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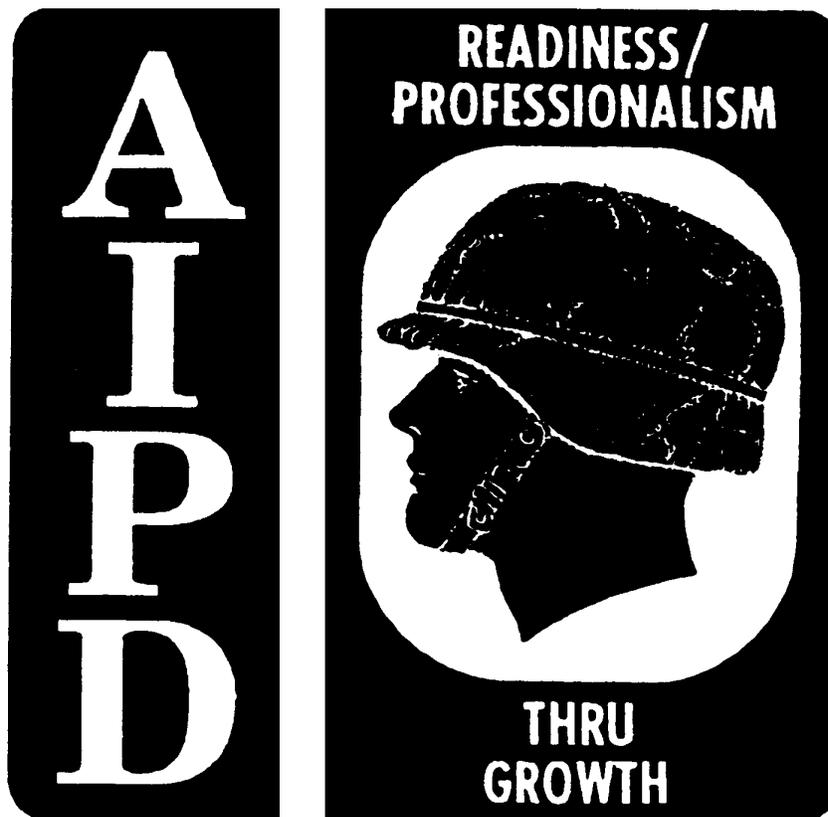
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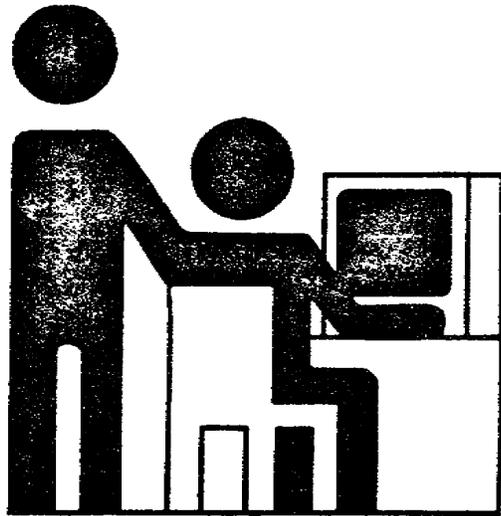
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**INTRODUCTION TO THE HIGH MOBILITY
MULTI-PURPOSE WHEELED VEHICLE (HMMWV)**



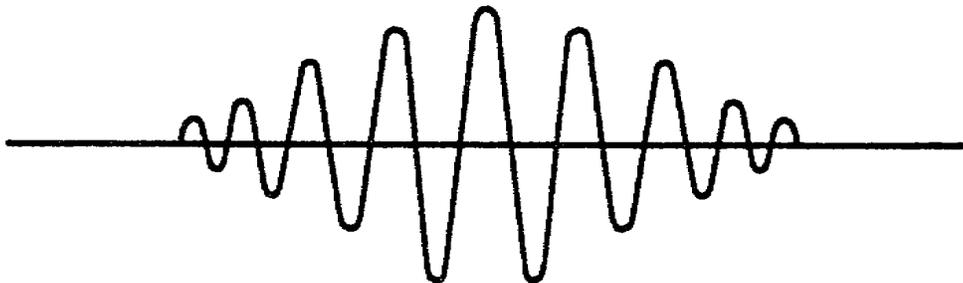
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US ARMY BRADLEY FIGHTING
VEHICLE SYSTEMS MECHANIC

MOS/SKILL LEVEL: 63T30

INTRODUCTION TO THE HIGH MOBILITY
MULTI-PURPOSE WHEELED VEHICLE (HMMWV)

SUBCOURSE NO. OD1615

US Army Correspondence
Course Program

6 Credit Hours

GENERAL

The purpose of this subcourse is to introduce the high mobility multi-purpose wheeled vehicle (HMMWV) family of vehicles (FOV).

The scope of the subcourse broadly covers the general characteristics of the HMMWV. These include the basic characteristics of the vehicle, the characteristics and operation of the 6.2 liter diesel engine, drive train and suspension system, the brake/steering system, and the electrical system.

Six credit hours are awarded for successful completion of this subcourse.

Lesson 1: THE BASIC CHARACTERISTICS OF THE HMMWV FOV AND THE CHARACTERISTICS AND OPERATION OF THE HMMWV ENGINE

TASK 1: Describe the basic characteristics of the HMMWV FOV.

TASK 2: Describe the characteristics and operation of the 6.2 liter diesel engine.

Lesson 2: THE CHARACTERISTICS AND OPERATION OF THE DRIVE TRAIN AND SUSPENSION SYSTEM

TASK 1: Describe the characteristics and operation of the drive train and the suspension system.

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Lesson 3: THE CHARACTERISTICS AND OPERATION OF THE BRAKE/STEERING SYSTEM

TASK 1: Describe the characteristics and operation of the brake system and the steering system.

Lesson 4: THE CHARACTERISTICS AND OPERATION OF THE ELECTRICAL SYSTEM

TASK 1: Describe the characteristics and operation of the electrical system.

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INTRODUCTION TO THE HMMWV - OD1615

STUDENT NOTES

INTRODUCTION TO THE HMMWV - OD1615 - LESSON 1/TASK 1

LESSON 1

THE BASIC CHARACTERISTICS OF THE HMMWV FOV AND THE CHARACTERISTICS AND OPERATION OF THE HMMWV ENGINE

TASK 1. Describe the basic characteristics of the HMMWV FOV.

CONDITIONS

Within a self-study environment and given the subcourse text, without assistance.

STANDARDS

Within one hour

REFERENCES

No supplementary references are needed for this task.

1. Introduction

The high mobility multi-purpose wheeled vehicle, or HMMWV for short, is an extremely important addition to today's new action Army. The HMMWV's small size and speed make it ideally suited for the roles that it performs. It provides troop transport, armed reconnaissance, and ambulance service, and provides for the mounting of the S250 communications shelter. It is designed to function primarily from the division area.

This task introduces the general characteristics of the HMMWV. The succeeding lessons and tasks will cover the characteristics and operation of the various systems that make up the vehicle.

2. General Characteristics

The 1 1/4 ton trucks that comprise the M998 series of vehicles are suitable for use on all types of roads and highways in all types of weather. They are also designed for use over rough terrain. Rougher terrain than normal can be negotiated due

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to the HMMWV's 16 inch high ground clearance (as measured from the bottom of the differential), larger tires, strengthened suspension system and wider vehicle dimensions. This increase in mobility will include the ability to overcome higher vertical obstacles, and permits the vehicle to operate in deeper mud, snow, and sand. Table 1 lists the vehicle dimensions for all models of the HMMWV.

TABLE 1. VEHICLE DIMENSIONS.

Vehicle	Length Overall		Height Overall*		Height Minimum Reducible	
	Inches	Centimeters	Inches	Centimeters	Inches	Centimeters
M966	180	457	73 69**	180	71	180
M996	206	523	101	257	77	196
M997	202	513	100	254	100	254
M998	180	457	69	175	55	140
M1025	180	457	73 69**	180	71	180
M1026	185	470	73 69**	180	71	180
M1035	180	457	69	175	55	140
M1036	185	470	73 69**	180	71	180
M1037	180	457	69	175	55	140
M1038	185	470	69	175	55	140
M1042	185	470	69	175	55	140
M1043	180	457	73 69**	180	71	180
M1044	185	470	73 69**	180	71	180
M1045	180	457	73 69**	180	71	180
M1046	185	470	73 69**	180	71	180
	Width Overall		Ground Clearance			
Vehicle	Inches	Centimeters	Under Axle		Under Chassis	
			Inches	Centimeters	Inches	Centimeters
All	85	216	16	41	24	61

INTRODUCTION TO THE HMMWV - OD1615 - LESSON 1/TASK 1

Another capability of the HMMWV is its increased payload of 2500 pounds. Due to the larger cargo area, a greater physical volume payload may also be carried. The low center of gravity of the HMMWV enables it to be a stable platform for weapons use. Its larger cargo area allows the HMMWV to carry the necessary equipment for the tube launched optically sighted wire guided (TOW) missile system.

Increased operating efficiency and less driver fatigue is realized through the use of applied technology such as the 6.2 liter diesel engine, automatic transmission, full-time four wheel drive and locking transfer, inboard power disc brakes, and power steering.

The HMMWV consists of a common chassis upon which various configurations can be installed. The 4X4 vehicle incorporates features that are necessary to provide mobility, agility, and ballistic protection, while carrying the required payload and crew. The HMMWV can move, shoot, and communicate in a variety of modes and, as such, is suited for roles in combat, combat support, and combat service support. The design configuration for each of these roles will be discussed next.

a. *Missions and Roles of the HMMWV.* In the paragraphs that follow, the various missions and roles the HMMWV is capable of performing will be discussed.

(1) *Combat Role.* In the combat role, the HMMWV can and does perform five different and distinct missions. The vehicles used in the combat role are the M966; armored TOW carrier, M1026; armored armament carrier (MK19 grenade launcher); and the M1025 armored armament carrier (M60 7.62mm machinegun installed). These missions will be listed and discussed in the paragraphs that follow.

(a) *Anti-Armor.* In this role the HMMWV serves as the launching platform for the TOW missile system. The TOW missile system is employed strictly against heavily armored vehicles such as the Soviet T-72 medium tank. The purpose of the vehicle is to mount and operate the TOW missile launcher system with armored protection for the crew, TOW system components, and ammunition.

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A fully loaded M966, armored TOW carrier, will climb road grades as steep as 60°. The vehicle fords hard bottom water crossings up to 30 inches without a deep water fording kit, and 60 inches of water with the kit installed. The maximum fully loaded cruising range is 325 miles.

(b) *Reconnaissance.* The HMMWV's ability to mount several different types of weapons, as well as its speed and agility over all types of terrain, make it ideally suited for the role of an armed reconnaissance vehicle. In this mode, the vehicle operates well in advance of friendly troops, relaying information about enemy troop movements and deployment. Armed with the M60, 7.62mm machinegun, and the M2 .50 caliber machinegun, the vehicle is capable of engaging lightly armed forces while reconnoitering the combat area.

(c) *Air Defense.* The vehicle may serve as a firing platform for the M2 .50 caliber machinegun in its air defense role.

(d) *Rear Area Combat Operations.* The vehicle can be used by cavalry and military police (MP) units in the rear to provide rear area and flank security for the maneuver forces.

(e) *Base Defense.* The vehicle's stability and ability to mount various weapons makes it ideally suited as a firing platform while in a fortified position along the base's defensive perimeter.

(2) *Combat Support.* In this paragraph and those that follow, reference will be made to combat support and combat service support. Do not get these terms confused; though they sound similar, there is a difference. Combat support is operational assistance furnished to combat elements by other designated units. Combat service support comprises (administrative, logistical, and maintenance) services supplied to a maneuver combat element by a designated support unit, i.e., a maintenance company.

In the role of combat support, the M998 and the M1037 vehicles are used. In this role, the M998 is used to transport fire support teams to the forward edge of the battle area (FEBA), and for target acquisition by forward observers and forward air controllers.

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The S250 communications shelter, which is used in conjunction with the M1037, is a container that is mounted on the back of the vehicle. The container, when received, is empty; however, it provides the attachments to incorporate radio communications equipment, depending on the needs of the unit, and on the equipment that the unit is authorized to use. This is usually found configured as a radio teletypewriter (RATT) and is normally found in the battalion area. This equipment permits the battalion commander to communicate, by voice, with his subordinate units and also to higher headquarters.

A fully loaded M1937 shelter carrier will climb road grades as steep as 60°. Like its counterparts previously discussed, the carrier is capable of fording hard bottom water crossings of 30 inches without the deep water fording kit being installed. If the kit is installed, the vehicle can ford water up to 60 inches. Fully loaded, the M1037 has a maximum cruising range of 300 miles.

(3) *Combat Service Support.* In the combat service support role, the HMMWV is used as either an ambulance or a logistics support vehicle. In the ambulance mode there are three vehicles used. The M996, capable of carrying two litter patients, and the M997 which is like the M996 except that it is expanded to hold two additional litter patients. These two vehicles provide armored protection for the crew and patients. The M996 can be transported by a CH47 Chinook helicopter, while the M997 cannot be. The third version is the M1035, two litter, soft top ambulance. The M1035 is the same as the M996, except that it has no armor protection for the crew and patients.

The M998 and the M1038 are the two logistics support versions of the HMMWV. The M998 and M1038 cargo/troop carriers are used to transport equipment, materials, and/or personnel. The cargo carrier is capable of transporting a payload (including crew) of 2500 pounds. The troop carrier is capable of transporting a two man crew and eight passengers. The cargo/troop carrier has a four-man crew configuration. Each uses a troop seat kit for troop transport operations. The M1038 is equipped with a winch that permits recovery operations of similar vehicles. Fully loaded, the M998 and the M1038 cargo/troop carriers are capable of climbing road grades of 60°. Again, like the previously

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mentioned versions, these two are capable of fording to a depth of 30 inches without a deep water fording kit, and 60 inches with the kit installed. Fully loaded, the M998 and M1038 have a maximum cruising range of 350 miles.

b. *Additional Features.* In addition, the HMMWV, fully equipped and with a full payload, can maintain speeds of 60 mph on hard surface roads and 23 mph cross country. The HMMWV is capable of accelerating from 0-30 mph in less than eight seconds. In an additional 22 seconds, the vehicle can reach a speed of 50 mph.

(1) *Run Flat Tires.* The vehicle can be operated for 30 miles at a speed of 30 mph after loss of air pressure without perceptible damage to any of the tires. An insert in the tire is designed to release a package of lube inside the tire to cool the tire and prevent damage to the side wall and tread. This unusual capability allows the vehicle to depart a combat area, even when the tires are damaged, preventing the loss of the vehicle and crew.

(2) *Plastic Fuel Tank (Polypropylene).* The fuel tank provides protection from small explosive charges. The capacity of the fuel tank is 25 gallons of diesel fuel. The mileage for the HMMWV is 17 miles per gallon, giving the vehicle a range greater than 300 miles, depending on payload and driving conditions.

(3) *Towing Capabilities.* Little or no degradation is evident when towing a two-wheel trailer or a M102 howitzer with a gross weight of 3400 pounds. In addition, the HMMWV is capable of towing another fully loaded HMMWV.

Other characteristics of this vehicle, such as the heater, steering, suspension, brakes, etc., will be discussed in the subsequent lessons and tasks of this subcourse.

3. Conclusion

From this brief discussion on the general characteristics of the HMMWV, one can easily see why the HMMWV is capable of performing the numerous tasks assigned to it.

INTRODUCTION TO THE HMMWV - OD1615 - LESSON 1/TASK 2

LESSON 1

THE BASIC CHARACTERISTICS OF THE HMMWV FOV AND THE CHARACTERISTICS AND OPERATION OF THE HMMWV ENGINE

TASK 2. Describe the characteristics and operation of the 6.2 liter diesel engine.

CONDITIONS

Within a self-study environment and given the subcourse text, without assistance.

STANDARDS

Within one hour

REFERENCES

No supplementary references are needed for this task.

1. Introduction

In the preceding task, the general characteristics of the high mobility multi-purpose wheeled vehicle (HMMWV) were discussed; this discussion included the vehicle weight and dimensions. In this task, the characteristics and operation of the 6.2 liter diesel engine will be discussed.

The engine used to power this family of vehicles (FOV) is a four-stroke, 6.2 liter, V8, diesel engine. The engine is a one-piece cast iron block with overhead valves. The engine is governed at 3600 rpm with a power output of approximately 150 horsepower. The normal operating range of the engine is between 1500 and 2300 rpm. There are six subsystems that support the operation of the engine. These subsystems are: fuel, air, cooling, lubrication, electrical, and exhaust. In the paragraphs that follow, each of these subsystems will be discussed.

INTRODUCTION TO THE HMMWV - OD1615 - LESSON 1/TASK 2

2. Fuel System

Ignition of the fuel in a diesel engine occurs because of heat developed in the combustion chamber during the compression stroke. Thus, no spark plugs or high voltage ignition is necessary for a diesel engine. However, fuel is required for combustion; therefore, we will look first at the fuel system and the travel of fuel from the fuel tank to the point of combustion.

Fuel is pulled from the fuel tank by a mechanical fuel pump located on the right side of the engine. The primary fuel pump is driven, through a push rod, by a lobe on the camshaft. The fuel, from the fuel pump, travels to the fuel filter/water separator, located on the body bulkhead above the engine. From the filter, the fuel travels to the fuel injection pump where it is metered to the injectors. The injectors open at approximately 1960 pounds per square inch (psi), injection pump pressure, and spray fuel into the combustion chamber of the cylinder.

a. *Components of the Fuel System.* In the preceding paragraphs the flow of fuel, from the fuel tank to the combustion chamber, was traced. In the paragraphs that follow, the components that comprise the fuel system will be discussed in a little more detail.

b. *Fuel Tank.* The first component of the fuel system is the fuel tank. The fuel tank used on the HMMWV is made out of plastic (polypropylene). This protects the fuel tank from small explosive charges. Another reason for the use of the plastic tank is that in a metal fuel tank, such as the one found in an automobile, condensation (water) will form as the fuel level in the tank decreases and the ambient or outside air temperature changes. The tank can hold up to 25 gallons of either diesel fuel 1 (DF1), diesel fuel 2 (DF2), or diesel fuel arctic (DFA). The fuel tank is located in the rear of the vehicle, on the right side.

c. *Fuel Pump.* Fuel injection pumps must be supplied with fuel under pressure for the following reasons: (1) The injection pump lacks the suction capacity to draw the fuel from the tank by itself; (2) It is necessary to supply the fuel to the injection pump in excess, so that the fuel may be used to cool and lubricate the system before

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passing it back to the tank; and (3) Without a supply pump, the system would lose its prime whenever the pump is in the nondelivery mode.

The HMMWV uses a cam-driven diaphragm (mechanical) type fuel pump; this type of fuel pump is currently most popular for an automotive fuel pump. The operation of the pump is as follows:

The rocker arm is moved up and down by the engine camshaft. The rocker arm spring causes the rocker arm to follow the cam lobe. The rocker arm hooks into an elongated slot in the pull rod. The other end of the pull rod is attached to the diaphragm. As the camshaft operates the rocker arm, it will operate the diaphragm against the pull of the diaphragm spring. As the rocker arm pulls the diaphragm down, the inlet check valve is unseated and fuel is drawn into the pump chamber. The outlet check valve seals the outlet passage. As the diaphragm spring pushes the diaphragm back up, the inlet check valve seals the inlet and the fuel in the pump chamber is pushed through the unseated outlet check valve and through the pump outlet. This operation is repeated each time the rocker arm operates the diaphragm.

The pressure will build up in the fuel line and the pump chamber as the fuel pump fills the fuel injection pump. As the pressure rises to the desired level in the pump chamber, it will hold the diaphragm down against the pressure of the diaphragm spring. When this happens, the rocker arm will just move up and down in the slotted pull rod with no pumping action, until the fuel line pressure drops below the desired level. In this way, the fuel pump regulates fuel line pressure. The operating range of the pump depends on the tension exerted by the diaphragm spring.

A vent hole is provided under the diaphragm to allow the pressure to change in the lower chamber as the diaphragm flexes. The pulsating chamber, located above the pump chamber, uses a soft diaphragm and a sealed chamber to cushion the pulsating action inherent in the diaphragm-type pump. An oil seal is provided to keep crankcase oil from entering the lower chamber and leaking from the vent hole.

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d. *Fuel/Water Separator.* Thorough and careful filtration is especially necessary to keep diesel engines efficient. Diesel fuels are more viscous than gasoline and contain more gums and abrasive particles that may cause premature wear of injection equipment. The abrasives may consist of material that is difficult to eliminate during refining, or they even may enter the tank during careless refueling. Whatever the source, it is imperative that means be provided to protect the system from abrasives.

The fuel filter/water separator is a dual element unit. One element is used to remove sediment from the fuel, while the other element separates and collects any water that has gotten into the fuel. A water drain is provided, so that the water that has been collected can be periodically drained. Since the vehicle uses a plastic fuel tank, eliminating condensation, the water does not have to be drained as often as one would think.

e. *Fuel Injection Pump.* The fuel injection pump directs metered fuel to the eight injector nozzles. The injector pump is mounted on the top of the engine under the intake manifold.

f. *Fuel Injectors.* For proper engine performance, the fuel must be injected into the combustion space in a definite spray pattern. This is accomplished by the fuel injector.

The fuel enters the nozzle holder body through the high-pressure inlet. It then passes down to the pressure chamber above the valve seat. When the pressure developed by the injection pump exceeds the force exerted by the pressure adjusting spring, the nozzle valve will be lifted off of its seat, resulting in the injection of fuel into the cylinder. The valve on the HMMWV will open at approximately 1960 psi.

A controlled seepage exists between the lapped surfaces of the nozzle valve and its body to provide for lubrication. This leakage or overflow passes around the spindle and into the pressure adjusting spring chamber. From there, the lubricating fuel leaves the injector, through an overflow outlet, to the overflow lines, which lead back to the low-pressure fuel supply.

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g. *Fuel Supply and Return Line(s)*. The final two components of the fuel system that will be discussed are the fuel supply and the fuel return lines. The fuel supply line is the line through which the fuel travels on its way from the fuel tank to the various other components of the fuel system. The fuel return line is the line through which unused fuel travels on its way back to the fuel tank from the injection pump.

3. Engine Construction and Operation

a. In many respects, the four-stroke cycle gasoline engine and the four-stroke cycle diesel engine are very similar. They both follow an operating cycle that consists of intake, compression, power, and exhaust strokes. They also share the same system for intake and exhaust valves. The major differences between gasoline and diesel engines will be discussed in the paragraphs that follow.

b. In a diesel engine, the fuel and air mixture is ignited by the heat generated by the compression stroke, in contrast to the use of a spark ignition system on a gasoline engine. The diesel engine needs no ignition system. For this reason, the gasoline engine is referred to as a spark ignition engine while the diesel engine is referred to as a compression ignition engine.

c. The air is compressed to about one-twentieth of its original volume in a diesel engine. In contrast, the fuel and air mixture in a gasoline engine is compressed to about one-eighth of its original volume. The diesel engine must compress the air tightly to generate enough heat to ignite the fuel when it is injected into the cylinder. The gasoline engine mixes the fuel and air before it reaches the combustion chamber. A diesel engine takes in only air through the intake port. Fuel is then injected into the combustion chamber just before completion of the compression stroke. As the fuel is injected, it mixes with the air and ignites because of the heat.

d. The engine speed and power output of the diesel engine are controlled by the quantity of the fuel admitted to the combustion chamber. The amount of air remains constant. This contrasts with the gasoline engine where the speed and power output are regulated by limiting the air entering the engine.

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e. *Operation.* In the paragraphs that follow, the operation of the engine will be followed through each of the four strokes that comprise one cycle of operation.

(1) *Intake.* When the intake stroke begins, the piston is at top dead center (TDC). As the piston moves downward, the intake valve opens and the downward movement of the piston creates a vacuum that sucks air into the cylinder. When the piston reaches bottom dead center (BDC), the intake valve closes and the intake stroke is complete.

(2) *Compression.* The compression stroke begins at BDC. As the piston travels upward toward TDC, the air that was drawn into the cylinder is compressed to a ratio of nearly 22 to 1, almost three times the ratio of a typical gasoline engine. This ultra-high compression causes the air to superheat, making it hot enough to ignite the diesel fuel. The compression stroke ends when the piston reaches TDC.

When the piston reaches TDC, the fuel injector sprays a precisely measured amount of fuel into the precombustion chamber. The superheated air in the combustion chamber ignites the fuel as it is injected. This is where the term compression ignition comes from. The very high compression ratio is part of the reason a diesel provides high efficiency and impressive fuel economy.

(3) *Power Stroke.* The power stroke begins with the initial burning of the fuel in the precombustion chamber. This initial combustion reaction forces the injector fuel into the cylinder area, where combustion is completed. The exploding gases push the piston downward, providing power to the engine's crankshaft and in turn to the vehicle's drive train.

(4) *Exhaust Stroke.* During the 6.2's exhaust stroke, the exhaust valve opens, and the piston again moves up in the cylinder, this time forcing out exhaust gases. As the piston reaches TDC again, the exhaust valve closes, the intake valve opens, and the entire process starts all over.

4. Air Induction System

The air induction system performs two vital functions. Since all internal combustion engines require a mixture of fuel and air to be introduced into the combustion chamber at some point in their operation, some method must be devised to induct fuel into the engine and eventually into the combustion chamber. This is the first and primary job of the air induction system.

The second job of the air induction system is to filter the air that has been inducted, before it passes into the combustion chamber. This is accomplished through the use of an air filter.

From the previous paragraphs concerning the air induction system, the following statement can be made concerning its function: "the air induction system filters the outside air and directs it to the engine". The air induction system on the HMMWV consists of the following components: an entry stack with raincap, paper air filter element, air filter canister, air duct hose, air to manifold duct, and an air restriction gage.

The air filter canister and intake stack are located on the right side of the vehicle, forward of the windshield and just to the rear of the engine compartment. The filter paper filter element is secured in the canister with a 5/8 inch nut; the canister cap itself is secured with a clamp.

As the air enters the intake stack, it passes through the filter element where impurities such as dirt and dust are removed. From there, it passes through the air to manifold duct which is secured to the intake manifold and connected to the air filter canister by the air duct hose. As the air passes through the air to duct manifold, it passes the air restriction sensor. The sensor is connected to the air restriction gage, located on the left side of the instrument panel. The sensor records the amount of dust in the air as it leaves the air filter. If the air contains too much dust, the indicator will read in the red zone. This means that the filter element should either be replaced or, if replacement is not possible, cleaned. The gage is equipped with a reset button that returns the float in the gage to its normal position.

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The air then continues to travel through the air to manifold duct and the air duct hose, into the intake manifold, where it is directed into each of the cylinders.

5. Cooling System

All internal combustion engines are equipped with some type of cooling system because of the high temperatures they generate during operation. High temperatures are necessary to generate the high gas pressures that act on the head of the piston. Power cannot be produced efficiently without high temperatures. However, it is not possible to use all the heat of combustion without harmful results. The temperature in the combustion chamber during the burning of fuel is well above the melting point of iron. Therefore, if nothing is done to cool the engine during operation, valves will burn and warp, lubricating oil will break down, and bearings and pistons will overheat, resulting in engine seizure.

The engine cooling system is a pressure type cooling system with thermostatic control of coolant circulation. The cooling system dissipates the heat generated from combustion and maintains the engine operating temperature at the most efficient range.

The cooling system on the HMMWV consists of the following components: a radiator, surge tank, thermostat, 10 blade fan and drive clutch, water pump, radiator hoses, pulleys and drive belts, and the radiator shroud.

When the engine is cold, and the thermostat is closed, coolant is circulated through the water pump and engine. As the engine coolant reaches 190° F, the thermostat opens, allowing coolant to flow through the radiator before returning to the water pump and the engine. Any air or vapor in the cooling system will be forced to the surge tank under the liquid level and leave through the vent tube. As the system cools, the extra coolant in the tank will be drawn back to the radiator. The normal operating temperature is between 190° to 230° F.

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The radiator is mounted at an approximate angle of 45° to accommodate the low silhouette of the vehicle. The radiator holds six gallons of coolant, while the surge tank holds half a gallon. The radiator shroud channels the air flow between the radiator and fan for more efficient operation. The fan is mounted on the fan drive clutch which activates the fan when the coolant temperature reaches approximately 200° F. Normally, a 50-50 mixture of water and ethylene glycol base anti-freeze should be used in the cooling system. This is to prevent freezing and to protect the metal components.

A separate oil cooler is mounted in front of the radiator. This cooler is divided into two parts. The top half is for transmission and transfer case oil; the bottom half is for engine oil.

When the cooling system pressure reaches approximately 15 psi, a valve in the surge tank cap opens and allows excess pressure to escape into the atmosphere. Another valve opens at approximately two inches of mercury (vacuum), letting air back into the cooling system.

6. Lubrication System

a. *Purpose of the Lubrication System.* The lubrication system in an automotive engine supplies a constant supply of oil to all moving parts. This constant supply of fresh oil is important to minimize wear, to flush bearing surfaces, and to remove the localized heat that develops between moving parts as a result of friction. In addition, the oil that is supplied to the cylinder walls helps the piston rings make a good seal, reducing blowby.

(1) *Oil as a Lubricant.* The primary function of engine oil is to reduce friction between moving parts (lubricate). Friction, in addition to wasting engine power, creates destructive heat and rapid wear of parts. The greater the friction, the greater the energy needed to overcome that friction. The increase in energy adds to the amount of heat generated, causing moving parts that are deprived of oil to melt, fuse, and seize after a very short period of engine operation. The effectiveness of a modern lubrication system makes possible the use of friction-type bearings in an engine. Friction between the pistons and the

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cylinder walls is severe, making effective lubrication of this area imperative. Lubrication of the connecting rod and main bearings is crucial because of the heavy loads that are placed on them. There are many other less critical engine parts such as the camshaft, valve stems, rocker arms, and timing chains that also need a constant supply of oil.

(2) *Oil as a Coolant.* Engine oil circulated throughout the engine also serves to remove heat from the friction points. The oil circulates through the engine and drains to the sump. The heat picked up by the oil while it is circulated is removed by an airflow around the outside of the sump. In some instances where the sump is not exposed to a flow of air, it is necessary to add an oil cooling unit that transfers the heat from the oil to the engine cooling system through an oil cooler mounted in front of the radiator. The HMMWV has this type of cooler.

b. *Characteristics and Operation of the HMMWV's Lubrication System.* The lubricating system in the HMMWV engine is a pressure feed type. Normal operating pressure for the system is 20 to 50 psi; at idle, the operating pressure may drop down to 15 psi. The engine crankcase (minus the oil filter) contains 7 quarts, 8 quarts with the filter.

There are three different weights of oil that are used in the HMMWV engine, depending under what temperature the vehicle is expected to operate. If the temperature is above 40° F, then heavy duty engine oil (OE/HDO 30) is used; if the temperature ranges between 40° F to -15° F, then OE/HDO 10 oil is used; if the temperature falls between -15° F to -65° F, an arctic type engine oil (OEA) must be used.

The engine lubrication system is composed of an oil pan reservoir, oil filter, gear-driven oil pump, and an oil cooler. The pump is mounted on the rear main bearing cap. Oil is picked up by a tube and is pumped to the oil cooler. The oil cooler is mounted in front of the radiator. The oil then flows from the oil cooler to the oil filter, located on the left side of the engine. The oil filter is of the cartridge-type and all oil going to the engine must first pass through it. This type of filter is also called a full flow filter.

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The engine is equipped with a spring-loaded bypass valve. This valve protects the engine from oil starvation by opening when the filter becomes restricted. From the oil filter, the oil passes on to the engine block. There is an oil sensing unit, located on the left rear of the cylinder block, which senses the pressure of the oil in the left main gallery. This sensing unit is connected to the oil pressure gage, located on the instrument panel. The gage registers the signal sent from the sending unit and indicates to the driver if the pressure of the lubrication system is above, at, or below its normal operating range.

7. Engine Electrical System

The electrical system for the 6.2 liter diesel engine is a 24 volt system capable of submerged operation during fording. The engine electrical system is composed of the starter, alternator, glow plugs, glow plug controller, protective control box, and the wiring harness.

Operation of the engine electrical system will be discussed in lesson four of this subcourse, since this system is a part of the vehicle electrical system as a whole.

8. Exhaust System

The waste products of combustion are carried from the engine to the rear of the vehicle by the exhaust system, where they are expelled to the atmosphere. The exhaust system also serves to dampen engine noise. The exhaust system consists of exhaust manifolds, a crossover pipe, a muffler, and a tail pipe.

Exhaust components are constructed of aluminized and stainless steel for corrosion protection. The exhaust crossover pipe is bolted to the exhaust manifolds. The muffler is a reverse-flow double-pass and is mounted between the frame rails. The tail pipe is routed in front of the left rear wheels and out to the side of the vehicle.

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9. Conclusion

This concludes the task on the characteristics and operation of the 6.2 liter diesel engine. In this task, we not only discussed the operation of the engine, but also the operation of the accessory or support systems that must perform correctly if the engine is to function properly. In the following lessons and tasks, we will discuss the other vehicle systems that all fit together to make a formidable addition to the Army's inventory.

INTRODUCTION TO THE HMMWV - OD1615 - LESSON 1/PE 1

PRACTICAL EXERCISE 1

1. Instructions

Read the scenario and respond to the requirements that follow the scenario.

2. Scenario

You have just reported to a small installation located in the Federal Republic of Germany. Upon reporting in, the transportation officer tasks you with preparing lesson plans to be used in indoctrinating new staff drivers about the vehicles that they will be operating while stationed in Germany.

Since the main vehicle in use throughout the Army is the high mobility multi-purpose wheeled vehicle (HMMWV), this vehicle will make up the backbone of your lessons.

You have prepared the lesson plan for the characteristics of the HMMWV FOV and the characteristics and operation of the 6.2 liter diesel engine. All that remains now is to prepare the quiz to be administered to the students to test their retention and knowledge concerning the HMMWV.

3. Requirement

Below are the questions to be used. Prepare an answer sheet, using your knowledge of the HMMWV and this subcourse.

- a. Name the three roles for which the HMMWV is suited.
- b. The HMMWV wheels and tires are designed with what capability?
- c. Without a deep water fording kit installed, how deep can the HMMWV ford water?
- d. The HMMWV fuel tank has a capacity of how many gallons of fuel?
- e. What type of engine does the HMMWV have?

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- f. Name the components that comprise the air induction system.
- g. To accommodate the low vehicle silhouette, how is the radiator mounted?
- h. What are the components of the exhaust system made of?

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LESSON 1. PRACTICAL EXERCISE - ANSWERS

1. Requirement

- a. The three roles of the HMMWV are combat, combat support, and combat service support.
- b. The HMMWV wheels and tires are designed with run flat capabilities.
- c. Without the deep water fording kit installed, the HMMWV can ford water as deep as 30 inches.
- d. The capacity of the HMMWV fuel tank is 25 gallons.
- e. The HMMWV engine is a 6.2 liter, V-8, 4-stroke diesel engine.
- f. The air induction system is composed of the following components:
 - 1) entry stack with raincap
 - 2) paper air filter element
 - 3) air filter canister
 - 4) air duct hose
 - 5) air to manifold duct
 - 6) air restriction gage
- g. To accommodate the low silhouette of the vehicle, the radiator is mounted at a 45° angle.
- h. The components of the exhaust system are made of aluminized and stainless steel.

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LESSON 2

THE CHARACTERISTICS AND OPERATION OF THE DRIVE TRAIN AND SUSPENSION SYSTEM

TASK 1. Describe the characteristics and operation of the drive train and the suspension system.

CONDITIONS

Within a self-study environment and given the subcourse text, without assistance.

STANDARDS

Within one hour

REFERENCES

No supplementary references are needed for this task.

1. Introduction

In the previous lesson, the basic characteristics of the high mobility multi-purpose wheeled vehicle (HMMWV) and the characteristics and operation of the 6.2 liter diesel engine used to power the vehicle were discussed. In this task, the characteristics and operation of the drive train and suspension system will be discussed.

2. Drive Train

The function of the drive train is to transmit the power of the engine to the wheels. In a simple situation, a set of gears or a chain could easily perform this task, but automotive vehicles usually are not designed for such simple operating conditions. They are designed to have a great deal of pulling power, move at high speeds, travel both in reverse and forward, and operate on rough ground as well as smooth roads. To meet these widely varying demands, a number of units have been added. These include clutches, transmissions, auxiliary

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transmissions, transfer cases, propeller shafts, universal joints, final drives, differentials, live axles, devices for resisting drive torques and thrust, and the bearings used therein.

a. *Components of the Drive Train.* The drive train on the HMMWV consists of seven components that work together to transmit power to the wheels. In the paragraphs that follow, each of these components will be discussed.

b. *Engine.* The first component in the HMMWV drive train is the engine. However, since the engine was discussed previously in lesson one, task two beginning on page 7, it will not be discussed here.

c. *Transmission.* The HMMWV family of vehicles are equipped with a series 400 hydromatic automatic transmission (THM 400), manufactured by General Motors, with some parts from the 475 hydromatic transmission. The transmission holds six quarts of Dexron II transmission fluid and maintains an operating pressure of 55-160 psi.

The transmission contains a three element torque convertor, compound planetary gear set, three multiple disc clutches, one sprag and one roller, and two friction bands. The torque convertor couples the engine smoothly to the planetary gear through oil, and provides additional hydraulic torque multiplication when required. The compound planetary gear set gives three forward ratios and one reverse. Changing of the gear ratios is fully automatic in relation to vehicle speed and engine torque input. The torque from the engine is transmitted to the transmission through the flex plate. Vehicle speed and engine torque signals are constantly fed to the transmission to provide the appropriate gear ratio for maximum efficiency and performance at all throttle openings.

d. *Transfer Case.* The transfer case directs engine-to-transmission power to the front and rear differentials simultaneously. This condition means the vehicle is always in four-wheel drive. The transfer case allows for selection of three driving ranges and a neutral position. The transfer case used on the HMMWV is a New Process 218 (MOD), two speed, locking, chain-driven transfer. The transfer case holds 3.5 quarts of Dexron II transmission fluid.

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There are four shift lever positions for transfer case drive ranges. The first is "L" which represents low lock. This position is used only when the vehicle is climbing or descending steep hills, or operating in deep mud, sand, and snow. The second position is the "N" or neutral position. This position is used when the vehicle is disabled and must be towed. The next position is "H" or high. This is used when operating the vehicle in normal driving conditions and when fording. The last position is the "H/L" or high lock position which is used when driving through mud, sand, snow, off road, or any slippery road conditions.

e. *Propeller Shafts.* Two tubular propeller shafts link the transfer case to the differentials. Universal joints, located at both ends of the front and rear propeller shafts, permit inline driving power between the transfer case and the differentials even though they are mounted at different angles.

f. *Differentials.* The differential is a gear system that divides torque between the axle shafts allowing them to rotate at different speeds when cornering. The dual drive differential is a limited slip (torque biasing) differential. It resists spinout by transferring more torque to the drive wheel that has the most resistance to spinout. A standard differential has no such provision. The differentials are mounted up between the frame rails to minimize drive line vibration, external damage, and to increase ground clearance. The front and rear differentials are identical and are interchangeable, providing that the yoke is changed. The differential uses gear oil (GO) 80/90.

g. *Axle Half Shafts.* The HMMWV utilizes axle drive shafts (half shafts) to accommodate the independent suspension system. The purpose of the half shafts is to transfer torque to the wheels from the differential through the geared hub. The unit is basically a one-piece assembly with boots on both the inboard (differential) and outboard (geared hub) ends. The inboard end is bolted to the differential side flange and the outboard end is splined to the drive gear of the geared hub. The inboard boot encloses a constant velocity joint which accommodates the in-and-out and angular motion of the axle drive shaft with no change to either system.

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The outer boot encloses a constant velocity joint which transmits torque through various steering angles to the geared hub. The outer constant velocity joint end of the shaft assembly is held in place by the axle shaft retaining bolt located opposite the pipe plug in the geared hub. The inner housing is held in place by both the differential output flange bolts and the caliper mounting brackets.

NOTE

The inner and outer velocity joints and half shafts are serviced as assemblies only.

h. *Geared Hub.* The geared hub has a gear box, located at the wheel ends, that serves as the front wheel spindle. It can be considered the final drive unit. It permits attainment of up to 16 inches of ground clearance without damaging the front or rear differentials. The geared hub also provides a lower gear ratio (1.92:1).

The geared hub includes a drive gear and a driven gear enclosed in a housing. The drive gear is turned by the differential driven half shaft and powers the driven gear which turns the wheel spindle.

The geared hub is joined to the upper and lower control arm by ball joints bolted to the outer end of each arm. The driven gear is splined to the wheel spindle. The drive gear is turned by the differential driven half shaft. The drive and driven gears are a matched set replaced as a unit at the differentials. The steering arm and cover is connected to the center bar by the tie rod. The side cover is removed only for the purpose of inspecting the drive and driven gears.

3. Suspension System

The suspension system's main purpose is to support the weight of the vehicle. Military vehicles, which are often very heavy and must be able to cross all types of terrain, depend heavily on their suspension systems. In wheeled vehicles, the

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suspension must not only be effective over a wide range of conditions, but must also allow for steering geometry and changes in terrain.

The suspension system is identical for all models of the HMMWV. The HMMWV uses an independent coil spring suspension system. The suspension system consists of eight components, which will be discussed in greater detail in the following paragraphs.

a. *Components of the Suspension System.* The following discussion of the HMMWV suspension system components will be divided into two sections. The first deals with the components at the front wheels, the second with the suspension components at the rear wheels.

b. *Front Wheel Suspension System Components.* In the paragraphs that follow, the five suspension system components that are located at each front wheel will be discussed. The five components are the upper and lower control arms, upper and lower ball joints, shock absorbers, stabilizer bar, and geared hubs.

The upper and lower control arms connect the geared hubs to the frame rails. The geared hub is joined to the control arms by ball joints bolted to the outer end of each arm. The arms pivot on rubber bushings to maintain the alignment of the geared hub with the vehicle frame. The steel coil spring, mounted between the lower control arm and a frame-mounted bracket maintains the proper ride height.

Mounted within the springs are heavy-duty shock absorbers. The springs support the frame and body, but the shock absorbers work with the springs to control movements of the body, frame, and wheel converting the energy of motion into heat. The shock absorbers are called double acting because they dampen motion in both directions of suspension travel.

The stabilizer bar is transverse-mounted on the frame side sill to the rear of the lower control arms. The bar is attached with rubber bushings and clamps and is connected to the lower arms by link bolts with rubber bushings at both ends. The stabilizer bar provides added roll-resistance by counteracting independent motion from either side

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of the front suspension. Tie rods connect the geared hubs and wheels to the steering linkage on the front suspension, and spherical ball joints allow turning movement transmitted by the steering linkage.

c. *Components of the Rear Suspension System.* The rear suspension system components are identical to the front suspension system components, with the exception of the radius rod. The radius rod attaches the geared hub (in the rear). In the front, this is done through the use of the tie rod.

4. Conclusion

In the preceding paragraphs, the drive train and suspension system used in the HMMWV were discussed. In the next task, the characteristics and operation of the HMMWV brake/steering system will be discussed.

INTRODUCTION TO THE HMMWV - OD1615 - LESSON 2/PE 2

PRACTICAL EXERCISE 2

1. Instructions

Read the scenario and respond to the requirements that follow the scenario.

2. Scenario

After preparing the lesson plan covering the characteristics of the high mobility multi-purpose wheeled vehicle (HMMWV) and the characteristics and operation of the HMMWV engine, the next lesson to be written concerns the characteristics and operation of the drive train and suspension system. You have already prepared the lesson plan and the test questions. All that remains is to prepare an answer sheet for the test questions.

3. Requirement

Using your knowledge of the HMMWV and this subcourse text, answer the questions that follow.

- a. What is the function of the drive train on the HMMWV?
- b. How many forward gear ratios does the transmission on the HMMWV have?
- c. What type of transfer case is used on the HMMWV?
- d. Name the five components of the front wheel suspension system.

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LESSON 2. PRACTICAL EXERCISE - ANSWERS

1. Requirement

- a. The function of the drive train is to transmit the power of the engine to the wheels.
- b. The HMMWV transmission has three forward gear ratios.
- c. The HMMWV uses a New Process 218 (MOD) type of transfer case.
- d. The five components that make up the front wheel suspension system on the HMMWV are as follows:
 - 1) upper and lower control arms
 - 2) upper and lower ball joints
 - 3) shock absorbers
 - 4) stabilizer bar
 - 5) geared hubs

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LESSON 3

THE CHARACTERISTICS AND OPERATION OF THE BRAKE/STEERING SYSTEM

TASK 1. Describe the characteristics and operation of the brake system and the steering system.

CONDITIONS

Within a self-study environment and given the subcourse text, without assistance.

STANDARDS

Within one hour

REFERENCES

No supplementary references are needed for this task.

1. Introduction

In the previous lessons and tasks, the general characteristics of the high mobility multi-purpose wheeled vehicle (HMMWV), characteristics and operation of the 6.2 liter diesel engine, the drive train, and the suspension system were covered. In this task, the characteristics and operation of the brake and steering systems will be discussed.

2. Brake System

There are two brake systems in use on the HMMWV. One is the service brakes, and the other the parking brakes. The service brake system is a four wheel hydraulic disc brake system boosted by hydraulic pressure supplied by the vehicle's power steering system. The service brake system is manually actuated and hydraulically assisted and operated.

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a. *Service Brakes.* The service brake system consists of the brake pedal, pushrod, hydro-boost, master cylinder, combination valve, calipers, rotors, and lines; hoses; and fittings.

When the driver steps on the brake pedal, the pedal force is transferred through the bellcrank assembly, directed into the hydro-boost unit, where it is hydraulically boosted and passed on to the master cylinder. From the master cylinder, fluid pressure in the brake lines passes through the combination valve and on to the disc brake calipers. The calipers close on the rotor, providing a stopping force. The braking system is split front and rear so that if a hydraulic failure occurs to either the front or the rear brakes, the vehicle may still be stopped with the other two brakes.

b. *Parking Brakes.* The parking brake is a lever operated brake that functions through a cable linkage. Its primary purpose is to hold the vehicle stationary. A secondary purpose of the parking brake system is to stop the vehicle in the event that there is a complete service brake failure.

The parking brake consists of a parking brake lever, cable linkage, mechanically operated brake shoes and a rotor, mounted to the rear differential between the drive shafts. When the driver pulls on the parking brake lever, the cable linkage squeezes the brake shoes on the parking brake rotor.

c. *Components of the Service Brake System.* In the paragraphs that follow, the components that comprise the service brake system will be discussed.

(1) *Master Cylinder.* The HMMWV is equipped with a dual reservoir master cylinder. The master cylinder has two fluid outlet ports, a piston bore, and two hydraulic piston assemblies. The piston assemblies are located in the piston bore and are operated in tandem by a pushrod. The master cylinder on the HMMWV holds .69 pints of brake fluid silicone (BFS).

The dual master cylinder contains two brake circuits that are separated hydraulically. The individual brake systems may be designed to divide the system front to rear, diagonally, or in various

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other fashions. In this case, the system is divided front and rear. If a brake fluid leak develops in one circuit, the other circuit still provides emergency stopping capability. As the brake pedal is depressed under normal operating conditions, it forces the primary piston forward to cover the primary compensating port. At this time, the primary chamber is sealed and direct hydraulic pressure is transmitted to the secondary piston. As the brake pedal continues to travel, the secondary piston covers the compensating port. Further application of the brake pedal develops the pressure required to apply the brake components.

Should a leak develop in the primary circuit, the brake system would not be rendered useless. During the application of the brakes, the primary piston would continue to move forward, unable to build up pressure due to the malfunction. Approximately halfway through its maximum stroke, the primary piston contacts the secondary piston. Further application of the brake would force the secondary piston forward to develop pressure in the secondary system, which would allow for braking action to take place in two wheels.

Should the secondary circuit fail, braking for the other two wheels would still be available. The primary piston would move forward and cover the primary compensating port as before. Because of the rupture in the secondary circuit, the secondary or floating piston would be moved to its extreme stop by the force of the return spring. Further application of the brake would develop enough pressure in the primary circuit to apply the brakes connected to this circuit, thereby allowing the vehicle to maintain some stopping ability.

(2) *Brake Lines.* The brake lines used on the HMMWV are of 3/16 of an inch seamless steel tubing with flared fittings. Flexible hoses connect the brake lines to the wheel calipers.

(3) *Brake Fluid.* In paragraph 3c(1), on the previous page, it was stated that the master cylinder contains .69 pints of BFS. The entire system, master cylinder, lines, calipers, etc. contains 1.2 pints of BFS.

Hydraulic brake fluid is the liquid medium in the brake system used to transmit fluid motion and pressure to the wheel brake components. The

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hydraulic brake fluid used in today's modern vehicles have some important properties; the most important are discussed in this paragraph. The fluid must remain a liquid during all operating temperatures. The boiling point of the fluid must, therefore, be well above the temperatures encountered during the most severe brake applications on the hottest day. It must also maintain an even viscosity at extreme cold temperatures. The brake fluid must be able to absorb and hold moisture and also act as a lubricant. There are several types of hydraulic brake fluids in use today.

After 40 years of research and development, a brake fluid that was acceptable under extreme operating conditions was developed. This fluid achieved low water pickup and good corrosion protection. The fluid also provides good lubrication qualities and rubber compatibility. Silicone brake fluid has been used in all military vehicles since the end of 1982. This is the only brake fluid used in the HMMWV.

(4) *Combination Valve*. The combination valve consists of a one-piece housing containing a rear brake proportioning valve section and a differential valve and switch. The proportioning section provides balanced front-to-rear braking action. The pressure differential valve sections activate the brake warning lamp, should a pressure loss in the front or rear hydraulic system occur. The combination valve is just that--a combination of two different valves often found in brake systems. These two valves are the proportioning valve and the limiting valve. The operational characteristics of these two valves will be discussed in the paragraphs that follow.

(5) *Hydro-Boost*. The hydro-boost is a hydraulically operated power assist mechanism used to increase fluid pressure in the brake system while at the same time decreasing the pedal effort. The hydro-boost is also a component of the steering system. This unit does the same job as a vacuum booster and is connected in the brake system in much the same way. The major difference between the two is that the hydro-boost unit uses pressurized power steering fluid to obtain its assist power. The vacuum booster depends on manifold vacuum and atmospheric pressure for its assist power. The unit's smaller size has made it

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easier to fit in the engine compartment and has eliminated the need for a remote or frame mounted booster previously used on some applications.

The hydro-boost system consists of a booster assembly, accumulator, power steering gear, steering pump and reservoir, filter, hydraulic lines, master cylinder and the brake system. The booster itself consists of an open center spool valve and sleeve assembly, lever assembly, input rod assembly, power piston and an output push rod. The booster assembly is mounted to the vehicle in much the same manner as a normal vacuum booster. The pedal rod is connected to the booster input rod end. The master cylinder is located at the opposite end of the booster. The booster's output push rod fits into the primary piston of the master cylinder. The power steering pump, which is unmodified except for a larger reservoir and an additional return port for the hydro-boost return line, supplies the hydraulic pressure to the hydro-boost unit through external lines. When the engine is running, the fluid enters the unit through the pump port where the majority of the fluid is directed to the gear port and then to the steering gear by an external line. The small quantity of power steering fluid that did not go to the power steering gear circulates inside the hydro-boost unit and then returns to the steering pump reservoir by an external line.

The hydro-boost unit includes a reserve brake system that makes available two or three power assisted brake applications in the event that the flow of fluid from the power steering pump is interrupted by a stopped engine, broken belt, pump failure, ruptured hose, etc. This system uses a gas accumulator to store fluid under gas pressure.

During normal operation, the accumulator is charged by fluid from the pump port. This fluid is taken from the pump port before it gets to the spool valve. The charging fluid flow is controlled by the accumulator valve which consists of a check ball, spacer, plunger and plunger seat. The check valve allows fluid under greater pressure than that in the accumulator to go through the valve and into the accumulator. Once past the check valve, the fluid then travels by internal passage to the accumulator. The fluid pressure exerts force on the accumulator piston which then compresses the

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accumulator. This fluid is then stored under pressure until normal fluid pressure is not available.

3. Steering System

The steering system on the HMMWV is a hydraulically assisted power steering system comprised of the following components: steering wheel, steering gear, power steering pump, hydro-boost, lines, steering column, steering linkage, tie rod, center link, idler arm, and pitman arm. The turning effort at the steering wheel is transmitted to the steering gear where it is hydraulically multiplied and transferred to the front wheels through the steering linkage.

a. *Components of the Steering System.* In the paragraphs that follow, each of the components comprising the HMMWV steering system will be discussed.

b. *Steering Wheel.* The steering wheel is a three-spoked, 15 1/2 inch steering wheel with a center-mounted horn button. It is secured to the upper steering column with a hex nut.

c. *Steering Column.* The steering column is a two-piece assembly consisting of an upper steering column and an intermediate steering shaft. The two pieces are universally-jointed and the intermediate shaft is also splined to the steering gear stub shaft and secured with a bolt through the slip yoke.

d. *Power System.* The power system is composed of the steering gear, power steering pump, and interconnecting hoses. The fluid supply is maintained in a reservoir mounted on the power steering pump. The pump is operated by a drive belt mounted on pulleys attached to the pump shaft and the engine crankshaft. The power steering system on the HMMWV holds one quart of Dexron II hydraulic fluid.

The gearbox used in an integral power steering system is basically a manual gearbox adapted to include a power assist package. The integral power steering gearboxes are of two types: offset and inline. However, since the HMMWV uses the offset or recirculating ball bearing type of gearbox, that is the only one that will be discussed in this text. The offset type uses a recirculating ball-

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type gearbox with a rack above or on the opposite side of the ball nut. The power steering force is developed in the power piston, which is offset from the worm and nut and attached to the rack. The power steering gear on the HMMWV uses a steel ball bearing within the gear to act as a rolling thread. With this type of gearbox, should a complete power steering system failure occur, the vehicle can still be steered manually, though with difficulty.

All power steering systems contain a pump that supplies hydraulic fluid under pressure to the other components in the system. The pump, which may be of the gear teeth, rotor, or vane type, is usually driven by the engine by means of a V-belt. The pump is functional whenever the engine is operating. The pressure and flow relief valves are always built into the pump. These valves are designed to limit the amount of pressure and flow the pump develops throughout the different engine speeds. The power steering pump on the HMMWV is a Saginaw 125, with a maximum output of 1450 psi and a maximum flow rate of 3.5 gallons per minute.

e. *Steering Linkage.* The steering linkage is of a parallelogram design that is sometimes referred to as the Ackerman system or articulated linkage. The steering linkage consists of two adjustable tie rod assemblies, a center link, pitman arm, and an idler arm. All components are connected by spring-loaded nonadjustable ball studs. Only the idler arm, pitman arm, and tie rod ball studs have lubrication fittings. Each tie rod assembly consists of a tie rod, tie rod end, adjusting tube and clamps. The threaded tube connects the tie rod and tie rod ends, which have left and right hand threads to allow for toe adjustment.

The parallelogram steering linkage is a very popular steering system for independent front suspension and is used on many of today's vehicles.

(1) *Centerlink.* The parallelogram steering system uses a centerlink, otherwise known as an intermediate rod or track rod, to connect the steering arms together. The turning action of the steering box is transmitted to the centerlink through the pitman arm. The pitman arm also provides support for the centerlink. The two components are connected by a hinge or ball joint. The pitman arm is the component that transfers

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steering torque from the power steering gear to the centerlink.

(2) *Idler Arm.* The centerlink is hinged on the opposite end of the pitman arm by means of an idler arm. The idler arm supports the free end of the centerlink and allows it to move left and right with ease.

(3) *Tie Rod.* The tie rod connects the steering arms together; it may be located in front of or behind the centerline of the wheel. The tie rod is usually of a solid rod construction, but tubular designs are also used.

(4) *Tie Rod Ends.* Tie rod ends are used to form a flexible link between the tie rod and steering arm. The tie rod end usually is fastened to the knuckle arm with a tapered stud. A socket is provided within the tie rod end to hold the end of the stud, which is in the form of a ball or yoke. The socket also allows movement between the knuckle arm and tie rod. A lubrication fitting is usually provided to keep the ball and socket joint properly lubricated. A dust seal covers the tie rod end to prevent dust from entering the joint and to prevent the loss of lubricant. In the solid axle configuration, the tie rod end is screwed onto the tie rod and is secured with clamps.

(5) *Adjusting Sleeves.* The inner and outer tie rods are connected by adjusting sleeves. These are tubular in design and threaded over the inner and outer tie rods. The adjusting sleeves provide a location for toe adjustment. Clamps and clamp bolts are used to secure the sleeves. Some manufacturers require the clamps to be placed in a certain position in relation to the tie rod top or front surface to prevent interference with other parts.

4. Conclusion

In the preceding paragraphs, the components that comprise the service brakes, parking brakes, and the steering system(s) on the HMMWV were discussed, together with the operation of these systems.

In the next lesson, the characteristics and operation of the electrical system found on the HMMWV will be discussed.

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PRACTICAL EXERCISE 3

1. Requirement

Using your knowledge of the HMMWV brake/steering system and this subcourse text, answer the questions that are listed below.

- a. What is the brake fluid capacity of the master cylinder used on the HMMWV?
- b. What type of brake fluid is used in the HMMWV brake system?
- c. Describe the brake lines used in the HMMWV brake system.
- d. Describe the HMMWV steering system.
- e. The power steering system on the HMMWV has a hydraulic fluid capacity of what?
- f. What type of hydraulic fluid is used in the HMMWV power steering system?
- g. What type of steering linkage is used in the HMMWV?

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LESSON 3. PRACTICAL EXERCISE - ANSWERS

1. Requirement
 - a. The master cylinder on the HMMWV has a fluid capacity of .69 pints.
 - b. The brake system on the HMMWV uses silicone brake fluid (BFS).
 - c. The brake lines on the HMMWV are 3/16th of an inch seamless steel tubing with flared fittings. Flexible hoses connect the brake lines to the wheel calipers.
 - d. The steering system on the HMMWV is a hydraulically assisted power steering system comprised of the following components; steering wheel, steering gear, power steering pump, hydro-boost, lines, steering column, steering linkage, tie rod, center link, idler arm, and pitman arm. The turning effort at the steering wheel is transmitted to the steering gear where it is hydraulically multiplied and transferred to the front wheels through the steering linkage.
 - e. The steering system on the HMMWV has a fluid capacity of one quart.
 - f. The steering system on the HMMWV uses Dexron II hydraulic fluid.
 - g. The steering linkage on the HMMWV is of the parallelogram type.

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LESSON 4

THE CHARACTERISTICS AND OPERATION OF THE ELECTRICAL SYSTEM

TASK 1. Describe the characteristics and operation of the electrical system.

CONDITIONS

Within a self-study environment and given the subcourse text, without assistance.

STANDARDS

Within one hour

REFERENCES

No supplementary references are needed for this task.

1. Introduction

In the previous lessons and tasks, we have discussed the characteristics of the high mobility multi-purpose wheeled vehicle (HMMWV). We also discussed the characteristics and operation of the 6.2 liter diesel engine, drive train, suspension system, and the brake steering system.

The electrical system on any vehicle serves an indispensable purpose. Without the electrical system, most vehicles could not be started, it would be impossible to operate the vehicle at night since there would be no external or internal lighting; additionally, there would be no way for the operator to monitor vehicle operation such as speed, engine coolant, oil and a multitude of other items that must be constantly checked to ensure correct vehicle operation. In this lesson, the characteristics and operation of the HMMWV electrical system will be discussed.

2. Electrical System

The HMMWV electrical system is a 24 volt system capable of submerged operation during fresh or saltwater fording. It provides for starting the vehicle, charging the batteries, and operating the controls, gages, and accessory items peculiar to this vehicle.

In the paragraphs that follow, the components that comprise the electrical system on the HMMWV will be discussed. The electrical system on the HMMWV consists of 15 components as follows: batteries, alternator, starter, wiring harness, protective control box, circuit breakers, instruments, gages, indicators, lights, horn, windshield wiper/washer, heater/defroster, slave receptacle, and trailer receptacle.

a. *Batteries.* Two 12 volt batteries are connected in series to supply the 24 volt current required to start and operate the engine and lights. The batteries are mounted in an enclosed compartment under the right front crew seat. They are secured by a holddown clamp. The batteries are joined by a negative to positive jumper cable. The remaining negative terminal is connected to the vehicle ground, while the other positive terminal is connected to the vehicle starter. The batteries supply the necessary power to the starter through the circuit designated SA in TM 9-2320-280-20. This circuit connects the batteries and the starter, however, it is also connected to the power control box (PCB), which will be discussed later in this text.

b. *Alternator.* Most military vehicles are now equipped with an alternating current (ac) charging system. The reason for changing to the ac system is that an alternator is capable of producing a higher voltage at idle speed. Alternators convert mechanical energy to electrical energy to power the vehicle.

Many military vehicles are equipped with radios, firing devices, and other high-current-drawing equipment. When this equipment is in operation and the vehicle's engine is operating at a low rpm, a dc generator will not produce the current and voltage required to keep the batteries charged, plus supply the current required to operate the accessories properly.

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The alternator is composed of the same basic parts as a direct current (dc) generator. There is a field that is called a rotor and a generating part known as the stator. The purpose of the alternator is to produce more power and operate over a wider speed range than that of a generator. Because of this, the construction of the functional parts is different. The stator is the section in which the current is induced. It is made of a slotted laminated ring with the conductors placed in the slots. The current generated in the windings is transferred to the rest of the system through three stationary terminals.

One of three different amperage rated alternators can be found on the HMMWV. One is the 60 amp alternator, which is similar to the alternator used on the M151. It is mounted on the left side of the engine and is driven by dual drive belts from the crankshaft pulley. A slotted bracket allows for belt tension adjustments. The other two alternators are the 100 amp alternator, found predominantly on the shelter carriers (M998 and M1037), and the 200 amp alternator which is used mainly on the ambulance (M996 and M997).

c. *Starter.* Any internal combustion engine must be cranked to start it running on its own. Early automotive vehicles were started manually through the use of a handcrank. A system for cranking the engine with an electric motor was developed as automotive technology progressed. The modern electric starting system has reduced the task of starting an internal combustion engine to the turn of a key or the pushing of a button.

The starter may drive the engine through a pinion, or by a dog clutch attached to the starter armature shaft. The shaft is brought together with the teeth cut on the rim of the flywheel or with the mating half of the dog clutch. The drive must be equipped with an overrunning clutch or some other means of quick disengagement. Owing to limitations of size and capacity of the battery, a high-speed starter with a high gear reduction is used to obtain the necessary torque. The great speed reduction required is effected in the majority of cases by utilizing the flywheel as a driven gear. In some instances, the gear is bolted or shrunk on the flywheel, while in others the gear teeth are

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cut directly in the rim of the flywheel itself. The starter is mounted on the flywheel housing.

The starter used on the HMMWV is a 24 volt unit activated by the RUN/START switch through a solenoid mounted on the starter motor housing. The switch is placed to the RUN position and the WAIT TO START lamp illuminates. A relay in the protective control box (PCB) energizes the glow plugs and after approximately six seconds, the WAIT TO START lamp will extinguish. The vehicle may now be started by positioning the switch to the START position. The starter will engage the crank and the engine. Releasing the switch allows it to return to the RUN position. In other words, the switch is spring-loaded to the RUN position. An ac output from the alternator to the PCB prevents the starter from reengaging once the engine is running. A neutral (safety) switch mounted in the transmission quadrant prevents the vehicle from being started in any gear other than neutral (N).

d. *Wiring Design.* The vehicle wiring design uses a harness type construction and a modular approach that separates the harness into four major subassemblies. These subassemblies are engine, body, simplified test equipment/internal combustion engine (STE/ICB), and hood. These harnesses have multi-circuit disconnects for removal of the major assemblies for maintenance.

e. *Protective Control Box (PCB).* The PCB used on the HMMWV is similar to the control boxes used on other military vehicles, with an added provision for the glow plugs. The functions of the PCB are to energize the glow plugs, prevent battery polarity reversals, energize the starter solenoid, and prevent reengagement while the engine is running. The PCB is mounted behind the instrument panel in the driver's compartment and is serviced only as an assembly.

f. *Circuit Breakers.* Two standard military circuit breakers provide overload protection on the HMMWV. These are of the thermal, cycling, automatic reset type. Circuits critical to vehicle operation are not run through circuit breakers. These are the starter, alternator, and radio power. The circuit breakers are located on a panel below the dashboard on the driver's side of the vehicle.

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g. *Driver's Compartment.* The driver's compartment contains vehicle control indicators, and a removable instrument cluster. The cluster contains gages that monitor the engine temperature, oil pressure, fuel level, vehicle speed/mileage, and battery voltage through sending units, except the speedometer and voltmeter. Also on the removable cluster is the hi-beam indicator. The WAIT TO START and BRAKE indicators are located to the left of the steering wheel on the dash.

h. *Brake Indicator.* The BRAKE indicator illuminates when a system hydraulic failure occurs or when the parking brake is engaged. A parallel circuit is formed through the parking brake switch and the proportioning valve switches if either or both switches are closed.

i. *Vehicle Lighting System.* The history of motor vehicle lighting parallels the history of the lighting of houses and other buildings, with oil and gas lamps having been used in the early motor vehicles. With the development of a satisfactory electrical system, electric lighting has become the standard means of lighting motor vehicles.

The lighting system on the HMMWV is a standard military system in which a main switch controls the service headlights, blackout lights, directional signals and the panel lights. When the panel is illuminated, a lamp in the transmission quadrant illuminates the shift lever position indicator. The directional signal switch is also a standard military unit. A solid state flasher, located under the dash next to the circuit breakers, pulses the directional lamps and provides a hazard flashing feature.

j. *Electric Horn.* A single electric horn is mounted under the hood, forward facing, near the front of the vehicle. It is a standard military 24 volt horn, activated by a horn button in the hub of the steering wheel.

k. *Windshield Wiper.* The HMMWV includes a windshield wiper/washer system to maintain a clear field of vision through the windshield. This system consists of a two-speed electric motor, two wiper blades, blade linkage, washer reservoir, two washer jets, connecting hoses, and a motor. The motor is located inside the vehicle at the top of the windshield; it drives the blade linkage inside

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the windshield header. Dual ten inch blades are actuated by the linkage and pivot from the top of the windshield frame. The blades operate in unison and return to a "park" position at the right side of the "wipe pattern" when the wiper switch is turned off. Windshield washing is accomplished through two jets on the cowl below the windshield. The fluid is contained in a reservoir located in the engine compartment. Always use an approved washing solution or water; NEVER use engine anti-freeze.

1. *Heater, Defroster, and Ventilation Mechanisms.* The heater, defroster, and ventilation mechanisms are usually contained in a single unit to make up a complete system. The unit, which is called a heater unit, consists of a chambered box containing a heater core and control doors which allow the operator to select the desired mode of operation. The outside of the box contains openings for outside air intake, so that fresh air can be recirculated, and an interior air intake, so that inside air can be recirculated. The box also has defroster outlets, so that forced air can be provided to clear the windshield; heater outlets, so that heated air can be provided, usually at floor level; and ventilation outlets, so that air can be forced into the passenger compartment at instrument panel level. An electric blower motor is also combined with this unit to provide air movement.

(1) *Heater Core.* The main component of the HMMWV's heater system is the heater core. The heater core is the component that transfers heat from the engine coolant to the passenger compartment. Its construction is similar to that of a radiator, except that it is on a much smaller scale. The heater core fits into the heater unit and is connected to the engine's cooling system by two hoses called heater hoses. The connection to the engine's coolant passages is made at strategic points that will cause the engine's water pump to force a constant supply of engine-heated coolant through the heater core. The heater core feed line is fitted with a control valve that can be controlled by the operator. The purpose of the valve is to open, restrict, or shut off the coolant flow through the heater core to control the heater temperature. The temperature control valve can be either cable operated, or it can be operated by a

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vacuum-actuated diaphragm that receives its vacuum supply from the engine.

(2) *Heater Control Knobs and Valves.* The heater core on the HMMWV has a mechanically actuated, mechanically controlled butterfly valve that is opened, adjusted, and closed by the operator pulling a control knob. This control knob is connected to one end of a cable; the other end is connected to the butterfly valve. When the operator pulls the knob, the cable pulls the valve actuating lever, opening the valve. There is also a cable operated flapper valve that allows the operator to direct the air to either the windshield vents or to the cab outlet.

(3) *Blower Motor.* The blower motor is a simple electric motor that drives a circular fan, commonly referred to as a squirrel cage. The blower motor on the HMMWV is controlled by a three-position switch which allows the operator to select the fan speed. The fan speed selections are OFF-LOW-HI. The switch, in conjunction with a multiple element resistor, provides the circuitry to make these motor selections possible.

m. *Trailer Receptacle.* The HMMWV trailer receptacle, mounted on the rear of the vehicle body, is protected by a spring-loaded door and is compatible with all standard military trailer wiring circuits.

n. *Slave Receptacle.* A slave receptacle, located on the front side of the battery box, provides for inter-vehicle cable-starting. The slave receptacle is compatible with all NATO vehicles.

o. *Glow Plugs.* Diesel engines of the prechamber design, like the HMMWV, require a preheating glow plug extending into the prechamber to aid in starting when cold. The plugs are located in the cylinder head, below each injector nozzle. When the RUN/START switch is placed in the RUN position, the glow plugs are energized and air in the prechamber is heated to approximately 1400° F. In 0° F weather, the glow plugs will preheat the prechamber in six seconds; the engine will then be easier to start.

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The glow plugs in the HMMWV are controlled by a fast start control system. The controller, located in the coolant outlet manifold, is a thermal model of the glow plugs and turns the glow plugs on and off by monitoring engine coolant temperature.

3. Conclusion

In the lessons and tasks contained in this subcourse, the characteristics and operation of the systems that comprise the HMMWV were discussed. From these lessons and tasks, we see how all of these systems fit together to produce a working automotive vehicle. If one or more of these systems is disabled or removed from the vehicle, it becomes virtually useless because there would be no way of starting and operating the vehicle, or of supplying the power to propel, steer, and stop the vehicle.

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PRACTICAL EXERCISE 4

1. Instructions

Using your knowledge of the high mobility multi-purpose wheeled vehicle (HMMWV) and this subcourse text, answer the questions that follow.

- a. What type of electrical system is used on the HMMWV?
- b. What prevents the starter from reengaging after engine has been started?
- c. Where is the protective control box mounted?
- d. What type of motor is used in the HMMWV windshield wiper system?
- e. Where are the glow plugs located?

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LESSON 4. PRACTICAL EXERCISE - ANSWERS

1. Requirement
 - a. The HMMWV uses a 24 volt electrical system.
 - b. An alternating current (ac) output from the alternator to the protective control box prevents the starter from reengaging.
 - c. The protective control box is mounted behind the instrument panel in the driver's compartment.
 - d. The windshield wiper system on the HMMWV uses a two-speed electric motor.
 - e. The glow plugs are located in the cylinder head, below each injector nozzle.

REFERENCES

INTRODUCTION TO THE HMMWV - OD1615 - REFERENCE

REFERENCES

The following documents were used as resource materials in developing this subcourse:

TM 9-2320-280-10

TM 9-2320-280-20

TM 9-2815-237-34

TM 9-8000