UNITED STATES MARINE CORPS
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AOM 6405

STUDENT OUTLINE

MAINTAIN HMMWVA2 FUEL AND ELECTRICAL SYSTEMS

LEARNING OBJECTIVES:

1. Terminal Learning Objective:

a. Given a HMMwVA2, technical manuals, tools, test equipment, and shop supplies, perform organizational maintenance on the fuel system, per the references. (6.4.5)

b. Given a HMMwVA2, technical manuals, tools, test equipment, and shop supplies, perform organizational maintenance on the battery system, per the references. (6.4.6)

c. Given a HMMwVA2, technical manuals, tools, test equipment, and shop supplies, perform organizational maintenance on the cranking system, per the references. (6.4.7)

d. Given a HMMwVA2, technical manuals, tools, test equipment, and shop supplies, perform organizational maintenance on the generating system, per the references. (6.4.8)

e. Given a charging, cranking, and fuel systems simulation training program and technical manuals, perform troubleshooting procedures to diagnosis simulated malfunctions displayed in the training program, per the references. (6.4.9)

2. Enabling Learning Objectives:

a. Given a HMMwVA2, TM 9-2320-280-20-1&2, tools, test equipment, and shop supplies, per the references:

(1) Inspect fuel filter for contamination. (6.4.5a)

(2) Test fuel pump for proper delivery. (6.4.5b)

(3) Test fuel solenoid. (6.4.5c)

(4) Replace the fuel filter. (6.4.5d)

(5) Bleed the fuel filter. (6.4.5e)

b. Given a HMMWVA2, TM 9-2320-280-20-1&2, tools, test equipment, and shop supplies, per the references:

(1) Check battery connections for proper installation. (6.4.6a)

(2) Test battery voltage. (6.4.6b)

(3) Test battery internal resistance. (6.4.6c)

(4) Test battery resistance change. (6.4.6d)

(5) Test negative battery cable voltage drop. (6.4.6e)

(6) Measure battery specific gravity. (6.4.6f)

c. Given a HMMWVA2, TM 9-2320-280-20-1&2, tools, test equipment, and shop supplies, per the references:

(1) Test for battery voltage at the starter motor. (6.4.7a)

(2) Test for battery voltage at the solenoid switch. (6.4.7b)

(3) Test for battery voltage at the neutral safety switch. (6.4.7c)

(4) Test the neutral safety switch for continuity. (6.4.7d)

(5) Test for continuity between the neutral safety switch and body connector harness. (6.4.7e)

(6) Test for continuity between the engine connector harness and starter solenoid wire. (6.4.7f)

(7) Test for battery voltage at the rotary switch. (6.4.7g)

(8) Test rotary switch for continuity. (6.4.7h)

(9) Test for continuity between the body connector harness and rotary switch. (6.4.7i)

d. Given a HMMWVA2, TM 9-2320-280-20-1&2, tools, test equipment, and shop supplies, per the references:

(1) Test for battery voltage at the connector harness. (6.4.7j)

(2) Check glowplug connectors for proper installation. (6.4.7K)

(3) Test glowplugs for amperage draw. (6.4.7l)

(4) Test glowplugs for serviceability. (6.4.7m)

(5) Measure voltage at glowplug controller. (6.4.7n)

(6) Test for continuity between the glowplug controller and engine ground. (6.4.7o)

e. Given a HMMWVA2, TM 9-2320-280-20-1&2, tools, test equipment, and shop supplies, per the references:

(1) Inspect for missing, broken or frayed serpentine belt. (6.4.8a)

(2) Test battery voltage at the alternator energized terminal. (6.4.8b)

(3) Test battery voltage at the protection control box. (6.4.8c)

(4) Test continuity between the protection control box and engine connector harness. (6.4.8d)

f. Given a charging, cranking, and fuel systems simulation training program and TM 9-2320-280-20-1, per the references, diagnose the complaint:

(1) Diagnose the complaint, starter not working, no solenoid thump. (6.4.9a)

(2) Diagnose the complaint, engine cranks, will not start (exhaust smoke visible). (6.4.9b)

(3) Diagnose the complaint, engine cranks, will not start (no exhaust smoke visible). (6.4.9c)

(4) Diagnose engine starts, runs rough, will not idle. (6.4.9d)

(5) Diagnose engine is hard to start, runs rough, and is noisy. (6.4.9e)

OUTLINE:

1. HMMWVA2 ENGINE FUEL SYSTEMS

a. Identification, Location, and Function of Fuel System Components

(1) The fuel tank is mounted between the frame rails under the right side of the vehicle.

(a) To prevent vapor locking, a vent allows air to enter the fuel tank.

(b) A sock type filter in the tank and a strainer located in the filler neck prevents contaminants from entering and damaging fuel system components.

(2) A fuel line connects the tank to a mechanical fuel pump that is mounted to the right front of the engine and driven by the camshaft.

(a) A diaphragm within the pump provides suction on the inlet side to draw fuel from the tank.

(b) When fuel enters the pump, the diaphragm pressurizes the fuel to approximately four pounds per square inch and pumps it under low pressure through a fuel line to a fuel filter/water separator.

(3) A fuel filter/water separator is mounted on the fire wall of the engine compartment. The filters removes water and sediment from the fuel before being routed to the fuel injection pump. A draincock allows for draining of any water or sediment.

(4) A fuel injection pump is mounted on the top front of the engine, partially under the intake manifold. Fuel, under low pressure, enters the injection pump where it is pressurized, metered, timed and delivered to the fuel nozzles under high pressure.

(5) A fuel solenoid mounted inside the injection pump cover is energized by voltage moving the metering valve to admit fuel to the injection pump for engine running and closes to stop fuel flow when shutting down the engine. Excess fuel is returned to the tank by way of a fuel return line.

(6) A cold advance solenoid also located in the cover advances injection timing 3 to 5 degrees when the engine is cold.

(7) Fuel nozzles are screwed into the engine cylinder heads located on each side of the engine, four nozzles to a side.

(a) The nozzles direct atomized fuel into a pre-combustion chamber at the proper time.

(b) The nozzles are connected to a return line by bleed-back hoses that return excess fuel to the fuel tank.

(8) The fuel level monitoring system consists of the fuel level sending unit, fuel gage and interconnecting chassis wiring harness.

(a) A fuel level sending unit is mounted on the top of the fuel tank. The fuel gage is located in the instrument cluster of the crew compartment.

(b) The fuel level sending unit monitors fuel level in the fuel tank and relays that information to the fuel indicator gage.

(9) Accelerator linkage.

(a) Accelerator linkage consists of those components or parts that transmit accelerator pedal movement to the arm of the fuel injection pump in order to regulate engine speed.

(b) Principal components and their functions are as follows:

1 A foot pedal provides the operator with a means of controlling throttle lever movement.

2 An accelerator rod is the mechanical linkage between the foot pedal and accelerator cable.

3 Bushings and retainers hold the accelerator rod in its proper position on the engine fire wall.

4 A gasket is provided as shown on the illustration to prevent the entry of foreign material that may cause bushing wear or binding in the linkage.

5 Body bracket provides a stationary point for the attachment of the lower cable end.

6 The accelerator cable is a flexible cable that transmits motion from the accelerator rod to the throttle lever. It is adjustable by means of adjusting nuts at the engine bracket and has appropriate terminal ends to attach it to the accelerator rod and throttle lever.

7 An engine bracket is provided at the engine end of the accelerator linkage. The accelerator cable and throttle return spring are attached to the engine bracket.

b. Principles of Operation of the Fuel System

(1) Ignition of fuel in a diesel engine occurs as a result of heat developed in the combustion chamber during the compression stroke.

(2) As stated earlier, fuel is pulled from the fuel tank by a mechanical fuel pump. A camshaft and pushrod drive this pump.

(3) Fuel then travels to a fuel filter/water separator located in the rear of the engine compartment. Here, fuel contaminants are removed from the fuel by filter elements.

(4) From the filter, fuel is fed to the fuel injection pump where it is then pressurized and delivered at precisely the correct moment to fuel nozzles.

(5) Fuel nozzles open at a pressure of about 1700 pounds per square inch (injection pump pressure) and sprays fuel into the combustion chamber of the cylinder where the heat of compression ignites the fuel.

c. Inspect Fuel System Components

(1) Inspect Fuel for Contamination

(a) Start the engine.

(b) Open the fuel draincock and allow approximately 1 pint of fuel to drain into a suitable container.

(c) Close the draincock, stop the engine.

(d) Inspect fuel for water, sediment, or other contaminants.

(e) If contaminants are present, drain, clean or replace filter elements, lines and tank,

(2) Inspect Fuel Filter/Water Separator Housing

(a) Check the fuel filter/water separator housing for cracks, dents, and leakage.

(b) Inspect the fuel filter for mounting security and tighten the mounting capscrew to torque specifications in the TM.

(c) Inspect attached hoses and clamps for security, damage, and serviceability.

(d) Make sure that the fuel pressure transducer is serviceable and connected to the STE/ICE wiring harness.

(3) Check Fuel Lines. Check fuel lines for security of mounting, splits, cracks, bends, restrictions, damage, leaks, and loose connectors. Tighten fittings or replace as necessary.

(4) Inspect Fuel Pump

(a) Inspect the fuel pump housing for cracks and leakage.

(b) Inspect the spring clamp securing the inlet hose for damage.

(c) Check inlet hose, outlet line, and vent line for bends and leakage.

(d) Check security of the fuel lines mounted to the pump.

(e) Make sure the pump and adapter are securely mounted to the engine block. Check the gasket for leaks.

(5) Inspect Fuel Injection Pump

(a) Make sure the fuel injection pump is securely mounted to the engine block.

(b) Check security of the modulator link attachment to the throttle lever.

(c) Inspect the fuel injection pump housing for cracks, damage and leakage.

(d) Inspect throttle components for security, damage, and leakage.

(e) Inspect the throttle-positioning sensor. Check electrical wiring for frays and breaks. Make sure the connection to the engine wiring harness is secure. Insure sensor is tight and secured to the pump.

(6) Inspect Fuel Nozzles and Hoses

(a) Check nozzle lines for security of attachment to the injection pump.

(b) Inspect fuel nozzles for security of mounting.

(c) Check the leak back lines hose connections and clamps on the nozzles for security and serviceability.

d. Test Engine Fuel System

(1) Test the Fuel Pump for Proper Delivery. Disconnect wire No. 54A from the fuel solenoid to prevent the engine from starting while conducting the test. To test the fuel pump for proper delivery, disconnect the fuel filter outlet hose at the filter and route it into a quart-capacity container. Crank the engine for thirty seconds. The container should be at least half full of fuel. If the volume is not sufficient, check the fuel supply lines and hoses for restriction and check the filter elements for serviceability. Replace any unserviceable components. If no restrictions or obvious damages are found, replace the fuel pump.

(2) Test Fuel Solenoid and Circuitry

(a) Check electrical connections at the injection pump. Make sure that wire 54A is connected to the fuel solenoid terminal and wire 569B is connected to the cold advance solenoid terminal.

(b) To check the operation of the fuel solenoid, disconnect wire 54A from the terminal on top of the injection pump and turn the rotary switch to the "RUN" position. Touch wire 54A to the fuel solenoid terminal and remove; an audible clicking sound should be heard from within the pump. If no sound is heard check wire 54A for voltage.

(3) Test Fuel Gage/Sending Unit

(a) Disconnect wire 28A from the fuel tank harness and turn the rotary switch to "RUN". The fuel level gage should read "FULL".

(b) Touch wire 28A to ground; the fuel level gage should read empty. Next, disconnect wire 58C from 58J and connect wire 28A to 58C; using a short jumper wire the gage should read empty.

(c) Remove the access plate located in the vehicle cargo area. Continue testing by disconnecting harness wires 28B and 58J. Connect wire 28B to 58J using a short jumper wire; the gage should read "EMPTY," if not,

repair the wiring harness. If the gage shows "FULL," the sending unit is defective and must be replaced. This will require lowering the fuel tank.

(d) Next, you would disconnect wires 28A, 27J, and 58H from the fuel gage. Using a multimeter, with the rotary switch in the "RUN" position; check for battery voltage at wire 27J; check for continuity at wire 58H and ground and check for continuity through wire 28A. If all wires test correctly and the fuel gage is malfunctioning, replace the fuel gage. If any wires do not test correctly, repair the body wiring harness.

e. Service HMMVA2 Engine Fuel Filter Assembly. When working on the fuel system, use caution because the fuel is highly flammable. Cover or plug all disconnected lines and fittings to prevent the entry of foreign material.

(1) Remove Fuel Filter and Separator Element

(a) Disconnect the transducer wire harness connector.

(b) Loosen the two hose clamps and disconnect the inlet hose and outlet hose from the fuel filter cover.

(c) Loosen the hose clamp and disconnect the fuel filter drain hose from the filter housing.

(d) Remove the two capscrews from the fuel filter bracket and remove the filter housing and bracket.

(e) Remove the three capscrews and washers securing the cover to the filter housing and remove cover.

(f) Remove the "O" ring seal from the filter housing. Discard the "O" ring seal.

(g) Remove the filter and separator from the filter housing.

(h) Remove the separator from the filter and discard the filter.

(2) Clean and Inspect Fuel Filter Assembly

(a) Use dry-cleaning solvent to clean all metallic parts. Dry cleaning solvent can be dangerous; use due caution.

(b) Inspect the filter housing and cover for distortion or damage.

(c) Inspect the separator for dirt, contamination, or damage. Replace if dirty, contaminated, or damaged.

(3) Install Fuel Filter

(a) Install a new filter into the filter housing.

(b) Install a clean separator on the cover.

(c) Install a new "O" ring seal into the filter housing.

(d) Install the fuel filter and bracket and secure them with two capscrews.

(e) Connect the fuel filter drain hose to the filter housing and secure with a hose clamp.

(f) Pour one pint of fuel into filter housing to prime filter to ease engine start up.

(g) Install the cover on the filter housing and secure it with three washers and capscrews. Tighten the capscrews to 50-60 inch-pounds.

(h) Connect the inlet hose and outlet hose to the fuel filter cover and secure with two hose clamps.

(i) Reconnect the transducer wiring harness connector.

(4) Bleed Fuel Filter Assembly

(a) Reconnect the electrical leads to the fuel pressure transducer.

(b) Loosen the fuel filter bleed screw 3/4 of a turn.

(c) Disconnect wire 54A from the solenoid.

(d) Position a drainage container to catch the fuel.

(e) Crank the engine until fuel exits from the bleed screw. Do not operate the starter continuously for more than 30 seconds; wait 10 to 15 seconds between periods of operation. Failure to do this will result in damage to the starter.

(f) Tighten the bleed screw to 40 to 50 inch-pounds.

(g) Connect wire 54A to the fuel solenoid, start the engine, and check for fuel leaks.

f. REPLACE HMMWVA2 ENGINE FUEL PUMP

(1) Remove the Fuel Pump

(a) Have a container ready to catch any fuel draining from disconnected lines or hoses.

(b) Loosen the inlet hose clamp, disconnect and plug the inlet fuel line hose from the fuel pump.

(c) Loosen the fuel outlet line from the fuel pump. Allow the fuel to drain into a container.

(d) Remove the clamp and disconnect the vent line from the fuel pump.

(e) Remove the two capscrews securing the fuel pump and gasket to the fuel pump mounting plate. Remove the fuel pump and discard the gasket.

(f) Remove the two capscrews securing the fuel pump mounting plate and gasket to the cylinder block. Remove the mounting plate and discard the gasket.

(g) Remove the push rod from the cylinder block.

(2) Install Fuel Pump

(a) Place a small amount of grease on the push rod to retain it in the cylinder block during installation.

(b) Insert the push rod into the cylinder block.

(c) Install the fuel pump mounting plate and gasket to the engine cylinder block and secure it with two capscrews. Tighten the capscrews to 4-7 foot pounds.

(d) Install the fuel pump and gasket on the mount plate. Ensure the lever and push rod alignment. Secure the pump with two capscrews and tighten to torque specifications.

(e) Connect the fuel vent line to the fuel pump and secure it with a spring clamp.

(f) Connect the inlet line to the fuel pump and secure it with a spring clip.

(g) Screw the outlet line into the fuel pump by hand and tighten using a line wrench.

g. Diagnose HMMWVA2 Engine Fuel System Malfunctions

(1) Determine if air is in the Fuel System

(a) Symptoms of air in the fuel system include:

1 hard starting,

2 rough idle whether the engine is cold or warm,

3 white exhaust smoke while cranking, and

4 excessive fuel consumption.

(b) To test for air leaks in the supply lines:

1 Install a section of clear plastic tubing on the fuel return line fitting of the engine injection pump.

2 Observe the fuel flowing through the clear plastic tubing. Bubbles in the fuel while cranking or running indicates an air leak in the fuel line.

(2) Determine the Cause of Engine Cranks but Will Not Start (Fuel System Only)

(a) Drain the fuel filter while cranking the engine for a maximum of 30 seconds. If water or contamination is present, wait two minutes and repeat the test twice more. If water or contamination is still present, drain and clean or replace the filter, the fuel tank, and refuel the vehicle.

(b) Check the fuel supply pressure using a pressure gage or STE/ICE. The pressure should be 3 pounds per square inch minimum. If pressure is not at least 3 pounds per square inch, clean the fuel filter and repeat the test. If pressure is still not at least 3 pounds per square inch, check the fuel supply lines and hoses for restrictions and obvious damage. Replace any damaged lines or hoses. Check fuel pressure at the fuel pump outlet; if pressure is not at least 3 pounds per square inch, replace the fuel pump.

(c) Disconnect the fuel filter outlet hose and route it into a quart capacity container. Crank the engine for 30 seconds. The container should be at least half-full. If the volume is not sufficient, check the fuel supply lines and hoses for restrictions. Also check the filter for serviceability if no restriction or damage are found, replace fuel pump.

(d) Check the electrical connections at the injection pump. Make sure that wire 54A is connected to the fuel solenoid terminal, the front terminal, and that wire 569B is connected to the cold advance solenoid, the rear terminal.

(e) Check for voltage at the fuel solenoid by, disconnecting wire 54A from the fuel solenoid terminal. Using a multimeter, check for voltage at wire 54A, with the rotary switch in the "RUN" position. If voltage is present, but less than 17 volts, check the batteries. If no voltage is present, disconnect the engine wiring harness connector from the protective control box and check for continuity between pin A in the engine wiring harness connector and wire 54A. Remember you must disconnect both battery ground cables before removing the harness connector from the protective control box. If no continuity is present repair the engine wiring harness. If continuity is present, attach the battery ground cable to the battery and check for battery voltage, which is approximately 24 volts, at wire 29C in the body wiring harness connector at the protective control box, with the rotary switch in the "RUN" position. If battery voltage is present, replace the protective control box. If no voltage is present, repair the body wiring harness.

(f) Check the operation of the fuel solenoid. Disconnect wire 54A from the terminal on top of the injection pump. Turn the rotary switch to the "RUN" position. Momentarily touch the wire to the fuel solenoid terminal; an audible clicking sound should be heard from within pump. If no sound is heard, the injection pump will have to be repaired by intermediate maintenance.

(g) If the fuel system checks out up to this point and the engine still will not start, check the operation of the glowplug system. The procedures for diagnosing a malfunctioning glowplug system will be covered later in this lesson.

(3) Determine the Cause of a Stiff Accelerator Linkage

(a) Inspect the accelerator pedal bushing for binding or damage that would limit pedal travel. Replace the bushing and gasket if they are damaged.

(b) Inspect the accelerator cable for kinks, corrosion, or damage, which would restrict cable movement. Replace the accelerator cable if it is damaged.

(c) Inspect the throttle bracket return spring on the left side of the injection pump for damage, which would restrict accelerator cable movement. Replace the spring if it is damaged.

(d) If the problem results from other causes, notify intermediate maintenance.

3. BATTERY, CRANKING, AND GENERATING SYSTEMS

a. Battery System

(1) Two 12-volt batteries are connected together by a cable attached to a negative terminal of one battery and positive terminal of the other battery. The remaining negative terminal is connected to a current shunt and positive terminal is connected to a power stud. The power stud is bolted to a bus bar at the battery box. You will be shown the shunt, power stud and bus bar shortly.

(2) The rotary Run/Start switch is located on the extreme left of the instrument panel. This three-position rotary switch activates the electrical system and controls the operation of the battery and starting systems.

(3) The protective control box, commonly referred to as the PCB, is located beneath the instrument panel on the driver's side. One of the functions of the PCB is to protect the electrical system of the vehicle in the event the battery system polarity is reversed.

b. Cranking System/Glowplugs

(1) You were introduced to the rotary switch in the battery system. The switch is also considered part of the starting system, because it provides power to the neutral safety switch.

(2) The neutral safety switch is mounted in the shift control housing assembly. When the transmission shift lever is in the neutral or park position, the switch closes a relay in the protective control box, allowing battery power to reach the starting motor solenoid.

(3) The starter solenoid and starter motor are also components of the cranking system. The starter solenoid, is a magnetic relay that transmits battery voltage to the starter motor. The starter motor cranks the engine for starting and is supplied battery power through circuit 6A of the cranking system.

(4) The glowplugs add heat to the pre-combustion chambers of the engine for faster starts. This is especially important when temperatures are low.

(a) The glowplugs are screwed into the cylinder heads, just below each fuel nozzle.

(b) The tips of the glowplugs extend into the pre-combustion chambers.

(c) When the rotary switch is placed in the "RUN" position the glowplugs are energized and become cherry red, similar to the heating elements on an electrical stove and heats the air in the pre-combustion chambers to approximately 1400 degrees.

(5) The glowplug controller is mounted in the coolant crossover pipe and controls operation of the engine glowplug system. This component monitors engine temperature and activates glowplugs as needed to maintain the correct temperature in the pre-combustion chambers for cold weather starting.

c. Generating System

(1) The HMMWA2 is equipped with the 200 Amp. Neihoff alternator.

(2) The alternator is located on the left side of the engine compartment, it is mounted on a support bracket which is bolted at the engine block and cylinder head. Additional support is provided by a bracket that attaches the rear alternator flange to the exhaust manifold.

(a) The alternator is driven by a serpentine belt from the crankshaft pulley, unlike the conventional V-belts that need periodic adjustment, serpentine belt tension is maintained by a self-adjusting belt tensioner.

(b) The HMMWA2's generating system is equipped with an alternator capable of producing 26 to 30.5 volts, to support the vehicle's 24-volt system. The regulator for this model has over voltage protection, any output voltage over 30.5 is an over voltage.

(c) This system also charges the batteries. Wire 6 carries voltage directly from the alternator to the battery box bus bar; this voltage replenishes the depleted batteries and supplies voltage to other circuitry when the engine is in service.

(d) The 200-ampere Niehoff alternator, has an external nonadjustable regulator; that is replaced at the organizational maintenance level. Procedures for testing are found in TM 9-2320-280-20-1.

(3) The battery gage is located in the instrument cluster in the crew compartment. The gage measures the voltage output between the protective control box and ground. The gage does not have a number scale; instead, color bands indicate charging system activity. The battery gage is activated by turning the rotary switch to the "RUN" or "START" position.

d. Wiring Diagram

(1) To provide the voltage necessary to turn the engine so it will start, we need to connect the two 12-volt batteries together. This is accomplished with wire No. 68 connecting the positive terminal of one battery to the negative terminal of another battery.

(2) Now we need to connect the remaining negative battery terminal to our shunt.

(3) The positive terminal of the other battery is connected to a terminal on the bus bar located at our battery box. Wire 6A connects the power stud and starter motor. The starter bus bar connects the starter motor to the starter solenoid. The starter solenoid is connected to the PCB by wire 74A. The starter motor is grounded to the right cylinder head with wire 7A. Wire 7E grounds the positive side of the shunt to the right cylinder head.

(4) Wire No. 6A connects the starter to the battery bus bar through the power stud. Wire No. 81A connects the battery bus bar to the protective control box. Wire No. 11A connects the protective control box to the rotary switch.

(5) To prevent the engine from starting in any transmission range other than neutral or park, wire 14A connects the rotary switch to the neutral safety switch and the neutral safety switch is connected to the PCB with wire No. 14B.

(6) Pins G and F of the PCB are connected to the alternator and Pin I of the PCB is connected to the starter solenoid.

4. TROUBLESHOOTING PROCEDURES

a. Battery Circuit Tests

(1) Page 2-31 of TM 9-2320-280-20-1 provides a list of electrical and mechanical troubleshooting procedures for the different systems of the vehicle. We're interested in the battery system, so let's look at the list and find battery circuit test (page 2-251).

(2) Page 2-251 informs us that these battery tests may be run any time you think you have a battery problem or if you were sent here by another test chain. We are also told that foldout 7 should be left open for a reference while testing the battery circuit. Open foldout 7, then turn to page 2-252.

(3) We're going to run these tests because the batteries will not turn the starter motor fast enough to start the engine.

(4) Look in the known information column. The word Nothing! has been entered. We are asked if all battery connections are clean and tight? The reason for the question is that loose or dirty connections can make good batteries function improperly and may not allow current to flow.

(5) Now look to the right of the page (2-253) and read the reference information.

(6) For training purposes, let's say that all the battery connections were clean and tight. The chain directs us to test 2 and asks if the batteries are filled to the proper level?

(7) The reason for the question is that the batteries need water for the electrolyte solution. Batteries won't work right if the electrolyte level is low. We'll answer the question with a no. We are instructed to add water to the proper level. The reference information explains and shows us how to add water to the battery cells.

(8) Again, for training purposes, we will answer all questions with a no, until the problem is found and corrected. Are there any questions about how to troubleshoot the battery circuit?

b. Starting Circuit Tests

(1) Page 2-261 provides a block diagram of the starter circuit and describes the function of each component in the circuit, now take a moment or two and read the information under General Description.

(2) Page 2-284 begins the troubleshooting procedures for the starting system. Turn to page 2-284. The known information column asks is battery voltage at least 20-volts.

(3) The instructions in the reference information are the same as in Test No. 1 for the battery circuit. If these instructions were followed while performing Test No. 1, there is no reason to repeat the procedures and we would continue following the flow chart until we located and corrected our problem.

(4) The illustration shown is a cutaway of the right side of the vehicle, depicting the starter, gasket and upper inspection cover shims.

(5) First, disconnect both negative battery cables. Notice, the torque converter housing cover is a two piece housing, remove the upper converter housing cover from the transmission.

(6) Next, remove the fastening hardware securing the electrical leads to the starter and solenoid and tag the electrical leads.

(7) Have an assistant support the starter while you remove the fastening hardware that secures the starter to the engine.

(8) Now, remove the starter and shims. The shim size is stamped on one side of the shim. Make a note of the shim size if the existing starter is to be replaced at a later date or in case the shim is misplaced or damaged.

(9) If the existing starter is to be installed, use the shim's that you removed, providing they are serviceable. Next, install the starter.

(10) To test the glowplugs, disconnect the electrical wire from the glowplug to be tested. Prepare the multimeter for resistance testing. Connect the positive multimeter wire to the end of the glowplug and the negative wire to ground. The resistance in the glowplug will be indicated in the LCD display window. Repeat the test on all eight glowplugs. Replace any glowplugs not having 1.0 to 2.0 ohms resistance.

(11) When the engine temperature is below 120 degrees Fahrenheit and the rotary switch is positioned to "RUN", the Wait-to-Start lamp will light for up to fifteen seconds. When the Wait-to-Start lamp goes out, the engine can then be started. After the engine is started, the glowplugs will continue to cycle for up to 5 minutes.

(a) With the engine running, the glowplug system is cycling normally when there is an "on" pulse for 1 second and "off" pulse for up to 15 seconds.

(b) To detect glowplug system cycling, watch the voltmeter. The gage needle will move to the left when the glowplugs are on and then return to its normal position when the glowplugs are off. A relay click should be heard from the protective control box as the system switches on and off. The multimeter, set to read battery voltage may be used on any glowplug wire to check the operation of the glowplug system. Disconnect any glowplug wire from a glowplug and connect the positive multimeter wire to the disconnected glowplug wire. Connect the negative wire to ground. Have an assistant start the engine. Battery voltage will be indicated in the LCD display window every time the glowplugs cycle on. Zero voltage will be displayed when the glowplugs cycle off.

c. Generating System Tests

(1) Test No 1. begins with the question, is the drive belt tight and in good condition? The reason for the question, is that if the belt is loose or worn the engine will not drive the alternator fast enough to recharge the batteries. Since the proper belt tension is maintained by the belt tensioner, we only need to inspect the drive belt for serviceability.

(2) If our belt is okay, we would continue and perform Test No. 2. Here we are asked if all wire connections to the alternator are clean, tight, and making a good connection? If the answer is no, we would clean and tighten them.

(3) If the answer is yes, we know the belt and wiring connections are okay and would perform the next test, which is Test No. 3. Here our test options are STE/ICE-R or a multimeter. Regardless of which test option you choose, continue testing, using the procedures in the flowchart until the problem is found and corrected. Are there any questions about how to use the flowchart to troubleshoot the generating system?

(4) To test alternator output voltage we must perform certain procedures.

(a) First, slide the boot back from wire lug of regulator to expose the red terminal. Using a digital multimeter connect red wire of multimeter to red energize terminal, including wire 5A.

(b) Next, slide the boot back from wire lug of the negative terminal located at the front of the regulator locating wire 3B and connect ground wire of the multimeter. Select the voltage setting.

(c) Start the engine and set engine speed to 1200-1500 rpm for 2-3 minutes.

(d) Place a load on the alternator by operating any accessory such as the headlights or heater.

(e) Record alternator voltage displayed. If alternator output voltage is over 30.5 volts replace the regulator.

(f) Stop the engine and turn the rotary switch to the run position.

(g) Check for battery voltage at the red (energize) terminal on the regulator. If all connections are clean and tight and no voltage is present at the red terminal, notify intermediate maintenance. The wiring harness needs replacement or repair.

7. FUEL SYSTEMS SIMULATION TRAINING

a. As you can see, this panel illustrates all fuel components you would be required to test when performing diagnosis on the fuel systems of a HMMWVA2. The panel is divided into three areas.

(1) The panel display (face) provides a pictorial of the system simulated. All components are depicted in the same place as on the actual vehicle. In some cases, we have used call-outs to provide more detail. The call-outs have an arrow leading from the called out component to its location on the system illustrated. You will also notice component switches; those are used in conjunction with mode switches that we will talk about later.

(2) The mode switches (Inspect, Repair or Replace, Clean, Remove/Install, Adjust, Touch, Disconnect/Connect, Drain, Sample Fuel, Install/Remove Clear Tube, Fill, and Loosen/Tighten) are on the top. They are used in conjunction with component switches, as previously mentioned. If you want to inspect a component, such as a fuel line, you simply push the component switch adjacent to the fuel line then push the "inspect" mode switch. When you do that, you will get a video display of that line in whatever condition it is in at the time. It may be connected, disconnected, leaking, et cetera. Let's say that you have just inspected the fuel line and the video that came up showed it in a disconnected state. If you wanted to connect it, you simply press the component switch again and then press the disconnect/connect switch. To reverse the action, you only need to press the same two switches again.

(3) The next set of switches down (Charge Batteries, Check Specific Gravity, Analyze Exhaust Smoke, or Send To Direct Support) are the action switches. Action switches are not used in conjunction with component switches. Action switches are used for unique actions, which we will discuss later.

(4) The bottom set of switches is status switches. Here you have lesson complete, next lesson, display ERO, help, check system condition, and incorrect procedure switches. When working an exercise or diagnostic problem, if you believe you are finished and the problem or exercise has been solved or completed, press the lesson complete switch. If you were correct, the next lesson switch lights up indicating you were correct and can proceed to the next exercise or problem. If you had not completed the exercise, the video monitor (the upper monitor) will display a message indicating lesson not complete.

(5) Sometimes, although you have repaired the malfunction, verified repair, and returned the system to normal, a cue to "Check System Condition" will be displayed on the video screen. When that happens, look at the computer screen for a list of conditions such as: "Ignition Off," "Throttle at Idle," "Light Switch," "All Test Probes Disconnected," and "All Test Equipment Disconnected." The help switch is used when you need instructor assistance. The check system condition switch causes a display on the video monitor indicating the system is in a normal state or in an improper condition that you have not cleared. The display ERO switch allows you to recall the ERO message if a malfunction has been inserted in the panel. You can use this switch at anytime during the exercise or diagnostic procedure. The incorrect procedure light comes on anytime you do something that presents a hazard. For example, if you try to take a fuel sample without disconnecting a fuel line first, the incorrect procedure light will illuminate. When that light is on, you will have to press the check system condition switch to continue.

c. We'll begin by covering the items along the bottom of the panel.

(1) Starting on the left side, you have the ignition switch. It operates just like the one on an actual vehicle. To start the engine, place the switch in the run position and wait for the wait-to-start light to go out. The light is just above the switch. Go ahead and start your engine now. Notice that all the gages on the instrument cluster are providing you with normal readings. By the way, don't use excessive force on any of the panel 3-D controls. The knobs can be easily damaged.

(2) To the right of the stop light and ignition switch, you see red, yellow, and green lights. The green light is illuminated now. These

lights simulate the air restriction indicator. Green indicates no restriction; yellow, a partial restriction; and red, a complete restriction.

(3) Outside the area where the switches we have been discussing are, you can see call-outs on the back of the ignition switch and the wait-to-start wiring. Each has the necessary component switches and test jacks for diagnostic testing.

(4) Below and slightly to the right of the steering wheel is a call-out of the rear of the fuel gage. All of these call-outs have component switches and/or jacks for testing so I won't be mentioning those again. You know how they are used.

(5) Next, you have an illustration of the instrument panel with active gages for fuel level, oil pressure, temperature, and a battery-generator indicator. The fuel gage and battery-generator indicator have their own component switches. At this time, I want you to inspect the battery-generator indicator. Notice that the video shows the needle in the red discharge band while the functional gage gives you a good reading; likewise, the fuel gage video would show an empty fuel tank whereas the functional gage may indicate full. This is just a program peculiarity; unless you are in a malfunctioning condition, rely on the actual gage.

d. Panel Unique Mode and Action Switches

(1) Mode switches

(a) The sample fuel mode switch allows you to look at a fuel sample by using a combination of component switches and cranking the engine to simulate pumping fuel in a fuel sample bottle. To do that, you have to disconnect the fuel delivery line and then crank the engine. While cranking, again cycle the components switch for the fuel delivery line and use the sample fuel mode switch. Go ahead and try that sequence now.

(b) There is also a "fill" component switch that allows you to fill the tank after you use the "drain" mode switch to drain it.

(2) Action switches. You must remember that the action switches are used by themselves. For example, to analyze smoke, you must crank the engine for the computer to accept the "send to direct support." You must ensure the problem is 3d echelon.

(3) Called-out components.

(a) Immediately above the multimeter, you can see the fuel lift pump. As you know, the fuel lift pump delivers fuel to the injection

pump. The component switch allows you to replace the pump, connect and disconnect the lines, and check for adequate fuel flow.

(b) Moving again left, there is a call-out of the glowplug connector. The male side of the connector is further called-out. There are test jacks on both sides of the connector.

(c) In the upper left corner of the panel, there is a call-out that depicts the top side of the fuel tank. It has various components switches and test jacks associated with it. Remember, to work on the top of the fuel tank on an actual vehicle, the tank would have to be drained and removed. Well, the simulator works the same way. If you forget that, you will be seeing a lot of incorrect procedure lights.

1 To remove the tank you first need to drain it.

2 Next, you need to disconnect the negative clamp from the grounded battery.

3 Then, disconnect lines 58C and 28A from the top of the tank.

4 At this time, you need to remove the tank. To do this, depress the call-out for the fuel tank and press the remove/install mode switch. Next, depress the call-out for the fuel tank and press the inspect mode switch. You should see the fuel tank on the deck. Now you have access to the fuel sending unit and the filter, if that is what you want to do.

(g) Moving to the right past the call-out for the circuit breakers, you will see a called-out glowplug. It also has component switches and jacks for testing and repair.

(4) Component switches, jacks and transducer associated with the engine and its accessories.

(a) Take a couple of minutes and inspect each item for which a component switch is provided. Being familiar with the actual items should tell you when the various component switches will come into play.

(b) The silver colored connector is for a simulated transducer that you will use in conjunction with the STE/ICE to test oil pressure.

(c) Look at the fuel filter. The line closest to the front of the vehicle is the fuel delivery line. The rear one is the inlet to the filter from the lift pump. We are interested in the fuel filter because, as you know, you need to take fuel samples and check adequate fuel delivery at

the fuel pump during trouble diagnosis on the fuel system. To do those things, you will need to disconnect the appropriate line, crank the engine, and use a component switch in conjunction with the sample fuel mode switch. The video presentation will give you diagnostic cue depending on whether the system is normal or malfunctioning.

(d) I also want you to locate the chassis ground. Point this item out to the assistant instructor responsible for your station.

REFERENCES:

TM 9-2320-280-20-1
TM 9-2320-280-20-2