH LEAD 770 IN ENVIRONMENTAL CONTROL BOX FROM LEAD 770 A. IS THERE BATTERY VOLTAGE AT LEAD 770?**

- **YES**: REPLACE FAN SWITCH AND/OR REPAIR LEAD 770
- **NO**: REPLACE DAMAGED LEADS AND/OR REPLACE DAMAGED COMPONENTS

**TEST OPTIONS**
- STE/ICE-R TEST 89, Page 2-750

**REASON FOR QUESTION**
No power would indicate a malfunction of fan switch or a damaged lead.

**13**

**DISCONNECT LEADS 770 C AND 770 E FROM EVAPORATOR FANS. IS THERE BATTERY VOLTAGE AT LEADS 770 C AND 770 E?**

- **YES**: REPLACE DAMAGED LEADS AND/OR REPLACE DAMAGED COMPONENTS
- **NO**: GO TO 14, Page 2-590

**TEST OPTIONS**
- STE/ICE-R TEST 89, Page 2-750

**REASON FOR QUESTION**
No power would indicate damage leads or resistors.


**REFERENCE INFORMATION**

---

**AMBULANCE**

---

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.

---

**Diagrams**

- Replace fan switch, refer to (para. 4-127).
- Repair lead, refer to (para. 4-85).
- Repair lead connector, refer to (para. 4-85).
- Repair lead, refer to (para. 4-85).
- Repair lead connector, refer to (para. 4-85).
AMBULANCE
(Evaporator Fans)
(M997 Only)
(Refer to Fig. 14.)

KNOWLEDGE INFO
LEAD 721 OK
FAN SWITCH OK
LEAD 770 OK
LEADS OK
COMPONENTS OK

POSSIBLE PROBLEMS

DO EVAPORATOR FANS OPERATE?

END TESTING

FROM 13,
Page 2-588

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If evaporator fans do not operate, that would indicate possible problems of fans not being grounded properly.

GO TO 5,
Page 3-542

NO

YES

2-590
REFERENCE INFORMATION

AMBULANCE

2-591
AMBULANCE
(Evaporator Fans)
(M997 Only)
(Refer to Fig. 14.)

FROM 5,
Page 2-582

TEST OPTIONS
1. STE/ICE-R TEST 91, PAGE 2-752
2. TRY IT

REASON FOR QUESTION
If properly grounded and evaporator fans are OK, the fans should operate.

REPAIR LEADS 799 E AND 799 F. DO EVAPORATOR FANS OPERATE?

KNOWLEDGE
PREVIOUSLY CORRECTED INFORMATION

POSSIBLE PROBLEMS
LEAD 799 E
LEAD 799 F

END OF TESTING

GO TO 16,
Page 2-594

YES

NO
Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."
AMBULANCE (Evaporator Fans)  
(M997 Only)  
(Refer to Fig. 14.)


**KNOWN INFO**
- PREVIOUSLY CORRECTED INFORMATION

**POSSIBLE PROBLEMS**
- LEAD 799 D
- LEAD 799 C
- LEAD 799 B
- LEAD 799 A
- EVAPORATOR FANS

**TEST OPTIONS**
- STE/ICE-R TEST 91
- PAGE 2-752

**REASON FOR QUESTION**
- No continuity would indicate damaged leads.

**REPAIR AND/OR REPLACE DAMAGED LEAD.**

**GO TO 17, PAGE 2-595**

**IS THERE CONTINUITY OF LEAD 799 C?**

**KNOWN INFO**
- LEAD 799 D OK

**POSSIBLE PROBLEMS**
- LEAD 799 C
- LEAD 799 B
- LEAD 799 A
- EVAPORATOR FANS

**TEST OPTIONS**
- STE/ICE-R TEST 91
- PAGE 2-752

**REASON FOR QUESTION**
- No continuity would indicate a damaged lead.

**REPLACE LEAD 799 C**

**GO TO 18, PAGE 2-595**

**IS THERE CONTINUITY BETWEEN LEAD 799 B IN ENVIRONMENTAL CONTROL BOX AND GROUND IN CONTROL BOX?**

**KNOWN INFO**
- LEAD 799 D OK
- LEAD 799 C OK

**POSSIBLE PROBLEMS**
- LEAD 799 B
- LEAD 799 A
- EVAPORATOR FANS

**TEST OPTIONS**
- STE/ICE-R TEST 91
- PAGE 2-752

**REASON FOR QUESTION**
- No continuity would indicate a damaged lead.

**REPAIR DAMAGED LEADS**

**GO TO 15, PAGE 2-592**
0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays *9.9.9.9.*
DO EVAPORATOR FANS OPERATE?

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If evaporator fans do not operate that would indicate a malfunction not handled at this level.

END OF TESTING
Replace evaporator fans, refer to (para.11-198).
AMBULANCE (Condenser Fans) (M997 Only) 
(Refer to Fig. 14.)

Fig. 14.

DIAGNOSTIC FLOWCHART

START

1

IS AIR-CONDITIONING CONTROL LEVER IN PROPER POSITION?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Control lever must be in correct position for fans to operate.

NO

PLACE CONTROL LEVER TO A/C NORMAL OR A/C MAX POSITION

YES

2

IS A/C ON/OFF SWITCH IN PROPER POSITION?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Switch must be in correct position for fans to operate.

NO

PLACE A/C ON/OFF SWITCH TO ON POSITION

YES

3

CHECK FUSE BLOCK ON CONTROL BOX COVER. IS FUSE OK?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If fuse is blown, circuit to A/C is incomplete.

NO

REPLACE BLOWN FUSE

YES

GO TO 4,
Page 2-600
AMBULANCE
(Condenser Fans)
(M977 Only)
(Refer to Fig. 14.)

FROM 3,
Page 2-598

TEST OPTIONS
TRY IT

REASON FOR QUESTION
Condenser fans are powered on same power source lines.

KNOWLEDGE

DOES COMPRESSOR CLUTCH ENGAGE?

PERFORM STEPS 2-23, PAGES 2-562 TO 2-578 AND RETURN TO 5 BELOW

TEST OPTIONS
STEAGE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate damaged leads.

KNOWLEDGE

DISCONNECT LEAD 437 B AND 437 C FROM CONDENSER FANS. IS THERE BATTERY VOLTAGE AT LEAD 437 B, AND 437 C?

TEST OPTIONS
STEAGE-R TEST 91, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

KNOWLEDGE

IS THERE CONTINUITY BETWEEN LEAD 799 G IN ENVIRONMENTAL CONTROL BOX AND GROUND?

TEST OPTIONS

NO

YES

REPAIR DAMAGED LEADS OR REPLACE HARNESS 437 A, 437 B, 437 C

YES

REPAIR LEAD 799 G

NO

GO TO 7,
Page 2-602
**REFERENCE INFORMATION**

**AMBULANCE**

---

**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.

---

**0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms STE/ICE displays "9.9.9.9."

---

Repair leads, refer to (para. 4-85).

Repair lead connectors, refer to (para. 4-85).

Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).
**AMBULANCE**  
(Condenser Fans)  
(M997 Only)  
(Refer to **Fig.14**)  

---

**KNOWN INFO**  
A/C CONTROL LEVER POSITION  
A/C ON/OFF SWITCH POSITION  
FUSE  
COMPRESSOR CLUTCH LEADS 437 B AND 437 C  
LEAD 799 G  

**POSSIBLE PROBLEMS**  
LEAD 799 H  
LEADS 799 J, 799 K, AND 799 L  
CONDENSER FANS

---

**TEST OPTIONS**  
STE/ICE TEST 9, PAGE 2-752

**REASON FOR QUESTION**  
No power would indicate a damaged lead.

---

**IS THERE CONTINUITY BETWEEN LEAD 799 H AND GROUND?**

---

**YES**

**REPLACE LEAD 799 H**

---

**NO**

**Known Info**  
A/C CONTROL LEVER POSITION  
A/C ON/OFF SWITCH POSITION  
FUSE  
COMPRESSOR CLUTCH LEADS 437 B AND 437 C  
LEAD 799 G  
LEAD 799 H  

**POSSIBLE PROBLEMS**  
LEADS 799 J, 799 K, AND 799 L  
CONDENSER FANS

---

**TEST OPTIONS**  
1. STE/ICE-R TEST 9, PAGE 2-752  
2. MULTIMETER

**REASON FOR QUESTION**  
No continuity would indicate damaged leads.

---


---

**YES**

**REPAIR DAMAGED LEAD OR REPLACE HARNESS 799 J, 799 K, 799 L**

---

**NO**

**Known Info**  
A/C CONTROL LEVER POSITION  
A/C ON/OFF SWITCH POSITION  
FUSE  
COMPRESSOR CLUTCH LEADS 437 B AND 437 C  
LEAD 799 G  
LEAD 799 H  
LEADS 799 J, 799 K, AND 799 L  

**POSSIBLE PROBLEMS**  
CONDENSER FANS

---

**TEST OPTIONS**  
TRY IT

**REASON FOR QUESTION**  
If condenser fans do not operate, that would indicate faulty fans or a malfunction not handled at this level.

---

**DOES CONDENSER FANS OPERATE?**

---

**YES**

**REPLACE CONDENSER FANS AND/OR NOTIFY DS MAINTENANCE**

---

**NO**

**Known Info**  
A/C CONTROL LEVER POSITION  
A/C ON/OFF SWITCH POSITION  
FUSE  
COMPRESSOR CLUTCH LEADS 437 B AND 437 C  
LEAD 799 G  
LEAD 799 H  
LEADS 799 J, 799 K, AND 799 L  

**POSSIBLE PROBLEMS**  
CONDENSER FANS

---

**END OF TESTING**
**REFERENCE INFORMATION**

**AMBULANCE**

---

**0-4500 OHMS STE/ACE-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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms STE/ACE displays "9.9.9.9."

---

**CONTINUITY (RESISTANCE) MULTIMETER**

1. Set the voltmeter to an ohms scale of about 1000 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 leads, refer to (para. 4-85). Repair lead connectors, refer to (para. 4-85).

Replace condenser fans, refer to (para. 11-201).
AMBULANCE
(Condenser Fan)
(M997 Only)
(Refer to Fig. 14.)

**DIAGNOSTIC FLOWCHART**

1. **DISCONNECT CONDENSER FAN MOTOR LEAD. IS THERE CONTINUITY OF CONDENSER FAN MOTOR LEADS 437 AND 799?**
   - **NO** → **REPAIR DAMAGED LEAD**
   - **YES** → **TEST OPTIONS**
     - STE/ICE-R TEST 81, PAGE 2-752
     - **REASON FOR QUESTION**
       - No continuity would indicate damaged leads.

2. **IS THERE BATTERY VOLTAGE AT LEAD 437?**
   - **NO** → **REPAIR LEAD 437 B**
   - **YES** → **TEST OPTIONS**
     - STE/ICE-R TEST 89, PAGE 2-750
     - **REASON FOR QUESTION**
       - No power would indicate a damaged lead.

**KNOWN INFO**
- OTHER CONDENSER FAN OPERATES
- LEAD 437
- LEAD 799
- LEAD 437 B
- CONDENSER FAN

**POSSIBLE PROBLEMS**
- LEAD 437 B
- CONDENSER FAN
Repair leads, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).

Replace condenser fan, refer to (para. 11-201).

- **0-4500 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, 0-4500 ohms.
  3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms STE/ICE displays “9.999.”

- **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.
AMBULANCE (Blower Fan) (M997 Only) (Refer to Fig. 15.)

DIAGNOSTIC FLOWCHART

### Known Info

1. **Nothing**

### Possible Problems

**Control Lever Position**
- Fuse
- Linkage
- Battery
- Cable 660
- Lead 660 B
- Lead 721
- Lead 721 A
- Relay

---

#### Test Options

**Visual**

**Reason for Question**
Control lever must be in correct position for blower fan to operate.

---

### Known Info

2. **Control Lever Position OK**

### Possible Problems

- Fuse
- Linkage
- Battery
- Cable 660
- Lead 660 B
- Lead 721
- Lead 721 A
- Relay

---

#### Test Options

**Visual**

**Reason for Question**
If fuse is blown, circuit is incomplete.

---

### Known Info

3. **Control Lever Position OK, Fuse OK**

### Possible Problems

- Linkage
- Battery
- Cable 660
- Lead 660 B
- Lead 721
- Lead 721 A
- Relay

---

#### Test Options

**Visual**

**Reason for Question**
Fan duct door must be open to allow air circulation.

---

---

---

2-606
Remove heater compartment panel, refer to (para. 11-214).

Installation/adjustment of fan duct door linkage, refer to (para. 11-211).
AMBULANCE
(Blower Fan)
(M997 Only)
(Refer to Fig. 15.)

FROM 3,
Page 2-606

TEST OPTIONS
1. STE/ICE TEST 89,
Page 2-750
2. MULTIMETER

REASON FOR QUESTION
Battery malfunction will cause any dependent circuit to malfunction.

4

IS BATTERY IN PROPER WORKING ORDER?

GO TO 1,
Page 2-252

5

IS THERE BATTERY VOLTAGE IN CONTROL BOX AT POWER STUD?

GO NO
REPAIR CABLE 660

TEST OPTIONS
1. STE/ICE TEST 89,
Page 2-750
2. MULTIMETER

REASON FOR QUESTION
No power at power stud would indicate a damaged cable or the power source.

6

IS THERE BATTERY VOLTAGE IN CONTROL BOX LEAD 660 B AT FUSE BLOCK?

REPAIR LEAD 660 B

GO TO 7,
Page 2-610
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.

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.

Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).
AMBULANCE
(Blower Fan)
(M997 Only)
(Refer to Fig. 15.)

**Fig. 15.**

**FROM 6, Pages 2-508**

**DIAGNOSTIC FLOWCHART**

**KNOWN INFO**

**CONTROL LEVER**
- POSITION OK
- FUSE OK
- LINKAGE OK
- BATTERY OK
- CABLE 660 OK
- LEAD 660 B OK

**POSSIBLE PROBLEMS**
- LEAD 721
- LEAD 721 A
- RELAY

**7**

**IS THERE BATTERY VOLTAGE IN CONTROL BOX AT TB TERMINAL 9?**

**TEST OPTIONS**
- STE/ICE TEST 89, PAGE 2-750.

**REASON FOR QUESTION**
- No power would indicate a damaged lead.

**YES**

**REPLACE LEAD 721**

**NO**

**8**

**IS THERE BATTERY VOLTAGE AT TERMINAL 30 OF RELAY ON HEATER CONTROL PANEL?**

**TEST OPTIONS**
- 1. STE/ICE TEST 89, PAGE 2-750.
- 2. MULTIMETER

**REASON FOR QUESTION**
- No power would indicate a damaged lead.

**YES**

**REPAIR LEAD 721 A**

**NO**

**9**

**PLACE JUMPER WIRE FROM TERMINAL 30 TO TERMINAL 87 A OF RELAY. DOES BLOWER FAN OPERATE?**

**TEST OPTIONS**
- TRY IT

**REASON FOR QUESTION**
- If blower fans operate then relay is malfunctioning.

**YES**

**GO TO 10, Pages 2-512**

**NO**

**REPLACE RELAY**
REFERENCE INFORMATION

AMBULANCE

**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.

**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.

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

Replace relay, refer to (para. 4-120).
**Diagnostic Flowchart**

10. **Is there battery voltage at vent lever switch on heater control panel?**
   - **Yes:** Replace Lead 721 B
   - **No:** Replace Lead 721 C

11. **Is there battery voltage at fan switch terminal 2 on heater control panel?**
   - **Yes:** Replace Lead 721 C
   - **No:** Replace Lead 721 B

12. **Is there continuity through fan switch at all speed settings?**
   - **Yes:** Replace fan switch
   - **No:** Go to 13

**Known Info**
- Previously Corrected Information

**Possible Problems**
- Lead 721 B
- Lead 721 C
- Fan Switch

**Test Options**
- STE/ICE Test 89, Page 2-750
- STE/ICE Test 91, Page 2-752

**Reason for Question**
- No power would indicate a damaged lead.
- No continuity would indicate a damaged fan switch.

(Refer to Fig. 15.)
**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.

---

**0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms STE/ICE displays "9.9.9.9."

---

Replace fan switch, refer to (para. 4-127).
AMBULANCE
(Blower Fan)
(M997 Only)
(Refer to Fig. 15.)

DIAGNOSTIC FLOWCHART

KNOWLEDGE INFO
LEAD 721 B OK
LEAD 721 C OK
FAN SWITCH OK

POSSIBLE PROBLEMS

13

FROM 12.
Page 2-612

DOES BLOWER FAN OPERATE?

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If blower fan is properly grounded and operable, then it should operate.

NO
GO TO 14.
Page 2-616

YES

END OF TESTING

2-614
AMBULANCE
(Blower Fan)
(M997 Only)
(Refer to Fig. 15.)

FROM 13,
Page 2-614

DIAGNOSTIC FLOWCHART

TEST OPTIONS
STE/ICE-R TEST 91, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

14

IS THERE CONTINUITY OF LEAD 799 A TO GROUND?

REPAIR LEAD 799 A

NO

YES

15

IS THERE CONTINUITY OF LEAD 799 D TO GROUND?

REPAIR LEAD 799 D

NO

YES

16

DOES BLOWER FAN OPERATE?

TRY IT

REASON FOR QUESTION
All connections and circuits are good and blower fan should operate.

REPLACE BLOWER ASSEMBLY

NO

YES

END OF TESTING

KNOWN INFO
PREVIOUSLY CORRECTED INFORMATION

POSSIBLE PROBLEMS
LEAD 799 A
LEAD 799 D
BLOWER ASSEMBLY

KNOWN INFO
LEAD 799 A OK

POSSIBLE PROBLEMS
LEAD 799 D
BLOWER ASSEMBLY

KNOWN INFO
LEAD 799 A OK
LEAD 799 D OK

POSSIBLE PROBLEMS
BLOWER ASSEMBLY
REFERENCE INFORMATION

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

Repair lead, refer to (para. 4-85).

Replace blower assembly, refer to (para. 11-212).

0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms STE/ICE displays "9.9.9.9."
AMBULANCE (Heater Fuel Pump) (Refer to Figs. 14-18.)

DIAGNOSTIC FLOWCHART

1. **IS HEAT LEVER IN ENVIRONMENTAL CONTROL BOX IN PROPER POSITION?**
   - **TEST OPTIONS**: VISUAL
   - **REASON FOR QUESTION**: Heat lever must be in proper position for heater fuel pump operation.
   - **KNOWN INFO**: NOTHING
   - **POSSIBLE PROBLEMS**: HEAT LEVER POSITION, CONTROL LEVER POSITION, HEATER SWITCH POSITION, FUSE, BATTERY, CABLE 660, LEAD 798, FUEL PUMP
   - **PLACE HEAT LEVER TO HEAT POSITION**
     - **YES**
     - **NO**

2. **IS CONTROL LEVER ON ENVIRONMENTAL CONTROL BOX IN PROPER POSITION?**
   - **TEST OPTIONS**: VISUAL
   - **REASON FOR QUESTION**: Control lever must be in proper position for heater fuel pump operation.
   - **KNOWN INFO**: HEAT LEVER POSITION OK
   - **POSSIBLE PROBLEMS**: CONTROL LEVER POSITION, HEATER SWITCH POSITION, FUSE, BATTERY, CABLE 660, LEAD 798, FUEL PUMP
   - **PLACE CONTROL LEVER TO HEAT/NORMAL OR HEAT/MAX POSITION**
     - **YES**
     - **NO**

3. **IS HEATER SWITCH ON ENVIRONMENTAL CONTROL BOX IN PROPER POSITION?**
   - **TEST OPTIONS**: VISUAL
   - **REASON FOR QUESTION**: Heater switch must be in proper position for heater fuel pump operation.
   - **KNOWN INFO**: HEAT LEVER POSITION OK, CONTROL LEVER POSITION OK
   - **POSSIBLE PROBLEMS**: HEATER SWITCH POSITION, FUSE, BATTERY, CABLE 660, LEAD 798, FUEL PUMP
   - **PLACE HEATER SWITCH TO START POSITION**
     - **YES**
     - **NO**

GO TO 4, [Page 2-620]
AMBULANCE (Heater Fuel Pump) (Refer to Figs. 14-18)

KNOWN INFO
HEAT LEVER
POSITION OK
CONTROL LEVER
POSITION OK
HEATER SWITCH
POSITION OK

POSSIBLE PROBLEMS
FUSE
BATTERY
CABLE 660
LEAD 798
FUEL PUMP

FROM 3, Page 2-618

CHECK FUSE BLOCK ON CONTROL COVER. IS FUSE OK?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If fuse is blown, circuit is incomplete.

NO
REPLACE BLOWN FUSE

YES

5

IS BATTERY IN PROPER WORKING ORDER?

TEST OPTIONS
1. STE/ICE-R TEST 89, Page 2-750
2. MULTIMETER

REASON FOR QUESTION
Battery malfunction will cause any dependent circuit to malfunction.

NO
GO TO 1, Page 2-352

YES

6

IS THERE BATTERY VOLTAGE IN CONTROL BOX AT POWER STUD?

TEST OPTIONS
1. STE/ICE-R TEST 89, Page 2-750
2. MULTIMETER

REASON FOR QUESTION
No power at power stud would indicate a damaged cable from the power source.

CABLE 660
LEAD 798
FUEL PUMP

NO
REPAIR CABLE 660

YES

GO TO 7, Page 2-622
0-45 DC VOLTS
STE/ACE-R TEST 69
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.

Repair lead, refer to (para. 4-85).
AMBULANCE
(Heater Fuel Pump)
(Refer to Figures 14-16.)

DIAGNOSTIC FLOWCHART

FROM 6,
Page 2-620

DISCONNECT LEAD 723 A FROM
FUEL PUMP LEAD. IS THERE
BATTERY VOLTAGE AT LEAD
723 A?

TEST OPTIONS
STE/CE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a
damaged lead.

TEST OPTIONS
STE/CE-R TEST 81, PAGE 2-752

REASON FOR QUESTION
No continuity would indicated a
damaged lead.

KNOWLEDGE INFO
HEAT LEVER
POSITION OK
CONTROL LEVER
POSITION OK
HEATER SWITCH
POSITION OK
FUSE OK
BATTERY OK
CABLE 660 OK

POSSIBLE PROBLEMS
LEAD 798
FUEL PUMP

KNOWLEDGE INFO
HEAT LEVER
POSITION OK
CONTROL LEVER
POSITION OK
HEATER SWITCH
POSITION OK
FUSE OK
BATTERY OK
CABLE 660 OK

POSSIBLE PROBLEMS
LEAD 798
FUEL PUMP

YES
NO
GO TO 9,
Page 2-624

IS THERE CONTINUITY
BETWEEN FUEL PUMP LEAD
798 AND GROUND?

YES
REPAIR LEAD 798

NO
REPLACE FUEL PUMP

TM 9-2320-280-20-1
2-622
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.

0-4500 OHMS
STE/ICE-R TEST 91

1. Connect RED clip and BLACK clip to the indicated terminate in 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 4500 ohms STE/ICE displays "9.9.9.9."

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).
Replace heater fuel pump, refer to (para. 11-194).
**REFERENCE INFORMATION**

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

---

**AMBULANCE**

**0-45 DC VOLTS STEACE-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.

---

**REFERENCE INFORMATION**

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).
REFERENCE INFORMATION

Replace Heater Evaporator Motors continuity switch, refer to DS Maintenance.

AMBULANCE

0-45 DC VOLTS
STEACE-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.

Replace Heater Fresh Air Door continuity switch, refer to DS Maintenance.
REPAIR LEAD, REFER TO (PARA. 4-85).

REPLACE HEATER SWITCH, REFER TO (PARA. 4-126 OR 4-127).

REPAIR LEAD, REFER TO (PARA. 4-85). REPAIR LEAD CONNECTOR, REFER TO (PARA. 4-85).
**Diagnostic Flowchart**

**KNOWN INFO**
- LEAD 660 B OK
- LEAD 722 OK
- LEAD 722 A OK
- HEATER CONTINUITY SWITCH OK
- LEAD 722 B OK
- HEATER FRESH AIR SWITCH OK
- LEAD 722 C OK
- HEATER SWITCH OK
- LEAD 723 D OK

**POSSIBLE PROBLEMS**
- ROLLOVER SWITCH
- LEAD 723 C
- LEAD 723 B
- LEAD 723 A
- FUEL PUMP

**18.** IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX THROUGH ROLLOVER SWITCH?
- **NO**
  - REPLACE ROLLOVER SWITCH

  **TEST OPTIONS**
  1. STE/ICE-R TEST 89, PAGE 2-750
  2. MULTIMETER

  **REASON FOR QUESTION**
  No power would indicate a switch malfunction.

- **YES**
  - IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT LEAD 723 C?

  **19.**
  - **NO**
    - **REPAIR LEAD 723 C**

    **TEST OPTIONS**
    - STE/ICE-R TEST 89, PAGE 2-750

    **REASON FOR QUESTION**
    No power would indicate a damaged lead.

  - **YES**
    - IS THERE BATTERY VOLTAGE AT LEAD 723 B?

    **20.**
    - **NO**
      - **REPAIR LEAD 723B**

      **TEST OPTIONS**
      - STE/ICE-R TEST 89, PAGE 2-750

      **REASON FOR QUESTION**
      No power would indicate a damaged lead.

    - **YES**
      - GO TO 21, PAGE 2-652
Replace Rollover Switch, refer to (para. 4-126 or 4-127).

Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).

<table>
<thead>
<tr>
<th>0-45 DC VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE/CE-R TEST 89</td>
</tr>
</tbody>
</table>

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.
AMBULANCE (Heater Fuel Pump)  
(Refer to Figs. 14-15.)

FROM 20,  
Page 2-580

21

IS THERE NOW BATTERY VOLTAGE AT LEAD 723 A?

NO

REPAIR LEAD 723 A

YES

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-790

REASON FOR QUESTION
No power would indicate a damaged lead.

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If heater fuel pump is inoperative at this point, a malfunction is the fuel pump.

22

DOES HEATER FUEL PUMP OPERATE?

NO

REPLACE HEATER FUEL PUMP

YES

END OF TESTING
**REFERENCE INFORMATION**

Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).

---

**AMBULANCE**

---

**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.

---

Replace Heater Fuel Pump, refer to (para. 11-194).
AMBULANCE
(Heater On Lamp)
(Refer to Figs. 15, 16.)

**KNOWLEDGE INFO**
- NOTHING

**POSSIBLE PROBLEMS**
- HEATER SWITCH POSITIONS
  - LEAD 766 B
  - LEAD 799 P
  - HEATER ON LAMP

---

1. **IS HEATER SWITCH ON ENVIRONMENTAL CONTROL BOX IN PROPER POSITION TO START HEATER?**

   **TEST OPTIONS**
   - VISUAL

   **REASON FOR QUESTION**
   Heater on lamp will not operate if heater is not on.

   **NO**

   **PLACE HEATER SWITCH TO RUN POSITION UNTIL HEATER STARTS**

   **YES**

---

2. **IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT LEAD 766 B OF HEATER ON LAMP?**

   **TEST OPTIONS**
   - STE/ICE-R TEST 89, PAGE 2-750

   **REASON FOR QUESTION**
   - No power would indicate a damaged lead.

   **NO**

   **REPAIR LEAD 766 B**

   **YES**

---

3. **IS THERE CONTINUITY IN ENVIRONMENTAL CONTROL BOX BETWEEN LEAD 799 P AT HEATER ON LAMP AND GROUND?**

   **TEST OPTIONS**
   - STE/ICE-R TEST 91, PAGE 2-752

   **REASON FOR QUESTION**
   - No continuity would indicate a damaged lead.

   **NO**

   **REPAIR LEAD 799 P**

   **YES**

---

**REPLACE HEATER ON LAMP ASSEMBLY**
REFERENCE INFORMATION

AMBULANCE

ROLL OVER SWITCH 723B AC
ENVIRONMENTAL CONTROL BOX
HEATER RUN-OFF-START SWITCH

PARA. 4-126 OR 4-127
PARA. 4-85
PARA. 4-85
PARA. 4-85

TM 9-2320-280-20-1
2-635

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.

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "8.8.8.8."

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).
Replace Heater on Lamp, refer to (para. 4-126 or 4-127).
AMBULANCE (Heater Output) (Refer to Figs. 14-16.)

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOTHING</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POSSIBLE PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEATER SWITCH POSITION</td>
</tr>
<tr>
<td>FUEL SWITCH POSITION</td>
</tr>
<tr>
<td>FUEL SHUTOFF VALVE POSITION</td>
</tr>
<tr>
<td>FUEL LINES</td>
</tr>
<tr>
<td>FUEL FILTER</td>
</tr>
<tr>
<td>LEAD 766 A</td>
</tr>
<tr>
<td>FUEL SWITCH</td>
</tr>
</tbody>
</table>

START

1

IS HEATER SWITCH ON ENVIRONMENTAL CONTROL BOX IN PROPER POSITION?

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Heater switch must be in correct position for heater to operate.

NO

PLACE HEATER SWITCH TO RUN POSITION

YES

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Selection switch must be in the correct position for desired heat output.

NO

REPLACE FUEL SWITCH IN HI POSITION

YES

TEST OPTIONS

VISUAL

REASON FOR QUESTION

Proper amounts of fuel must be supplied for heater to operate correctly.

NO

OPEN SHUT OFF VALVE AND REPLACE ANY DAMAGED FUEL LINES

YES

GO TO 4,

Page 2-638
Replace damaged fuel lines, refer to (para. 11-193).
AMBULANCE (Heater Output) (Refer to Figs. 14-16.)

DIAGNOSTIC FLOWCHART

FROM 3, Page 2-636

TEST OPTIONS
INSPECT

REASON FOR QUESTION
Proper amounts of fuel must be supplied unobstructed for heater to operate properly.

IS FUEL FILTER FREE OF RESTRICTIONS?

NO

SERVICE OR REPLACE FUEL FILTER

YES

TEST OPTIONS
STE/ICE-R TEST 89, Page 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT LEAD 766 A TO HEATER HI-LO SWITCH?

NO

REPAIR LEAD 766 A

YES

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If high heat output occurs that would indicate a fuel switch malfunction.

PLACE JUMPER WIRE BETWEEN LEAD 766 A AND 766 AT HI-LO SWITCH. IS THERE HIGH OUTPUT OF HEAT?

NO

GO TO 7, Page 2-640

YES

REPLACE FUEL SWITCH
REFERENCE INFORMATION

AMBULANCE

Repair/replace fuel filter, refer to (para. 11-192).

Repair lead, refer to (para. 4-85).

Replace fuel switch, refer to (para. 4-127).

0-45 DC 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.
AMBULANCE (Heater Output) (Refer to Figs. 14-16.)

KNOWN INFO
PREVIOUSLY CORRECTED INFORMATION

POSSIBLE PROBLEMS
LEAD 766 HEATER ASSEMBLY

IS THERE BATTERY VOLTAGE OF LEAD 766 AT TERMINAL B OF FUEL COMBUSTION HEATER?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-760

REASON FOR QUESTION
No power would indicate a damaged lead.

7
NO
REPAIR LEAD 766

YES

8

TEST OPTIONS
TRY IT

REASON FOR QUESTION
Low heat output would indicate a heater assembly malfunction.

IS THERE HIGH OUTPUT OF HEAT?

NO
REPLACE HEATER ASSEMBLY

YES

END OF TESTING
REFERENCE INFORMATION

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

Replace heater assembly, refer to (para. 11-180 or 11-209).

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.

AMBULANCE
AMBULANCE (Heater Starting) (Refer to Figs. 14-16.)

KNOWN INFO

NOTHING

POSSIBLE PROBLEMS

HEATER ASSEMBLY
LEAD 723 D
ROLLOVER SWITCH
LEAD 723 B
LEAD 723 A
LEAD 798
FUEL PUMP
LEAD 768

START

WITH HEATER SWITCH ON ENVIRONMENTAL CONTROL BOX IN THE START POSITION IS HEATER ACTIVATED AT ALL?

TEST OPTIONS
TRY IT

REASON FOR QUESTION
To determine if any power is getting to heater switch on control box.

1

YES

GO TO 10,
Page 2-644

NO

2

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT ROLLOVER SWITCH?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

YES

REPAIR LEAD 723 D

NO

3

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX THROUGH ROLLOVER SWITCH?

TEST OPTIONS
1. STE/ICE-R TEST 80, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate a switch malfunction.

YES

REPLACE ROLLOVER SWITCH

GO TO 4,
Page 644

NO
**REFERENCE INFORMATION**

**AMBULANCE**

**0-45 DC VOLTS STEACE-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 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.

---

Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).

Replace Rollover Switch, refer to (para. 4-127).
**AMBULANCE (Heater Starting) (Refer to Figs. 14-16.)**

<table>
<thead>
<tr>
<th>KNOWN INFO</th>
<th>POSSIBLE PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAD 723 D OK</td>
<td>HEATER ASSEMBLY</td>
</tr>
<tr>
<td>ROLLOVER SWITCH OK</td>
<td>LEAD 723 B</td>
</tr>
<tr>
<td></td>
<td>LEAD 723 A</td>
</tr>
<tr>
<td></td>
<td>LEAD 798</td>
</tr>
<tr>
<td></td>
<td>FUEL PUMP</td>
</tr>
<tr>
<td></td>
<td>LEAD 768</td>
</tr>
</tbody>
</table>

**DIAGNOSTIC FLOWCHART**

4. **IS THERE BATTERY VOLTAGE AT LEAD 723 B?**
   - **YES**
     - REPLACE LEAD 723 B
   - **NO**
     - FROM 3., Page 2-642

5. **DISCONNECT LEAD 723 A FROM FUEL PUMP LEAD. IS THERE BATTERY VOLTAGE AT LEAD 723 A?**
   - **YES**
     - REPLACE LEAD 723 A
   - **NO**
     - TEST OPTIONS
       - STE/ICE-R TEST 89, PAGE 2-750
       - REASON FOR QUESTION
         - No power would indicate a damaged lead.

6. **IS THERE CONTINUITY BETWEEN FUEL PUMP LEAD 798 AND GROUND?**
   - **NO**
     - TRY IT
     - REASON FOR QUESTION
       - No continuity would indicate a damaged lead.
   - **YES**
     - REPAIR LEAD 798

GO TO 7., Page 2-648
0-45 DC Volts
Ste/ce-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 lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).

---

TM 9-2320-280-20-1

2-645
AMBULANCE (Heater Starting)  
(Refer to Figs. 14-16.)

| KNOWN INFO |  
| LEAD 723 D OK |  
| ROLLOVER SWITCH OK |  
| LEAD 723 A OK |  
| LEAD 798 OK |  

| POSSIBLE PROBLEMS |  
| HEATER ASSEMBLY |  
| FUEL PUMP |  
| LEAD 768 |  

7  

DOES FUEL PUMP OPERATE PROPERLY ELECTRICALLY?  

TEST OPTIONS  
TRY IT

REASON FOR QUESTION  
Faulty fuel pump could be due to a mechanical malfunction.

8  

DOES FUEL PUMP OPERATE PROPERLY MECHANICALLY?  

TEST OPTIONS  
VISUAL

REASON FOR QUESTION  
Faulty fuel pump could be due to an electrical malfunction.

9  

WITH HEATER SWITCH ON ENVIRONMENTAL CONTROL BOX IN THE RUN POSITION, IS THERE BATTERY VOLTAGE AT HEATER CONNECTOR PLUG PIN D?  

TEST OPTIONS  
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION  
No power would indicate a damaged lead.

YES  
REPAIR LEAD 768

NO  
PERFORM STEPS 1 AND 2, PAGE 2-708 AND RETURN

10  

YES  
REPLACE FUEL PUMP

NO  
REPLACE HEATER ASSEMBLY
Replace fuel pump, refer to (para. 11-194).

Replace heater assembly, refer to (para. 11-190 or 11-209).

**0-45 DC VOLTS STE/ICE-R TEST 69**

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.
**AMBULANCE (Heater Starting)**
(Refer to Figs. 14-16.)

**KNOWN INFO**
- HEAT LEVER POSITION OK
- CONTROL LEVER
- POSITION OK
- FUSE OK

**POSSIBLE PROBLEMS**
- FUSE
- BATTERY
- CABLE 860
- LEAD 660 B
- LEAD 722
- LEAD 722 A
- CONTINUITY SWITCHES
- LEAD 722 B
- LEAD 722 C
- HEATER SWITCH
- LEAD 769
- LEAD 799 N
- HEATER ASSEMBLY

---

**DIAGNOSTIC FLOWCHART**

13. **IS BATTERY IN PROPER WORKING ORDER?**

**TEST OPTIONS**
1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

**REASON FOR QUESTION**
Battery malfunction will cause any dependent circuit to malfunction.

---

14. **IS THERE BATTERY VOLTAGE IN CONTROL BOX AT POWER STUD?**

**TEST OPTIONS**
1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

**REASON FOR QUESTION**
No power at power stud would indicate a damaged cable from the power source.

---

15. **IS THERE BATTERY VOLTAGE IN CONTROL BOX THROUGH LEAD 660 B AT FUSE BLOCK?**

**TEST OPTIONS**
- STE/ICE-R TEST 89, PAGE 2-750

**REASON FOR QUESTION**
No power would indicate a damaged lead.

---

GO TO 16,
Page 2-852
0-45 DC VOLTS STE/CE-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.

Repair lead, refer to (para. 4-85).

Repair lead, refer to (para. 4-85).
Repair lead connector, refer to (para. 4-85).
**AMBULANCE**  
(Heater Starting)  
(Refer to Figs. 14-18.)

**KNOWLEDGE**  
HEAT LEVER POSITION OK  
CONTROL LEVER  
POSITION OK  
FUSE OK  
BATTERY OK  
CABLE 660 OK  
LEAD 660 B OK

**POSSIBLE PROBLEMS**  
LEAD 722  
LEAD 722 A  
CONTINUITY SWITCHES  
LEAD 722 B  
LEAD 722 C  
HEATER SWITCH  
LEAD 769  
LEAD 799 N  
HEATER ASSEMBLY

---

**Diagnostic Flowchart**

**16**  
**IS THERE BATTERY VOLTAGE IN CONTROL BOX AT TB TERMINAL 10?**

**TEST OPTIONS**  
STEP/R TEST 89, PAGE 2-750

**REASON FOR QUESTION**  
No power would indicate a damaged lead.

**YES**  
REPAIR LEAD 722

**NO**  
17  
**IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT HEATER EVAPORATOR MOTORS CONTINUITY SWITCH?**

**TEST OPTIONS**  
STEP/R TEST 89, PAGE 2-750

**REASON FOR QUESTION**  
No power would indicate a damaged lead.

**YES**  
REPAIR LEAD 722 A

**NO**  
18  
**IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX THROUGH HEATER EVAPORATOR MOTORS CONTINUITY SWITCH?**

**TEST OPTIONS**  
1. STEP/R TEST 89, PAGE 2-750  
2. MULTIMETER

**REASON FOR QUESTION**  
No power would indicate a switch malfunction.

**YES**  
REPLACE SWITCH

**NO**  
GO TO 19, PAGE 2-454
Repair lead, refer to (para. 4-85). Repair lead connector, refer to (para. 4-85).

Replace Heater Evaporator Motors continuity switch, refer to DS Maintenance.

---

**0-45 DC 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.

**BATTERY VOLTAGE MULTIMETER**

1. Set the voltmeter to 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.
AMBULANCE (Heater Starting)  
(Refer to Figs. 14-16.)

KNOWN INFO
HEAT LEVER POSITION OK
CONTROL LEVER OK
FUSE OK
BATTERY OK
CABLE 660 OK
LEAD 660 B
LEAD 722 OK
LEAD 722 A OK

POSSIBLE PROBLEMS
CONTINUITY SWITCHES
LEAD 722 B
LEAD 722 C
HEATER SWITCH
LEAD 769
LEAD 799 N
HEATER ASSEMBLY

DIAGNOSTIC FLOWCHART

19

FROM 18,
Page 2-652

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT HEATER FRESH AIR DOOR CONTINUITY SWITCH?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

NO

REPAIR LED 722 B

YES

20

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX THROUGH HEATER FRESH AIR DOOR CONTINUITY SWITCH?

TEST OPTIONS
1. STE/ICE-R TEST 89, PAGE 2-750
2. MULTIMETER

REASON FOR QUESTION
No power would indicate a switch malfunction.

NO

REPLACE SWITCH

YES

21

IS THERE BATTERY VOLTAGE IN ENVIRONMENTAL CONTROL BOX AT HEATER SWITCH?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

NO

REPAIR LED 722 C

YES

GO TO 22,
Page 2-656
Repair lead, refer to (para. 4-85).

Replace heater fresh air door continuity switch, refer to DS Maintenance.

---

**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.

**BATTERY VOLTAGE MULTIMETER**

1. Set the voltmeter to 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.
**REFERENCE INFORMATION**

**AMBULANCE**

---

**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.

---

**BATTERY VOLTAGE MULTIMETER**

1. Set the voltmeter to 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.

---

**0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."
AMBULANCE
(Heater Starting)
(Refer to Figs. 14-16.)

**KNOWN INFO**
- Heat Lever Position OK
- Control Lever Position OK
- Fuse OK
- Battery OK
- Cable 660 OK
- Lead 660 B OK
- Lead 722 OK
- Lead 722 A OK
- Continuity Switches OK
- Lead 722 B OK
- Lead 722 C OK
- Heater Switch
- Lead 769 OK
- Lead 799 N OK

**POSSIBLE PROBLEMS**
- Heater Assembly

**RETURN TO STEP 2,**
Page 2-658

**FROM 24,**
Page 2-656

**DIAGNOSTIC FLOWCHART**

**WITH HEATER SWITCH ON**
**ENVIRONMENTAL CONTROL BOX**
**STILL IN THE "START" POSITION,**
**IS HEATER NOW ACTIVATED AT**
**ALL?**

**TEST OPTIONS**
- Try It

**REASON FOR QUESTION**
No activation at all would indicate a heater malfunction.

**REPLACE HEATER ASSEMBLY**

**RETURN TO STEP 2,**
Page 2-658

2-658
Replace heater assembly, refer to (paras.11-190 or 11-209).
AMBULANCE (NBC Filter Blower) (Refer to Fig. 17.)

**DIAGNOSTIC FLOWCHART**

**START**

1. **IS NBC SWITCH ON NBC CONTROL PANEL IN PROPER POSITION?**
   - **TEST OPTIONS** VISUAL
     - **REASON FOR QUESTION** If switch is open, no power is supplied to NBC filter blower.
   - Place NBC switch to 'ON' position

2. **DISCONNECT LEAD 783 B FROM NBC FILTER BLOWER. IS THERE BATTERY VOLTAGE AT LEAD 783 B?**
   - **TEST OPTIONS** STE/ICE-R TEST 89, PAGE 2-750
     - **REASON FOR QUESTION** No power would indicate damaged leads and/or components.
   - Go to 4, Page 2-662

3. **IS THERE CONTINUITY BETWEEN NBC FILTER BLOWER LEAD 796 B AND GROUND?**
   - **TEST OPTIONS** STE/ICE-R TEST 81, PAGE 2-752
     - **REASON FOR QUESTION** No continuity would indicate damaged leads and/or components.
   - Go to 13, Page 2-662

4. **REPLACE NBC FILTER BLOWER**
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.

0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

Replace NBC filter blower, refer to DS Maintenance.
AMBULANCE
(NBC Filter Blower)
(Refer to Fig. 17.)

FROM 2,
Page 2-660

TEST OPTIONS
1. STE/ICE-R TEST 89,
Page 2-750
2. MULTIMETER

REASON FOR QUESTION
Battery malfunction will cause any dependent circuit to malfunction.

KNOWED INFO
PREVIOUSLY CORRECTED INFORMATION

POSSIBLE PROBLEMS
BATTERY
CABLE 660
LEAD 782
LEAD 782 A
CIRCUIT BREAKER
LEAD 783
NBC SWITCH
LEAD 783 A
LEAD 783 B

KNOWED INFO
BATTERY OK

POSSIBLE PROBLEMS
CABLE 660
LEAD 782
LEAD 782 A
CIRCUIT BREAKER
LEAD 783
NBC SWITCH
LEAD 783 A
LEAD 783 B

5

IS THERE BATTERY VOLTAGE IN CONTROL BOX AT POWER STUD?

TEST OPTIONS
1. STE/ICE-R TEST 89,
Page 2-750
2. MULTIMETER

REASON FOR QUESTION
No power at power stud would indicate a damaged cable from the power source.

GO TO 1,
Page 2-252

YES
NO

REPAIR CABLE 660

6

IS THERE BATTERY VOLTAGE IN NBC CONTROL PANEL AT LEAD 782 OF RELAY 3?

TEST OPTIONS
STE/ICE-R TEST 89,
Page 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

YES
NO

REPAIR LEAD 782

GO TO 7,
Page 2-664
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.

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.

Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).
AMBULANCE
(NBC Filter Blower)
(Refer to Fig. 32.)

FROM 6,
Page 3-662

DIAGNOSTIC FLOWCHART

7

IS THERE BATTERY VOLTAGE IN
NBC CONTROL PANEL AT
CIRCUIT BREAKER?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a
damaged lead.

POSSIBLE PROBLEMS
LEAD 782 A
CIRCUIT BREAKER
LEAD 783
NBC SWITCH
LEAD 783 A
LEAD 783 B

YES

REPAIR LEAD 782 A

NO

8

IS THERE BATTERY VOLTAGE IN
NBC CONTROL PANEL THROUGH
CIRCUIT BREAKER?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a
damaged circuit breaker.

POSSIBLE PROBLEMS
CIRCUIT BREAKER
LEAD 783
NBC SWITCH
LEAD 783 A
LEAD 783 B

YES

REPLACE CIRCUIT BREAKER

NO

9

IS THERE BATTERY VOLTAGE IN
NBC CONTROL PANEL AT NBC
SWITCH?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a
damaged lead.

POSSIBLE PROBLEMS
LEAD 783
NBC SWITCH
LEAD 783 A
LEAD 783 B

YES

REPLACE LEAD 783

NO

GO TO 10,
Page 2-665

2-664
REFERENCE INFORMATION

AMBULANCE

Repair lead, refer to (para. 4-65).

Replace circuit breaker, refer to DS Maintenance.

| 0-45 DC VOLTS |
| STEACE-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.
AMBULANCE (NBC Filter Blower) (Refer to Fig. 17.)

FROM 9, Page 2-664

10

IS THERE BATTERY VOLTAGE IN NBC CONTROL PANEL THROUGH NBC SWITCH?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged switch.

YES

REPLACE NBC SWITCH

NO

11

IS THERE BATTERY VOLTAGE IN NBC CONTROL PANEL AT LEAD 783 A OF RELAY 3?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

YES

NO

12

IS THERE BATTERY VOLTAGE AT LEAD 783 B OF NBC FILTER BLOWER?

TEST OPTIONS
STE/ICE-R TEST 89, PAGE 2-750

REASON FOR QUESTION
No power would indicate a damaged lead.

YES

NO

REPAIR LEAD 783 A

REPAIR LEAD 783 B

RETURN TO STEP 3, Page 2-660
Replace NBC switch, refer to DS Maintenance.

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.

Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).
Repair lead, refer to (para. 4-85).

Repair lead connector, refer to (para. 4-85).

---

**0-4500 OHMS STE/ACE-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, 0-4500 ohms.

3. Displayed reading in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."
AMBULANCE
(NBC Filter Blower)
(Refer to Fig. 17.)

Page 2-668

Fig. 17.

FROM 15,
Page 2-668

TEST OPTIONS
STE/ICE-R TEST 01, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

KNOW INFO
LEAD 793 OK
LEAD 796 OK
LEAD 796 B OK

POSSIBLE PROBLEMS
LEAD 796 B
NBC FILTER BLOWER

16

IS THERE CONTINUITY OF LEAD 796 B AT NBC FILTER BLOWER?

YES

REPAIR LEAD 796 B

NO

REPLACE LEAD 796 B

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If NBC filter blower does not operate, there is a malfunction of the unit.

KNOW INFO
LEAD 793 OK
LEAD 796 OK
LEAD 796 A OK
LEAD 796 B OK

POSSIBLE PROBLEMS
NBC FILTER BLOWER

17

DOES NBC FILTER BLOWER OPERATE?

YES

END OF TESTING

NO

REPLACE NBC FILTER BLOWER
REFERENCE INFORMATION

AMBULANCE

Repair lead, refer to (para. 4-65).

Replace NBC filter blower, refer to DS Maintenance.

| 0-4500 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, 0-4500 ohms. |
| 3. Displayed reading in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9." |
AMBULANCE
(NBC Heaters)
(Refer to Fig. 17.)

START

IS NBC SWITCH ON NBC CONTROL PANEL IN PROPER POSITION?

NO

PLACE NBC SWITCH TO 'ON' POSITION

YES

DOES NBC FILTER BLOWER OPERATE?

NO

PLACE JUMPER WIRE BETWEEN LEAD 782 AND LEADS 786, 785, 784, AND 787 AT RELAY 3 IN NBC CONTROL PANEL. DO NBC HEATERS OPERATE?

NO

GO TO 4,
Page 2-674

REPLACE RELAY 3

YES

GO TO 2,
Page 2-660

TEST OPTIONS

TM 9-2320-280-20-1

VISUAL

REASON FOR QUESTION
If switch is open, no power is supplied to NBC heaters.

TRY IT

REASON FOR QUESTION
If NBC filter blower operates, power is supplied to NBC control panel.

TRY IT

REASON FOR QUESTION
NBC heaters' operation would indicate a relay 3 malfunction.
Fig. 17.

**Diagnostic Flowchart**

From 3, Page 2-672

**Known Info**

4. **Check Both Fuse Blocks in NBC Control Panel. Are All the Fuses OK?**

**Possible Problems**

**Fuses**
- Lead 786
- Lead 785
- Lead 784
- Lead 787
- Damaged Leads

**Test Options**

- Visual

**Reason for Question**

If fuse is blown, individual circuits are incomplete.

**Known Info**

5. **Is There Battery Voltage in NBC Control Panel at Leads 786 and 785 of First Fuse Block?**

**Possible Problems**

- Lead 786
- Lead 785
- Lead 784
- Lead 787
- Damaged Leads

**Test Options**

- Ste/ICE-R Test 89, Page 2-750

**Reason for Question**

No power would indicate damaged leads.

**Known Info**

6. **Is There Battery Voltage in NBC Control Panel at Leads 784 and 787 of Second Fuse Block?**

**Possible Problems**

- Lead 784
- Lead 787
- Damaged Leads

**Test Options**

- Ste/ICE-R Test 89, Page 2-750

**Reason for Question**

No power would indicate damaged leads.

Go to 7, Page 2-676
**REFERENCE INFORMATION**

**AMBULANCE**

**Circuit Diagram**

- **Fuse Block**: 786A NBC, SPARE FUSE 784A NBC, 784B NBC, 20A, 20A, 20A, 20A, 12 AWG, 785 NBC, 12 AWG, 787 NBC, 10 AWG, 782 NBC, 782A NBC
- **Circuit Breaker**: 786 NBC, 787 NBC, 783 NBC, relay No. 3
- **Switch**: NBC Switch

---

**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.
AMBULANCE (NBC Heaters) (Refer to Fig. 17.)

DIAGNOSTIC FLOWCHART

KNOWLEDGE INFO

| FUSES OK | LEAD 786 OK | LEAD 785 OK | LEAD 784 OK | LEAD 787 OK |

POSSIBLE PROBLEMS

DAMAGED LEADS

TEST OPTIONS


REASON FOR QUESTION

No power would indicate a damaged lead.

TEST OPTIONS

TRY IT

REASON FOR QUESTION

If NBC heaters do not operate, that would indicate a possible problem with ground wires.

END OF TESTING

GO TO 8, PAGE 2-678

REPAIR DAMAGED LEADS

YES

NO

DO NBC HEATERS OPERATE?

YES

NO

PAGE 2-674

FROM 8, PAGE 2-674

TM 9-2320-280-20-1

2-676
0-45 DC VOLTS
STE/CE-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

FROM 8, Page 2-676

9
IS THERE CONTINUITY OF LEAD 795 AT NBC HEATER NO. 5 TO GROUND?

TEST OPTIONS
STE/ICE-R TEST 91, Page 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

YES
REPAIR LEAD 795

NO

10
IS THERE CONTINUITY OF LEAD 795 A BETWEEN NBC HEATERS NO. 5 AND NO. 4?

TEST OPTIONS
STE/ICE-R TEST 91, Page 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

YES
REPAIR LEAD 795 A

NO

11
IS THERE CONTINUITY OF LEAD 795 B BETWEEN NBC HEATERS NO. 4 AND NO. 3?

TEST OPTIONS
STE/ICE-R TEST 91, Page 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

YES
REPAIR LEAD 795 B

NO

GO TO 12, Page 2-680
0-4500 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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

---

Repair lead, refer to (para. 4-85).

---

Repair lead, refer to (para. 4-85).

---

Repair lead, refer to (para. 4-85).
AMBULANCE
(NBC Heaters)
(Refer to Fig. 17.)

FROM 11,
Page 2-678

DIAGNOSTIC FLOWCHART

TEST OPTIONS
STE/ICE-R TEST 91, PAGE 2-752

REASON FOR QUESTION
No continuity would indicate a damaged lead.

12

IS THERE CONTINUITY OF LEAD 794 AT NBC HEATER NO. 6 TO GROUND?

NO

YES

REPAIR LEAD 794

KNOWN INFO
LEAD 795 OK
LEAD 795 A OK
LEAD 795 B OK
LEAD 794 OK

POSSIBLE PROBLEMS
LEAD 794
LEAD 794 A
NBC HEATERS

13

IS THERE CONTINUITY OF LEAD 794 A BETWEEN NBC HEATERS NO. 6 AND NO. 7?

NO

YES

REPAIR LEAD 794 A

KNOWN INFO
LEAD 795 OK
LEAD 795 A OK
LEAD 795 B OK
LEAD 794 OK
LEAD 794 A OK

POSSIBLE PROBLEMS
LEAD 794 A
NBC HEATERS

14

DO NBC HEATERS OPERATE?

NO

YES

REPLACE NBC HEATERS

TEST OPTIONS
TRY IT

REASON FOR QUESTION
If NBC heaters do not operate, that would indicate heater malfunction.

END OF TESTING
0-4500 OHMS
STER/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, 0-4500 ohms.

3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

---

Replace NBC heaters, refer to (para. 11-164).

---

Repair lead, refer to (para. 4-85).

---

Repair lead, refer to (para. 4-85).
AMBULANCE (NBC Heater)  
(Refer to Fig. 17.)

1. CHECK Fuse blocks in NBC control panel. Is NBC heater fuse OK?
   - KNOWN INFO: NOTHING
   - POSSIBLE PROBLEMS: FUSE, POWER LEAD, NBC HEATER, GROUND LEAD
   - TEST OPTIONS: VISUAL
   - REASON FOR QUESTION: If fuse is blown, circuit is incomplete.
   - TEST OPTIONS: STE/ICE-R TEST 89, PAGE 2-750
   - REASON FOR QUESTION: No power would indicate a damaged lead.
   - TEST OPTIONS: STE/ICE-R TEST 91, PAGE 2-752
   - REASON FOR QUESTION: No continuity would indicate a damaged lead.

2. DISCONNECT NBC HEATER power lead. Is there battery voltage at lead?
   - KNOWN INFO: FUSE OK
   - POSSIBLE PROBLEMS: POWER LEAD, NBC HEATER, GROUND LEAD
   - TEST OPTIONS: STE/ICE-R TEST 89, PAGE 2-750
   - REASON FOR QUESTION: No power would indicate a damaged lead.

3. IS THERE CONTINUITY OF NBC HEATER ground lead?
   - KNOWN INFO: FUSE OK, POWER LEAD OK
   - POSSIBLE PROBLEMS: NBC HEATER, GROUND LEAD
   - TEST OPTIONS: STE/ICE-R TEST 91, PAGE 2-752
   - REASON FOR QUESTION: No continuity would indicate a damaged lead.

REPLACE BLOWN FUSE
REPAIR LEAD
REPAIR LEAD
REPLACE NBC HEATER
**REFERENCE INFORMATION**

**AMBULANCE**

![Diagram of circuit](image)

**0-45 DC 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.

**0-4500 OHMS**

STE/ACE-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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."
Figure 11. Lighting System
Figure 12. Aspirator System
Figure 13. DC Voltage System
Figure 14. Air-Conditioning Control System
Figure 15. M996 and M996A1 Heater/Ventilation Control Box and Blower Fan
Figure 16. Heater Control System
Figure 17. NBC Control System
2-40. AMBULANCE MECHANICAL SYSTEM TESTS

These ambulance system mechanical tests may be run anytime you think you have an ambulance mechanical 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.
AMBULANCE (Upper Litter Rack)

1. ARE LATCH AND STRIKER IN PROPER ALIGNMENT?
   - TEST OPTIONS: VISUAL
   - REASON FOR QUESTION: If latch and striker are not properly aligned, upper litter rack will not lock in upright position.
   - NO: ADJUST UPPER LITTER RACK LATCH
   - YES: GO TO 2

2. IS STRIKER IN GOOD CONDITION AND NOT MISSING?
   - TEST OPTIONS: VISUAL
   - REASON FOR QUESTION: If striker is damaged or missing, upper litter rack will not lock in upright position.
   - NO: REPLACE STRIKER IF DAMAGED OR MISSING
   - YES: GO TO 3

3. IS LATCH FREE FROM ANY STICKING, BINDING, OR DAMAGE?
   - TEST OPTIONS: VISUAL
   - REASON FOR QUESTION: If latch is sticking, binding, damaged, or missing, upper litter rack will not lock in upright position.
   - NO: REPLACE LATCH IF STICKING, BINDING, OR DAMAGED
   - YES: GO TO 4

4. [Page 2-696]
Adjust upper litter rack latch, refer to (para. 11-142).

Replace striker, refer to (para. 11-139).

Replace latch, refer to (para. 11-142).
AMBULANCE SYSTEM (Upper Litter Rack)

**KNOWN INFO**
- LATCH OK
- STRIKER OK
- LATCH AND STRIKER ALIGNED PROPERLY

**POSSIBLE PROBLEMS**
- SUSPENSION STRAPS

**TEST OPTIONS**
- VISUAL

**REASON FOR QUESTION**
Upper litter rack will not fold to backrest position if suspension straps are not unhooked.

**FLOWCHART**

1. **DOES UPPER LITTER RACK FOLD TO BACKREST POSITION?**
   - **NO**
     - UNHOOK SUSPENSION STRAPS
   - **YES**
     - NO FAULTS FOUND

FROM 3, PAGE 2-694
Unhook suspension straps, refer to (TM 9-2320-280-10).
Unhook safety straps, refer to (TM 9-2320-280-10).

Replace retractor, refer to (para. 11-137).

Replace latches, refer to (para. 11-135).
DIAGNOSTIC FLOWCHART

1.

DO REAR DOORS LOCK?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Sticking, binding, or damage of the latch rods will cause a malfunction of the rear door lock.

1. NO

REPLACE LATCH RODS

1. YES

REPLACE LATCH RODS

2.

IS THE HANDLE LATCH FREE OF ANY DAMAGE?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Any defect in the handle latch will not allow the rear doors to lock.

2. NO

REPLACE HANDLE LATCH

2. YES

REPLACE HANDLE LATCH

3.

ARE DOOR CATCHES INTACT AND NOT BROKEN?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If door catches are missing or broken, rear doors will not lock.

3. NO

REPLACE DOOR CATCHES

3. YES

REPLACE DOOR CATCHES

NO FAULTS FOUND
Replace latch rods, refer to (para. 11-128).

Replace handle latch, refer to (para. 11-128).

Replace door catches, refer to (para. 11-131).
To ensure the proper alignment of attendant seat tracks and rails, remove and reinstall attendant seat making sure that tracks fully engage. Refer to (para. 11-157).

Replace latch, refer to (para. 11-157).

Replace spring, refer to (para. 11-157).
AMBULANCE
(Bulkhead Door)

DIAGNOSTIC FLOWCHART

START

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Any sticking, binding, or damage to the latch rods will not allow the bulkhead door to lock.

1

ARE LATCH RODS FREE FROM STICKING, BINDING, OR DAMAGE?

REPLACE BULKHEAD DOOR

NO

YES

TEST OPTIONS
VISUAL

REASON FOR QUESTION
A malfunction of the handle latch will result in the bulkhead door not being able to lock.

2

IS SEAT LATCH FREE FROM STICKING, BINDING, OR ANY OTHER DAMAGE?

NO

REPLACE HANDLE LATCH

YES

NO FAULTS FOUND

KNOWN INFO
NOTHING

POSSIBLE PROBLEMS
LATCH RODS
HANDLE LATCH

KNOWN INFO
LATCH RODS OK

POSSIBLE PROBLEMS
HANDLE LATCH
Replace bulkhead door, refer to (para. 11-155).

Replace handle latch, refer to (para. 11-156).
AMBULANCE
(Heater)

TEST OPTIONS

1

IS THE FUEL PUMP FREE FROM LEAKS OR ANY OTHER DEFECTS?

REASON FOR QUESTION
If the fuel pump is damaged or defective, the heater will either not start or shuts off after it starts.

NO

REPLACE FUEL PUMP

YES

TEST OPTIONS

2

ARE FUEL LINES WITHOUT ANY DAMAGE OR LEAKS?

REASON FOR QUESTION
Heater will not start or will shut off after starting if fuel lines are damaged or leaking.

NO

REPLACE FUEL LINES

YES

TEST OPTIONS

3

IS FUEL FILTER IN GOOD CONDITION AND WITHOUT RESTRICTIONS?

REASON FOR QUESTION
If there is any damage to the fuel filter or if it has restrictions, heater will not start or will shut off, after it starts.

NO

CLEAN OR REPLACE FUEL FILTER

YES

GO TO 4,
Replace fuel pump refer to (para. 11-194).

Replace fuel lines refer to (para. 11-193).

Clean or replace fuel filter refer to (para. 11-192).
AMBULANCE HEATER

DIAGNOSTIC FLOWCHART

KNOWLEDGE

FUEL PUMP OK
FUEL LINES OK
FUEL FILTER OK
HEATER EXHAUST PIPE OK

POSSIBLE PROBLEMS
HEATER EXHAUST PIPE
AIR INTAKE DUCT DOOR

NO

TEST OPTIONS

VISUAL

REASON FOR QUESTION
Restrictions or damage to the heater exhaust pipe will not allow the heater to start or will make it shut off.

CLEAN OR REPLACE HEATER EXHAUST PIPE

YES

5

IS THE AIR INTAKE DUCT DOOR OPERATING PROPERLY?

KNOWLEDGE

FUEL PUMP OK
FUEL LINES OK
FUEL FILTER OK
HEATER EXHAUST PIPE OK

POSSIBLE PROBLEMS
AIR INTAKE DUCT DOOR

NO

TEST OPTIONS

VISUAL

REASON FOR QUESTION
Without proper operation of the air intake duct door, the heater will either not start, or will shut off after starting.

ADJUST OR REPLACE DOOR CABLE OR REPLACE DUCT DOOR

YES

6

DOES THE HEATER START?

KNOWLEDGE

FUEL PUMP OK
FUEL LINES OK
FUEL FILTER OK
HEATER EXHAUST PIPE OK
AIR INTAKE DUCT DOOR OK

POSSIBLE PROBLEMS
ELECTRICAL

NO

GO TO HEATER ELECTRICAL TROUBLESHOOTING

YES

OTHER CAUSES NOTIFY DS MAINTENANCE

FROM 3, PAGE 2-708

TM 9-2320-280-20-1
Clean or replace heater exhaust pipe, refer to (para. 11-189 or 11-207).

Adjust or replace door cable, refer to (para. 11-199). Replace duct door, refer to (para. 11-185).

At the completion of the mechanical troubleshooting steps, the heater should start. If not, there might be an electrical problem. Refer to electrical troubleshooting section, para. 2-39 (heater electrical troubleshooting, page 2-636).
**AMBULANCE (Air-Conditioning Unit)**

**KNOWN INFO**
- AIR-CONDITIONING UNIT PROVIDES INSUFFICIENT COOLING

**POSSIBLE PROBLEMS**
- OUTLET GRILLES
- COMPRESSOR
- DRIVEBELT
- EVAPORATOR INTAKE CABLE
- HEATER/AIR-CONDITIONING OUTLET CABLE

**TEST OPTIONS**

**TEST OPTIONS**
- SEE INSTRUCTIONS AT RIGHT VISUAL INSPECTION
- REASON FOR QUESTION
  Outlet grilles must be clean and without restrictions to ensure air-conditioning unit will provide sufficient cooling.

**TEST OPTIONS**

**TEST OPTIONS**
- VISUAL
- REASON FOR QUESTION
  Air-conditioning unit will provide insufficient cooling if it has a loose compressor drivebelt.

**TEST OPTIONS**

**TEST OPTIONS**
- VISUAL
- REASON FOR QUESTION
  If the intake and outlet cables for the evaporator and heater/air conditioning are not properly installed and adjusted, air-conditioning unit will not provide sufficient cooling.

**KNOWN INFO**
- OUTLET GRILLES OK
- COMPRESSOR DRIVEBELT OK

**POSSIBLE PROBLEMS**
- EVAPORATOR INTAKE CABLE
- HEATER/AIR-CONDITIONING OUTLET CABLE

**START**

**CHECK AIR INTAKE OR CONDENSER OUTLET GRILLES. ARE THEY FREE OF DIRT OR DEBRIS?**

**REMOVE ANY RESTRICTIONS FROM GRILLES**

**IS COMPRESSOR DRIVEBELT BOUND?**

**ADJUST DRIVEBELT**

**ARE EVAPORATOR INTAKE CABLE AND HEATER/AIR-CONDITIONING OUTLET CABLE PROPERLY INSTALLED AND ADJUSTED (M997 ONLY)?**

**ADJUST EVAPORATOR INTAKE CABLE AND HEATER/AIR-CONDITIONING OUTLET CABLE PROPERLY**

**OTHER CAUSES NOTIFY DS MAINTENANCE**

3-710
Turn on air-conditioning and set controls to maximum cooling and blower speed settings (TM 9-2320-280-10). Maintain engine speed at 1500 rpm with hand throttle. Verify rpm with STE/ICE equipment. Open ambulance body doors to allow flow of fresh air through vehicle. Run air-conditioner five minutes to allow temperature and pressure to stabilize. Check outlet ducts for cool air.

Adjust drivebelt, refer to (para. 11-202).

Properly adjust evaporator intake cable and heater/air-conditioning outlet cable, refer to (para. 11-199).
AMBULANCE
(NBC Door/Unit)

START

1

CHECK LATCH FOR STICKING BINDING, OR DAMAGE. IS EVERYTHING OK WITH THE LATCH?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
The latch is an integral part of the NBC door. If it is not functioning properly, NBC door will not lock in either closed or open position.

POSSIBLE PROBLEMS
LATCH

NO

REPAIR OR REPLACE LATCH

YES

2

IS TUBING OK (NOT DAMAGED)?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
Once there is damage to the tubing, NBC unit will not operate.

POSSIBLE PROBLEMS
TUBING

NO

REPLACE TUBING IF DAMAGED

YES

3

TAKE A GOOD LOOK AT THE FILTERS. ARE THEY FREE OF ANY RESTRICTIONS OR DAMAGES?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If the filter is damaged or restricted, NBC unit will not operate.

POSSIBLE PROBLEMS
FILTER

NO

REPLACE FILTER

YES

NO FAULTS FOUND
REFERENCE INFORMATION

- Repair or replace latch, refer to (para. 11-163).

- Replace tubing if damaged, refer to (para. 11-166).

- Replace filter, refer to (para. 11-168).
2-41. WINCH SYSTEM TESTS

These winch system tests may be run anytime 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

1. IS WINCH CABLE BOUND?
   - YES: SECURE WINCH CABLE FIRMLY
   - NO: MECHANICAL SERVICE

2. IS WINCH CONTROL CABLE CONNECTOR FREE FROM LOoseness OR CORROSION?
   - YES: CLEAN CORRODED CONNECTOR OR SECURE LOOSE CONNECTION
   - NO: JOIN CABLES AND CONNECTORS

3. ARE WINCH POWER CABLES FIRMLY SECURED AND NOT DAMAGED? IS BATTERY VOLTAGE PRESENT IN POSITIVE LEAD 6 AND NEGATIVE LEAD 7?
   - YES: GO TO 4
   - NO: REPAIR/REPLACE WINCH POWER CABLE

4. TEST OPTIONS
   - VISUAL

REASON FOR QUESTION
A loose winch cable may cause the winch not to operate properly.

Looseness and corrosion at winch cables and connectors will interfere with the proper operation of the winch.

When winch power cables are loose or damaged, winch will not operate properly.
Repair/replace winch power cables, refer to (para. 10-107 or 10-108).

### 0-45 DC VOLTS
**STE/CE-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.
WINCH

DIAGNOSTIC FLOWCHART

FROM 3, PAGE 2-718

KNOWLEDGE INFO
WINCH POWER CABLES OK
WINCH CABLE OK
WINCH CONTROL CABLE CONNECTOR OK

POSSIBLE PROBLEMS
WINCH
WINCH CONTROL

Test Options
1. STE/ICE-R TEST 91, PAGE 2-752
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.

DISCONNECT WINCH CONTROL CABLE. IS CONTINUITY PRESENT BETWEEN COMMON TERMINAL 471 AND 472 "IN" AND 471 AND 473 "OUT"?

NO
REPLACE WINCH OR WINCH CONTROL

YES
NO FAULTS FOUND
Replace winch or winch control, refer to (paras. 10-107, 10-108, or 10-109).

### 0-4500 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, 0-4500 ohms.
3. Displayed reading is in ohms. Less than 5 ohms is continuity. If the resistance is over 4500 ohms, STE/ICE displays "9.9.9.9."

### CONTINUITY (RESISTANCE) MULTIMETER

1. Set the voltmeter to an ohms scale of about 1000 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).
ARMAMENT/TOW CARRIERS

START

1

DETECT WEAPON STATION
ROTATE PROPERLY?

TEST OPTIONS
VISUAL

REASON FOR QUESTION
If the lockpin in the turret lock
assembly binds, sticks, is
damaged, or out of alignment,
weapon station will not rotate.

YES

REPLACE TURRET
LOCK ASSEMBLY

NO

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

KNOWN INFO
NOTHING

POSSIBLE PROBLEMS
TURRET LOCK
ASSEMBLY LOCKPIN
BRAKE HANDLE

KNOWN INFO
TURRET LOCK
ASSEMBLY OK

POSSIBLE PROBLEMS
BRAKE HANDLE
Replace turret lock assembly, refer to (para. 11-56).

Place brake handle in locked position, refer to (TM 9-2320-280-10).
2-42. DCA TROUBLESHOOTING

These DCA tests can be run anytime 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) uses 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 FO-16 gives a cross reference between DCA tests and TK 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

START

WE WERE YOU RUNNING A FUEL PRESSURE, RPM, OR POWER TEST?

NO

GO TO A

YES

WE WERE YOU RUNNING STE/ICE-R TEST #24, FUEL PRESSURE?

NO

GO TO B

YES

DISCONNECT CONNECTOR DIRECTLY BEFORE FUEL PRESSURE TRANSUDER. INSPECT FOR BENT PINS. DOES EVERYTHING LOOK OK?

NO

REPAIR OR REPLACE WIRING/TRANSUDER AS NEEDED

YES

GO TO 4,

TEST OPTIONS

SEE NOTE TO RIGHT ABOUT THIS PARAGRAPH.

REASON FOR QUESTION
You need to know which transducer is causing the problem.

TEST OPTIONS

N/A

REASON FOR QUESTION
You need to know which transducer is causing the problem.

TEST OPTIONS

VISUAL INSPECTION

REASON FOR QUESTION
If the transducer pins are bent or broken you will get bad measurements.
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 (BatteryCurrent). 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 or replace transducer, refer to (para 4-26).
DCA TROUBLESHOOTING

KNOWN INFO
STE/ICE-R OK
W1 OK
RUNNING TEST 24
WIRING LOOKS OK

POSSIBLE PROBLEMS
TRANSDUCER
DCA
FUEL SYSTEM

TEST OPTIONS
STE/ICE-R TEST 49

REASON FOR QUESTION
This will tell if you have a fuel system problem or a DCA problem.

REMOVE THE FUEL PRESSURE TRANSUDER 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 (RED) TRANSUDER. IS THE FUEL PRESSURE OK?

NO

YES

VEHICLE PROBLEM. IF YOU CAME FROM ANOTHER PARAGRAPH, RETURN THERE AND FOLLOW THE PATH CORRESPONDING TO A FAILURE OF THE TEST YOU WERE RUNNING

5

TEST OPTIONS
DID TEST 24 GIVE A CORRECT RESULT?

N/A

REASON FOR QUESTION
If test 24 gave the same result as test 49, then everything is ok.

SEE NOTE TO RIGHT

NO

YES

NO FAULTS
REFERENCE INFORMATION

The fuel pressure should always be greater than 3 psi. If you get about the same pressure with the 2 transducers, then you have a fuel system problem. Remove fuel pressure transducer, refer to (para 4-25). 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.

<table>
<thead>
<tr>
<th>STE/ICE-R TEST 49</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 TO 25 PSIG PRESSURE</td>
</tr>
<tr>
<td>1. CONNECT RED TRANSDUCER TO FUEL FILTER.</td>
</tr>
<tr>
<td>2. CONNECT TRANSDUCER 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>
</tbody>
</table>
DCA TROUBLESHOOTING

A1

KNOWN INFO
STE/ICE-R OK
CABLES OK
TK OK
MEASURING THROUGH
SHUNT OR ACROSS
BATTERIES.

POSSIBLE PROBLEMS
SHUNT WIRING
BATTERY WIRING
VEHICLE SYSTEMS
DCA

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?

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, then the problem is
in the DCA. Otherwise, the
vehicle itself has a fault.

YES

VEHICLE PROBLEM.
IF YOU CAME FROM ANOTHER
PARAGRAPH, RETURN THERE AND
FOLLOW THE PATH CORRESPONDING
TO A FAILURE OF THE TEST
YOU WERE RUNNING

NO

A2

KNOWN INFO
VEHICLE OK
STE/ICE-R OK
CABLES OK
TK OK

POSSIBLE PROBLEMS
SHUNT WIRING
BATTERY WIRING
DCA

TEST OPTIONS
N/A

REASON FOR QUESTION
If you got a substantially
different test result through
the DCA, then you have a DCA
problem.

YES

NO

DID THE ORIGINAL DCA TEST
GIVE A CORRECT RESULT?

NO

SEE NOTE TO
RIGHT

NO FAULTS
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, then 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

**Known Info**
- STE/ICE-R OK
- Cables OK
- TK OK using pulse tachometer

**Possible Problems**
- Tachometer
- Vehicle systems
- DCA

**Test Options**
- **B FROM 2, Page 2-724**
- Visual inspection - check for broken wires or connectors and worn parts. Also check the slot in the oil pump drive.

**Reason for Question**
If the tachometer is no good, you can't expect good test results.

**Flowchart**

**B1**

- **Remove the tachometer from the engine and inspect it. Is it OK?**
  - **Yes**
  - Replace tachometer
  - **No**

**B2**

- **Install the tachometer from the TK kit. Run the original test with the VTM in the TK Mode. Is the vehicle OK?**
  - **Yes**
  - **Vehicle problem. If you came from another paragraph, return there and follow the path corresponding to a failure of the test you were running**
  - **No**

**B3**

- **Did the original DCA test give a correct result?**
  - **No**
  - See note to right
  - **Yes**
  - No faults

**Test Options**
- **See the chart on the foldout page to run the TK version of the test you want**

**Reason for Question**
You want to know if the vehicle is OK.

**Reason for Question**
If you got a substantially different test result through the DCA, then you have a DCA problem.
Remove tachometer, refer to (para 4-13). 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 STE/ICE-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.

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.
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 procedure, control codes, and additional notes as necessary. The following chart will help you find the test you need. The STE/ICE setup and internal checks (test no. G01 [Page 2-763]) must be performed prior to performing tests. A complete description and operation of the STE/ICE-R is found on [Page 2-753]. See TM 9-4910-571-12&P for additional information.

<table>
<thead>
<tr>
<th>TEST NAME</th>
<th>TEST #</th>
<th>PAGE #</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGINE RPM (AVERAGE)</td>
<td>10</td>
<td>2-734</td>
</tr>
<tr>
<td>POWER TEST (RPM/SEC)</td>
<td>12</td>
<td>2-735</td>
</tr>
<tr>
<td>POWER TEST (PERCENT)</td>
<td>13</td>
<td>2-736</td>
</tr>
<tr>
<td>COMPRESSION UNBALANCE TEST</td>
<td>14</td>
<td>2-737</td>
</tr>
<tr>
<td>FUEL SUPPLY PRESSURE (PSI)</td>
<td>24</td>
<td>2-738</td>
</tr>
<tr>
<td>PRESSURE (PSI) 0 TO 1000</td>
<td>50</td>
<td>2-739</td>
</tr>
<tr>
<td>BATTERY VOLTAGE</td>
<td>67</td>
<td>2-740</td>
</tr>
<tr>
<td>STARTER MOTOR VOLTAGE</td>
<td>68</td>
<td>2-741</td>
</tr>
<tr>
<td>STARTER NEGATIVE CABLE VOLTAGE DROP</td>
<td>69</td>
<td>2-742</td>
</tr>
<tr>
<td>STARTER SOLENOID VOLTS</td>
<td>70</td>
<td>2-743</td>
</tr>
<tr>
<td>STARTER CURRENT AVERAGE</td>
<td>71</td>
<td>2-744</td>
</tr>
<tr>
<td>CURRENT FIRST PEAK</td>
<td>72</td>
<td>2-745</td>
</tr>
<tr>
<td>BATTERY INTERNAL RESISTANCE</td>
<td>73</td>
<td>2-746</td>
</tr>
<tr>
<td>STARTER CIRCUIT RESISTANCE</td>
<td>74</td>
<td>2-747</td>
</tr>
<tr>
<td>BATTERY RESISTANCE CHANGE</td>
<td>75</td>
<td>2-748</td>
</tr>
<tr>
<td>BATTERY CURRENT</td>
<td>80</td>
<td>2-749</td>
</tr>
<tr>
<td>DC VOLTAGE 0 TO 45 VOLTS</td>
<td>39</td>
<td>2-750</td>
</tr>
<tr>
<td>DC CURRENT 0 TO 1500 AMPS</td>
<td>90</td>
<td>2-751</td>
</tr>
<tr>
<td>RESISTANCE AND CONTINUITY 0 TO 4500 OHMS</td>
<td>91</td>
<td>2-752</td>
</tr>
</tbody>
</table>
ENGINE RPM (Average) TEST #10

Description:
This procedure measures engine speed in the range 50 to 5000 RPM. At speeds below 50 RPM the VTM will display 0. At speeds above 5000 RPM the display may give a false reading. Test requires DCA hookup only.

Pre-Test Procedures
Run Confidence Test.

Typical Applications:
Check Engine Speed

Possible Error Messages
E014 Incorrect # of cylinders entered

Test Procedure:
1. Set TEST SELECT switches to 10
2. Press and release TEST button
3. Start engine
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 end 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 end hold it to the floor. When VTM displays a number, release accelerator.
10. Observe displayed value (RFM/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 rechecked before performing power test. Idle speed must be within the range 625-675 RPM (6.2L and 6.5L) range to run test.
Engine governor no load speed must be checked before performing power test. Governor no-load speed must be within the 3900-4100 RPM (6.2L) end 3600-3600 RPM (6.5L) 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.

Typical Applications:
Check engine power

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.

Pm-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.
E024 Test not valid for VID entered

NOTES:
Engine idle speed must be checked before performing power test. Idle speed must be within the 625-675 RPM (6.2L and 6.5L) range to run test. Engine governor no load speed must be checked before performing power test. Governor no load speed must be within the 3600-3800 RPM (6.2L) and 3900-4100 RPM (6.5L) range to run test.
COMPRESSION UNBALANCE TEST #14 (6.2L ONLY)

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.

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.

Pre-Test Procedures:
Run Confidence Test. Warmup engine to operating temperature. Run first-peak series tests 72, 73, 74, 75.

Possible Error Messages:
E006 VTM doesn’t detect battery voltage.
E013 VTM cannot use date 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.

Pre-Test Procedure:
Run Confidence Test. Wait for 1 minute after turning engine off to run this test.

Typical Applications:
Fuel Supply Pressure

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.
6. Start engine
7. Observe displayed value.

Possible Error Messages:
E005 offset not performed.
PRESSURE (psi) 0 TO 1000 TEST #50

Description:
This procedure measures pressure, in the 0 to 1000 PSIG range. Test requires the use of the TK adapters and transducers.

Typical Applications:
Oil Pressure

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.

Pre-Test Procedures
Run Confidence Test.

Control Functions:
01,02,03,04,06

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 range volts. The voltage is measured directly at the power source of the VTM, and maybe done with the vehicle operating or shut down. Test requires DCA hookup only.

Typical Applications:
Check Battery Voltage

Pre-Test Procedures:
Run Confidence Test.

Control Functions:
01,02,03,04,06

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.

Typical Applications:
Check Starter Motor Voltage

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.

Pm-Test Procedures:
Run Confidence Test.

Control Functions:
01,02,03,04,06

Possible Error Messages:
none
STARTER 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.

Typical Applications:
Check Starter Negative Cable Voltage Drop.

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.

Pre-Test Procedures:
Run Confidence Test.

Control Functions:
01,02,03,04,06

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.

Typical Applications:
Check Starter Solenoid Volts.

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.

Pre-Test Procedures:
Run Confidence Test.

Control Functions:
01,02,03,04,08

Possible Error Messages:
None
STARTER CURRENT AVERAGE TEST #71

Description:

This procedure measures the average starter current in the 0 - 1000 amps range. Test requires DCA hookup only.

Typical Applications:

Check Starter Current.

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.

Pre-Test Procedures:

Run Confidence Test.

Control Functions:

01,02,03,04,08

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 C1 engines with VTM triggered 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, then 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 you want to.

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, then 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 Cl engines with VTM powered from batteries of Vehicle being tested.

Possible Error Messages
E002 Transducer not connected.
E005 Offset not performed.
E003 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, then 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.
E006 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/second).
   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, then 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 Cl 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

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.

Pre-Test Procedures:
Run Confidence Test.

Control Functions:
01,02,03,04,06

Possible Error Messages
E005 Offset not performed.
DC CURRENT 0 TO 1500 AMPS TEST #90

Description:
This procedure measures DC current in the range of 0 to 1500 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:
- Alternator output
- Average Starter Current
- Battery Current
- Any DC Current up to 1500 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.
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.

Control Functions:
01,02,03,04,06

Possible Error Messages
E002 Offset not performed.
E005 Transducer not connected.
RESISTANCE AND CONTINUITY 0 TO 4500 OHMS TEST #91

Description:
This procedure measures resistance in the range of 0 to 4500 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

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 no go to DCA Troubleshooting Procedure.
7. Press and release TEST button. Observe displayed value.

Pre-Test Procedures
Run Confidence Test.

Control Functions:
01, 02, 03, 04, 06

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 (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 measurement 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 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 transducer 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: 0-1000 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, and 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-volt 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 ten 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 4-characters (for example .8.8.8.8). The types of readouts are described in detail in paragraph 3 below and are summarized as follows:

      (1) **Statute 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.** Connector J2 or J3 connects 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 of 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 2-1.

(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 2-2.

(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.
(d) **Error Readout. E0001 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 2-3. 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 2-1. Status Readouts.

<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 the test or fails the test.</td>
</tr>
<tr>
<td>FAIL</td>
<td></td>
</tr>
</tbody>
</table>
Table 2-2. 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 ID 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 dial in 99. In test no. 12, the first numerical readout signals the technician to shut off fuel.</td>
</tr>
</tbody>
</table>

Table 2-3. 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 vehicle ID 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 vehicle identification 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 vehicle identification number (VID) dialed in the 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 vehicle identification number 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 one (1) time.</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>
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.

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.

e. Transducer Kit.

Table 2-4. Transducer Kit Components

<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>1</td>
<td>10</td>
<td>11669227</td>
<td>1</td>
<td>Hose and fitting assy (spark plug adapter)</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>12258878</td>
<td>1</td>
<td>Current probe</td>
</tr>
<tr>
<td>3</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>4</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>5</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>6</td>
<td>15</td>
<td>444620</td>
<td>1</td>
<td>Hex head plug, 1/4 MPT</td>
</tr>
<tr>
<td>7</td>
<td>16</td>
<td>5327970</td>
<td>1</td>
<td>Hex head plug, 1/8 MPT</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>12258876</td>
<td>1</td>
<td>Pressure transducer, 0-1000 psig</td>
</tr>
<tr>
<td>9</td>
<td>21</td>
<td>12258881</td>
<td>1</td>
<td>Snubber</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>3204X2</td>
<td>2</td>
<td>Adapter, 1/8 MPT to 1/4 FPT</td>
</tr>
<tr>
<td>11</td>
<td>19</td>
<td>3304X2</td>
<td>1</td>
<td>Coupling reducer, 1/8 FPT to 1/4 FPT</td>
</tr>
<tr>
<td>12</td>
<td>18</td>
<td>234X5</td>
<td>1</td>
<td>Male connector, 5/16 tube to 1/4 MPT</td>
</tr>
<tr>
<td>13</td>
<td>22</td>
<td>12258877</td>
<td>1</td>
<td>Pressure transducer, -30 in. Hg to 25 psig</td>
</tr>
<tr>
<td>14</td>
<td>23</td>
<td>444152</td>
<td>1</td>
<td>Street tee, 1/2 pipe thread</td>
</tr>
<tr>
<td>15</td>
<td>24</td>
<td>3750X4</td>
<td>1</td>
<td>Street tee, 1/4 pipe thread</td>
</tr>
<tr>
<td>16</td>
<td>25</td>
<td>547002</td>
<td>1</td>
<td>Street tee, 1/8 pipe thread</td>
</tr>
<tr>
<td>17</td>
<td>26</td>
<td>12258879-2</td>
<td>1</td>
<td>Street elbow, 1/4 pipe thread</td>
</tr>
<tr>
<td>18</td>
<td>27</td>
<td>12258879-1</td>
<td>1</td>
<td>Street elbow, 1/8 pipe thread</td>
</tr>
<tr>
<td>19</td>
<td>34</td>
<td>12258875</td>
<td>1</td>
<td>Pulse tachometer</td>
</tr>
<tr>
<td>20</td>
<td>32</td>
<td>12258880</td>
<td>1</td>
<td>Fuel line adapter</td>
</tr>
<tr>
<td>21</td>
<td>31</td>
<td>MS53099-2</td>
<td>1</td>
<td>Tachometer drive adapter</td>
</tr>
<tr>
<td>22</td>
<td>30</td>
<td>7540877</td>
<td>1</td>
<td>Ignition adapter</td>
</tr>
<tr>
<td>23</td>
<td>29</td>
<td>MS3119E14-19</td>
<td>1</td>
<td>Adapter (connector-to-connector)</td>
</tr>
<tr>
<td>24</td>
<td>28</td>
<td>12258762</td>
<td>1</td>
<td>Tee, inverted flare</td>
</tr>
<tr>
<td>25</td>
<td>33</td>
<td>8840543</td>
<td>1</td>
<td>Air chuck</td>
</tr>
<tr>
<td>26</td>
<td>35</td>
<td>1169236</td>
<td>1</td>
<td>Hose assembly, 1/8 MPT</td>
</tr>
<tr>
<td>27</td>
<td>36</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 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 drive shaft 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.
2-44. 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, Vehicle ID 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 nulls out 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 a star (*) 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 five 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.
06 Interleave.

Control tests 01, 02, 03, 04, and 06 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 CON will signal the technician to dial into 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), 0-1500 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 2-1. STE/ICE-R GO-Chain 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 indicated .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.

   **3**
Table 2-1. STE/ICE-R GO-Chain Tests. (Cont’d)

2 Display Does Not Light Up
Proceed as Follows:
- Pull off power switch.
- Check and clean all battery connections and interconnecting cables.
- Push on the power switch.
- Does the VTM display .8 .8 .8 .8 and then change to ----?

Yes
- No power for VTM, connect to a known good battery to see if problem is the vehicle or the VTM.
- 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 ----?

Yes
- 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.

No
- Check the vehicle battery electrolyte level.
- Clean vehicle battery terminals.
- Check vehicle battery specific gravity (para. 4-79).
- 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.

1
Table 2-1. STE/ICE-R GO-Chain Tests. (Cont'd)

3. RUN CONFIDENCE TEST:
   - Dial 66 into TEST SELECT and press TEST.
   - Does the VTM display and hold 0066?

   Yes
   - Dial 99 into TEST SELECT and press TEST.
   - Look for this display.

   No
   - PULL OFF the power switch.
   - PUSH ON the VTM power switch.
   - Verify that the display indicates .88.8.8 for approximately 2 seconds and then change to ----.
   - Re-dial 66 and press TEST.
   - Does the VTM display and hold 0066?

   Yes
   - STE/ICE-R is bad. Replace.

   No
   - Proceed to following page.

TEST NO. | TEST
---------|--------
66       | CONFIDENCE TEST

Note:
At this point in the test, several numbers will appear on the display. Wait for readout display of PASS.
Table 2-1. 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.

- Does the VTM display PASS?

- Repeat step 3.
  - Does the VTM display PASS?

- STE/ICE-R is bad. Replace.

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?

- Repeat step 4.
  - Does the VTM display the number 21?

- STE/ICE-R is bad. Replace.

- Proceed to troubleshooting procedures.
## INDEX VOLUME 1

<table>
<thead>
<tr>
<th>A</th>
<th>Para</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-conditioning, system operation, ambulance (M997, M997A1, and M997A2)</td>
<td>1-32</td>
<td>1-54</td>
</tr>
<tr>
<td>Air intake/exhaust tests</td>
<td>2-23</td>
<td>2-137</td>
</tr>
<tr>
<td>Alternator tests</td>
<td>2-27</td>
<td>2-194</td>
</tr>
<tr>
<td>Ambulance (M997, M997A1, and M997A2) air-conditioning system operation</td>
<td>1-32</td>
<td>1-54</td>
</tr>
<tr>
<td>Ambulance patient compartment fuel burning heater system operation</td>
<td>1-31</td>
<td>1-53</td>
</tr>
<tr>
<td>Army equipment, destruction of, to prevent enemy use</td>
<td>1-3</td>
<td>1-1</td>
</tr>
<tr>
<td>Ambulance mechanical system tests</td>
<td>2-40</td>
<td>2-693</td>
</tr>
<tr>
<td>Battery circuit tests</td>
<td>2-29</td>
<td>2-251</td>
</tr>
<tr>
<td>Battery system operation</td>
<td>1-24</td>
<td>1-43</td>
</tr>
<tr>
<td>Brake, parking, system operation</td>
<td>1-26</td>
<td>1-45</td>
</tr>
<tr>
<td>Brake, service/parking, system operation</td>
<td>1-27</td>
<td>1-46</td>
</tr>
<tr>
<td>Brake, service system operation</td>
<td>1-28</td>
<td>1-47</td>
</tr>
<tr>
<td>Brake system tests</td>
<td>2-36</td>
<td>2-445</td>
</tr>
<tr>
<td>Break-in procedure</td>
<td>1-9</td>
<td>1-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C</th>
<th>Para</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics, capabilities, and features, equipment</td>
<td>1-10</td>
<td>1-2</td>
</tr>
<tr>
<td>Common tools and equipment</td>
<td>2-1</td>
<td>2-1</td>
</tr>
<tr>
<td>Compression/mechanical tests</td>
<td>2-24</td>
<td>2-143</td>
</tr>
<tr>
<td>Cooling system operation</td>
<td>1-20</td>
<td>1-38</td>
</tr>
<tr>
<td>Cooling system tests</td>
<td>2-19</td>
<td>2-57</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D</th>
<th>Para</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data, tabulated</td>
<td>1-15</td>
<td>1-31</td>
</tr>
<tr>
<td>DCA troubleshooting</td>
<td>2-42</td>
<td>2-723</td>
</tr>
<tr>
<td>Destruction of Army equipment to prevent enemy use</td>
<td>1-3</td>
<td>1-1</td>
</tr>
<tr>
<td>Differences between models</td>
<td>1-14</td>
<td>1-30</td>
</tr>
<tr>
<td>Drivetrain operation</td>
<td>1-18</td>
<td>1-36</td>
</tr>
<tr>
<td>Drivetrain tests</td>
<td>2-38</td>
<td>2-479</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E</th>
<th>Para</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical circuit description</td>
<td>2-16</td>
<td>2-39</td>
</tr>
<tr>
<td>Electrical tests</td>
<td>2-21</td>
<td>2-71</td>
</tr>
<tr>
<td>Engine cooling tests</td>
<td>2-25</td>
<td>2-155</td>
</tr>
<tr>
<td>Engine lubrication tests</td>
<td>2-26</td>
<td>2-187</td>
</tr>
<tr>
<td>Engine running tests</td>
<td>2-18</td>
<td>2-47</td>
</tr>
<tr>
<td>Equipment description and data: Differences between models</td>
<td>1-14</td>
<td>1-30</td>
</tr>
<tr>
<td>Equipment characteristics, capabilities, and features</td>
<td>1-10</td>
<td>1-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E (Cont’d)</th>
<th>Para</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location and contents of warning, caution, and data plates</td>
<td>1-13</td>
<td>1-18</td>
</tr>
<tr>
<td>Location and description of major exterior components</td>
<td>1-11</td>
<td>1-14</td>
</tr>
<tr>
<td>Location and description of major interior components</td>
<td>1-12</td>
<td>1-16</td>
</tr>
<tr>
<td>Tabulated data</td>
<td>1-15</td>
<td>1-31</td>
</tr>
<tr>
<td>Equipment improvement report and maintenance digest (EIR MD)</td>
<td>1-6</td>
<td>1-2</td>
</tr>
<tr>
<td>Equipment improvement recommendations (EIR), reporting</td>
<td>1-5</td>
<td>1-1</td>
</tr>
<tr>
<td>Exterior components, location and description of</td>
<td>1-11</td>
<td>1-14</td>
</tr>
<tr>
<td>Features, characteristics, and capabilities, equipment</td>
<td>1-10</td>
<td>1-2</td>
</tr>
<tr>
<td>Fuel system operation</td>
<td>1-19</td>
<td>1-37</td>
</tr>
<tr>
<td>Fuel system tests</td>
<td>2-22</td>
<td>2-95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G</th>
<th>Para</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>General information, introduction: Break-in procedure</td>
<td>1-9</td>
<td>1-2</td>
</tr>
<tr>
<td>Destruction of Army equipment to prevent enemy use</td>
<td>1-3</td>
<td>1-1</td>
</tr>
<tr>
<td>Equipment improvement report and maintenance digest (EIR MD)</td>
<td>1-6</td>
<td>1-2</td>
</tr>
<tr>
<td>Mandatory replacement parts</td>
<td>1-8</td>
<td>1-2</td>
</tr>
<tr>
<td>Maintenance forms, records, and reports</td>
<td>1-2</td>
<td>1-1</td>
</tr>
<tr>
<td>Metric system</td>
<td>1-7</td>
<td>1-2</td>
</tr>
<tr>
<td>Preparation for shipment</td>
<td>1-4</td>
<td>1-1</td>
</tr>
<tr>
<td>Reporting equipment improvement recommendations (EIR)</td>
<td>1-5</td>
<td>1-1</td>
</tr>
<tr>
<td>Scope of manual</td>
<td>1-1</td>
<td>1-1</td>
</tr>
</tbody>
</table>

| Generating system operation (60/100 amp. alternator) | 1-22 | 1-41 |
| Generating system operation (200 amp. alternator) | 1-23 | 1-42 |
| Generating system operation (100 amp. dual voltage alternator) | 1-23.1 | 1-42.1 |
| Generating system operation (200 amp. dual voltage alternator) | 1-23.2 | 1-42.2 |
| Generating system operation (400 amp. dual voltage alternator) | 1-23.3 | 1-42.3 |
| Glossary of abbreviations and commonly used terms | 2-15 | 2-38 |
| Glowplugs circuit tests (protective control box) | 2-31 | 2-303 |
| Glowplugs circuit tests (distribution box) | 2-31.1 | 2-318.1 |
### INDEX (Cont'd)

<table>
<thead>
<tr>
<th>Para</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H</strong></td>
<td></td>
</tr>
<tr>
<td>Heater, fuel burning, ambulance patient compartment, system operation</td>
<td>1-31 1-53</td>
</tr>
<tr>
<td>How to use this manual</td>
<td>v</td>
</tr>
<tr>
<td>How to use this troubleshooting guide</td>
<td>2-14 2-32</td>
</tr>
<tr>
<td><strong>I</strong></td>
<td></td>
</tr>
<tr>
<td>Index, troubleshooting</td>
<td>2-13 2-31</td>
</tr>
<tr>
<td>Index, references, principles of operation</td>
<td>1-17 1-35</td>
</tr>
<tr>
<td>Instrument tests</td>
<td>2-32 2-319</td>
</tr>
<tr>
<td>Interior components, location and description of</td>
<td>1-12 1-16</td>
</tr>
<tr>
<td><strong>L</strong></td>
<td></td>
</tr>
<tr>
<td>Light tests</td>
<td>2-33 2-389</td>
</tr>
<tr>
<td>Location and contents of warning, caution, and data plates</td>
<td>1-13 1-18</td>
</tr>
<tr>
<td>Location and description of major exterior components</td>
<td>1-11 1-14</td>
</tr>
<tr>
<td>Location and description of major interior components</td>
<td>1-12 1-16</td>
</tr>
<tr>
<td>Lubrication system tests</td>
<td>2-20 2-65</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td></td>
</tr>
<tr>
<td>Maintenance forms, records, and reports</td>
<td>1-2 1-1</td>
</tr>
<tr>
<td>Mandatory replacement parts</td>
<td>1-8 1-2</td>
</tr>
<tr>
<td>Metric system</td>
<td>1-7 1-2</td>
</tr>
<tr>
<td>Models, difference between</td>
<td>1-14 1-30</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td></td>
</tr>
<tr>
<td>Parking brake system operation</td>
<td>1-26 1-45</td>
</tr>
<tr>
<td>Parts, mandatory replacement</td>
<td>1-8 1-2</td>
</tr>
<tr>
<td>Plates, warning, caution, and data, location and contents of</td>
<td>1-13 1-18</td>
</tr>
<tr>
<td>Preventive maintenance checks and services:</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>2-7 2-2</td>
</tr>
<tr>
<td>General service and inspection procedures</td>
<td>2-10 2-3</td>
</tr>
<tr>
<td>Intervals</td>
<td>2-8 2-2</td>
</tr>
<tr>
<td>Reporting repairs</td>
<td>2-9 2-3</td>
</tr>
<tr>
<td>Specific PMCS procedures</td>
<td>2-11 2-4</td>
</tr>
<tr>
<td>Principles of operation:</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>1-16 1-35</td>
</tr>
</tbody>
</table>

### Principles of operation reference index:

- Ambulance air-conditioning, system operation (M997, M997A1, and M997A2) | 1-32 1-54 |
- Ambulance patient compartment fuel burning heater system operation | 1-31 1-53 |
- Battery system operation | 1-24 1-43 |
- Cooling system operation | 1-20 1-38 |
- Drivetrain operation | 1-18 1-36 |
- Fuel system operation | 1-19 1-37 |
- Generating system operation (60/100 amp. alternator) | 1-22 1-41 |
- Generating system operation (200 ampere alternator) | 1-23 1-42 |
- Parking brake system operation | 1-26 1-45 |
- Service brake system operation | 1-28 1-47 |
- Service/parking brake system operation | 1-27 1-46 |
- Starting system operation | 1-21 1-40 |
- Steering control system operation | 1-29 1-49 |
- Suspension system operation | 1-30 1-51 |
- Windshield wiper/washer system operation | 1-25 1-44 |
- Protective control box/distribution box tests | 2-28 2-227 |

### R

- Records, and reports, maintenance forms | 1-2 1-1 |
- Repair parts, special tools, test, measurement, and diagnostic equipment (TMDE), and support equipment:
  - Common tools and equipment | 2-1 2-1 |
  - Repair parts | 2-3 2-1 |
  - Special tools, TMDE, and support equipment | 2-2 2-1 |

### S

- Scope of manual | 1-1 1-1 |
- Service and troubleshooting instructions:
  - Common tools and equipment | 2-1 2-1 |
  - Repair parts | 2-3 2-1 |
  - Special tools, TMDE, and support equipment | 2-2 2-1 |
- Service brake system operation | 1-28 1-47 |
- Service/parking brake system operation | 1-27 1-46 |
### INDEX (Cont'd)

<table>
<thead>
<tr>
<th>S (Cont'd)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service upon receipt:</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>2-4</td>
</tr>
<tr>
<td>General inspection and servicing instructions</td>
<td>2-5</td>
</tr>
<tr>
<td>Specific inspection and servicing instructions</td>
<td>2-6</td>
</tr>
<tr>
<td>Shipment, preparation for</td>
<td>1-4</td>
</tr>
<tr>
<td>Special tools, TMDE, and support equipment</td>
<td>2-2</td>
</tr>
<tr>
<td>Startability tests</td>
<td>2-17</td>
</tr>
<tr>
<td>Starter circuit tests</td>
<td>2-30</td>
</tr>
<tr>
<td>Starting system operation</td>
<td>1-21</td>
</tr>
<tr>
<td>STE/ICE-R test procedures</td>
<td>2-43</td>
</tr>
<tr>
<td>Steering control system operation</td>
<td>1-29</td>
</tr>
<tr>
<td>Steering system tests</td>
<td>2-37</td>
</tr>
<tr>
<td>Stowage racks and tiedown straps</td>
<td>1-33</td>
</tr>
<tr>
<td>Suspension system operation</td>
<td>1-30</td>
</tr>
</tbody>
</table>

| Tables: | |
| Differences between models (table 1-1) | 1-14 |
| Preventive maintenance checks and services (table 2-1) | 2-5 |
| Tabulated data (table 1-2) | 1-15 |
| Transmission system tests (3L80) | 2-34 |
| Transmission system tests (4L80-E) | 2-35 |
| Troubleshooting, electrical/mechanical: | |
| Air intake/exhaust tests | 2-23 |
| Alternator tests | 2-27 |
| Ambulance electrical system tests | 2-39 |
| Ambulance mechanical tests | 2-40 |
| Battery circuit tests | 2-29 |
| Brake system tests | 2-36 |
| Compression/mechanical tests | 2-24 |
| Cooling system tests | 2-19 |
| DCA troubleshooting | 2-42 |
| Drivetrain tests | 2-38 |
| Electrical circuit description | 2-16 |
| Electrical tests | 2-21 |
| Engine cooling tests | 2-25 |
| Engine lubrication tests | 2-26 |
| Engine running tests | 2-18 |

<table>
<thead>
<tr>
<th>T (Cont'd)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel system tests</td>
<td>2-22</td>
</tr>
<tr>
<td>Glossary of abbreviations</td>
<td>2-15</td>
</tr>
<tr>
<td>Glowplugs circuit tests</td>
<td>2-31</td>
</tr>
<tr>
<td>Glowplugs circuit tests (protective control box)</td>
<td>2-303</td>
</tr>
<tr>
<td>Glowplugs circuit tests (distribution box)</td>
<td>2-31.1</td>
</tr>
<tr>
<td>How to use troubleshooting guide</td>
<td>2-14</td>
</tr>
<tr>
<td>Index</td>
<td>2-13</td>
</tr>
<tr>
<td>Instrument tests</td>
<td>2-32</td>
</tr>
<tr>
<td>Light tests</td>
<td>2-33</td>
</tr>
<tr>
<td>Lubrication system tests</td>
<td>2-20</td>
</tr>
<tr>
<td>Protective control box/distribution box tests</td>
<td>2-28</td>
</tr>
<tr>
<td>Startability tests</td>
<td>2-17</td>
</tr>
<tr>
<td>Starter circuit tests</td>
<td>2-30</td>
</tr>
<tr>
<td>STE/ICE-R test procedures</td>
<td>2-43</td>
</tr>
<tr>
<td>Steering system tests</td>
<td>2-37</td>
</tr>
<tr>
<td>Transmission system tests (3L80)</td>
<td>2-34</td>
</tr>
<tr>
<td>Transmission system tests (4L80E)</td>
<td>2-35</td>
</tr>
<tr>
<td>Vehicle testing</td>
<td>2-44</td>
</tr>
<tr>
<td>Winch system tests</td>
<td>2-41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Umbilical power cable, 200 ampere</td>
<td>1-34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle testing</td>
<td>2-44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>W</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Winch system tests</td>
<td>2-41</td>
</tr>
<tr>
<td>Windshield wiper/washer system operation</td>
<td>1-25</td>
</tr>
</tbody>
</table>

Change 2
Distribution:
To be distributed in accordance with the initial distribution number (IDN) 380900, requirements for TM 9-2320-280-20-1.
<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</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2-316</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Under E-1, test options should include STE/ICE-R test 91.</td>
</tr>
</tbody>
</table>

*Reference to line numbers within the paragraph or subparagraph.

**SAMPLE**
### PART II - REPAIR PARTS AND SPECIAL TOOLS LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

<table>
<thead>
<tr>
<th>PAGE NO.</th>
<th>COLM 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>

### SAMPLE

### 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.
### RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS
For use of this form, see AR 25-30; the proponent agency is ODISC4.

Use Part II (reverse) for Repair Parts and Special Tools Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

<table>
<thead>
<tr>
<th>DATE:</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)

---

## PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

<table>
<thead>
<tr>
<th>PUBLICATION/FORM NUMBER</th>
<th>DATE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 9-2320-280-20-1</td>
<td>31 JAN 96</td>
<td>TECHNICAL MANUAL, UNIT MAINTENANCE</td>
</tr>
</tbody>
</table>

<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>

*Reference to line numbers within the paragraph or subparagraph.

**TYPED NAME, GRADE, OR TITLE**
**TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION**
**SIGNATURE**

---

**DA FORM 2028, FEB 74**
REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

USAPPC V3.00
<table>
<thead>
<tr>
<th>PAGE NO.</th>
<th>COLM 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.)

**USAPPC V3.00**
NOT APPLICABLE TO THIS SYSTEM
NOT APPLICABLE TO THIS SYSTEM
FO-7 Battery Functional Flow and Location of Parts Diagrams

Batteries provide power to start engine and run accessories.

Power Stud is a connection through the battery box for the battery cables.

The shunt is used to measure the voltage in the battery circuit. The voltage across the shunts is proportional to the current flowing through it. 100 millivolts correspond to a current of 1000 amperes.

Wires 6A, 9B, 12B, and 14A go to OCA.

Power Bar from PCB Pin 1.

Wires 4A and 9B go to OCA Pin 9.

All circuits must return through vehicle ground.

Starter solenoid switches on the starter to crank the engine.

Neutral safety switch.

Run/Start switch.

Alternator.
FO-13 Brakes Functional Flow and Location of Parts Diagrams
NOT APPLICABLE TO THIS SYSTEM
### 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 = 3.86 Sq Miles

#### CUBIC MEASURE
1 Cu Centimeter = 1,000 Cu Millimeters = 0.06 Cu Inches
1 Cu Meter = 1,000,000 Cu Centimeters = 35.31 Cu Feet

#### 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 \cdot 9 \div 5 + 32
Degrees Celsius (C) = °F - 32 \cdot 5 \div 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

### APPROXIMATE CONVERSION FACTORS

<table>
<thead>
<tr>
<th>TO CHANGE</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>Millimeters</td>
<td>25.4</td>
</tr>
<tr>
<td>Inches</td>
<td>Centimeters</td>
<td>2.540</td>
</tr>
<tr>
<td>Feet</td>
<td>Meters</td>
<td>0.305</td>
</tr>
<tr>
<td>Yards</td>
<td>Meters</td>
<td>0.914</td>
</tr>
<tr>
<td>Miles</td>
<td>Kilometers</td>
<td>1.609</td>
</tr>
<tr>
<td>Square Inches</td>
<td>Square Centimeters</td>
<td>6.451</td>
</tr>
<tr>
<td>Square Feet</td>
<td>Square Meters</td>
<td>0.093</td>
</tr>
<tr>
<td>Square Yards</td>
<td>Square Meters</td>
<td>0.836</td>
</tr>
<tr>
<td>Square Miles</td>
<td>Square Kilometers</td>
<td>2.590</td>
</tr>
<tr>
<td>Acres</td>
<td>Square Hectometers</td>
<td>0.405</td>
</tr>
<tr>
<td>Cubic Feet</td>
<td>Cubic Meters</td>
<td>0.028</td>
</tr>
<tr>
<td>Cubic Yards</td>
<td>Cubic Meters</td>
<td>0.765</td>
</tr>
<tr>
<td>Fluid Ounces</td>
<td>Milliliters</td>
<td>29.573</td>
</tr>
<tr>
<td>Pints</td>
<td>Liters</td>
<td>0.473</td>
</tr>
<tr>
<td>Quarts</td>
<td>Liters</td>
<td>0.946</td>
</tr>
<tr>
<td>Gallons</td>
<td>Liters</td>
<td>3.785</td>
</tr>
<tr>
<td>Ounces</td>
<td>Grams</td>
<td>28.349</td>
</tr>
<tr>
<td>Pounds</td>
<td>Kilograms</td>
<td>0.4536</td>
</tr>
<tr>
<td>Short Tons</td>
<td>Metric Tons</td>
<td>0.907</td>
</tr>
<tr>
<td>Pound-Feet</td>
<td>Newton-Meters</td>
<td>1.356</td>
</tr>
<tr>
<td>Pounds Per Square Inch</td>
<td>Kilopascals</td>
<td>6.895</td>
</tr>
<tr>
<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>

<table>
<thead>
<tr>
<th>TO CHANGE</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millimeters</td>
<td>Inches</td>
<td>0.03937</td>
</tr>
<tr>
<td>Centimeters</td>
<td>Inches</td>
<td>0.3937</td>
</tr>
<tr>
<td>Meters</td>
<td>Feet</td>
<td>3.280</td>
</tr>
<tr>
<td>Yards</td>
<td>Meters</td>
<td>1.094</td>
</tr>
<tr>
<td>Kilometers</td>
<td>Miles</td>
<td>0.621</td>
</tr>
<tr>
<td>Square Centimeters</td>
<td>Square Inches</td>
<td>0.155</td>
</tr>
<tr>
<td>Square Meters</td>
<td>Square Feet</td>
<td>10.764</td>
</tr>
<tr>
<td>Square Yards</td>
<td>Square Yards</td>
<td>1.196</td>
</tr>
<tr>
<td>Square Kilometers</td>
<td>Square Miles</td>
<td>0.386</td>
</tr>
<tr>
<td>Square Hectometers</td>
<td>Acres</td>
<td>2.471</td>
</tr>
<tr>
<td>Cubic Meters</td>
<td>Cubic Feet</td>
<td>35.315</td>
</tr>
<tr>
<td>Cubic Yards</td>
<td>Cubic Yards</td>
<td>1.308</td>
</tr>
<tr>
<td>Milliliters</td>
<td>Fluid Ounces</td>
<td>0.034</td>
</tr>
<tr>
<td>Liters</td>
<td>Pints</td>
<td>2.113</td>
</tr>
<tr>
<td>Liters</td>
<td>Quarts</td>
<td>1.057</td>
</tr>
<tr>
<td>Liters</td>
<td>Gallons</td>
<td>0.264</td>
</tr>
<tr>
<td>Grams</td>
<td>Ounces</td>
<td>0.035</td>
</tr>
<tr>
<td>Kilograms</td>
<td>Pounds</td>
<td>2.2046</td>
</tr>
<tr>
<td>Metric Tons</td>
<td>Short Tons</td>
<td>1.102</td>
</tr>
<tr>
<td>Newton-Meters</td>
<td>Pound-Feet</td>
<td>0.738</td>
</tr>
<tr>
<td>Kilopascals</td>
<td>Pounds Per Square Inch</td>
<td>0.145</td>
</tr>
<tr>
<td>Kilometers Per Liter</td>
<td>Miles Per Gallon</td>
<td>2.354</td>
</tr>
<tr>
<td>Kilometers Per Hour</td>
<td>Miles Per Hour</td>
<td>0.621</td>
</tr>
</tbody>
</table>
This fine document...

Was brought to you by me:

Liberated Manuals -- free army and government manuals

Why do I do it? I am tired of sleazy CD-ROM sellers, who take publicly available information, slap “watermarks” and other junk on it, and sell it. Those masters of search engine manipulation make sure that their sites that sell free information, come up first in search engines. They did not create it... They did not even scan it... Why should they get your money? Why are not letting you give those free manuals to your friends?

I am setting this document FREE. This document was made by the US Government and is NOT protected by Copyright. Feel free to share, republish, sell and so on.

I am not asking you for donations, fees or handouts. If you can, please provide a link to liberatedmanuals.com, so that free manuals come up first in search engines:

<A HREF=http://www.liberatedmanuals.com/>Free Military and Government Manuals</A>

– Sincerely
   Igor Chudov
   http://igor.chudov.com/