Chapter 1
Engine

Notes

Chapter 1 Engine

NOTICE
Information provided in this chapter is compiled from manufacturer manuals provided with your chassis. This information is intended to serve as a quick reference and provide guidelines in performing daily maintenance and troubleshooting of problems which may arise with engine related components and systems on you motor home. When using this information, and before performing any services on the Caterpillar 3116 engine, it is your responsibility as owner or maintenance personnel to be thoroughly familiar with procedures described in the engine manufacturers' manual.

Refer to the manufacturers' manual for procedures required to perform component testing, disassembly or assembly not included in the information provided in this manual.

Engine Description

Your motor home is equipped with a Caterpillar 3116 diesel engine. The 3116 is available in 215 hp and 250 hp models. Except for the horsepower difference, both engines are functionally the same.

The 3116 is a four cycle, in-line 6 cylinder engine with direct injection. It has 6.6 liter (403 cu. in.) displacement, with 105 mm (4.13 in.) bore and 127 mm (5.0 in.) stroke. The horsepower rating (215/250) is 2600 rpm, with turbocharger and air-to-air aftercooler installed. Information plates providing more detailed specifications pertaining to the engine of your motor home are found in three locations on the engine. See Figure 1.1.

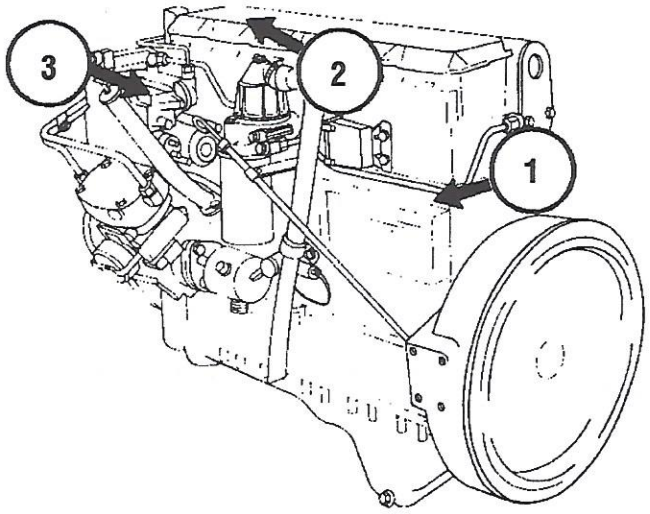

Figure 1.1. Information Plate Locations

The engine has a mechanical governor and high pressure unit injection fuel system which provide good engine response and fuel economy.

The cooling system has a belt driven centrifugal pump, a thermostat which regulates the engine coolant temperature and an oil cooler and radiator incorporating a shunt system.

The lubrication system consists of a gear-type oil pump and bypass valves which provide unrestricted oil flow to the engine parts when oil viscosity is high, or if either the oil cooler or the oil filter elements become clogged.

ENGINE FUEL SYSTEM

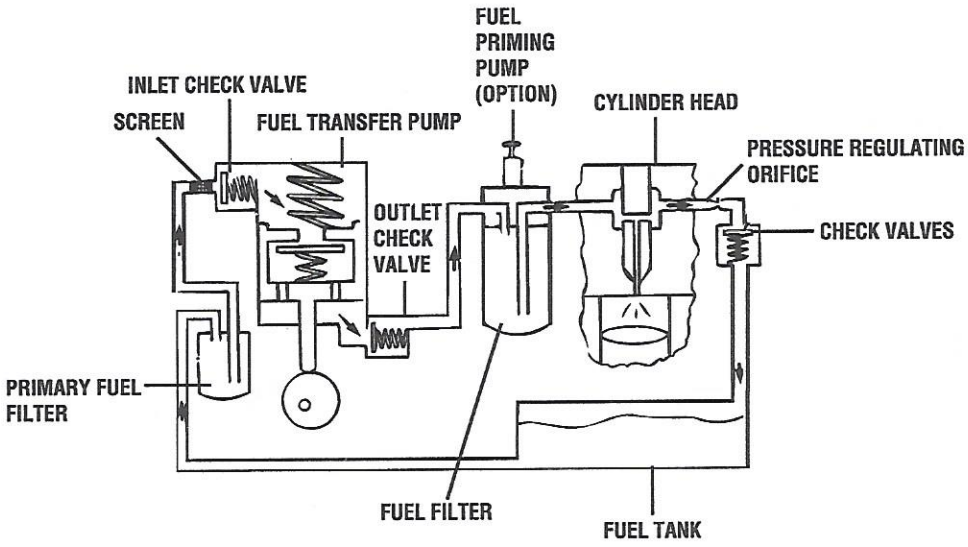

Figure 1.2. Fuel System

CAUTION
Do not use starting fluids in your engine. Such aids can cause immediate engine damage.

The Caterpillar 3116 engine uses a fuel injection system to control the fuel-air mixture. Fuel is injected into a small chamber at the top of each cylinder where it is mixed with the already compressed air in the cylinder. Ignition then follows and the power of the explosion is converted into mechanical energy. Engine speed is controlled by varying the amount of fuel injected into the system.

The fuel system includes the tank, pump, filter, fuel-water separator, and the feed and return lines. The fuel pump provides pressure to move fuel when operating in very cold temperatures.

A fuel priming pump (optional) may be installed on the 3116 engine. If your engine includes this option, refer to the Caterpillar Service Manual for regarding maintenance and operation of the priming pump.

Fuel Tank

WARNING
Diesel fuel is flammable, especially the vapors present in an empty tank. Use extreme caution when draining or removing a fuel tank to avoid fire or other injury.

The fuel tank is mounted to the frame behind the front axle. The tank includes the filler cap and neck, and fuel gauge sending unit, which has a resistance range of 0 to 240 ohms. The tank for Caterpillar 3116 has a capacity of 99 gallons. The fuel tank and mounting are illustrated in the Parts section of this Manual.

Fuel Filter

CAUTION
Diesel fuel oil can permanently damage electrical insulation. The wiring harness and other electrical equipment must be shielded during the filter change.

Caterpillar recommends the use of a primary fuel filter with a rating only fine enough to protect the fuel transfer pump. Using a filter which is too fine will result in the filter being plugged by wax in cold weather.
The fuel filter element is replaced by removing the screw-off case, discarding the old element, installing a new element and then replacing the case. DO NOT fill the new element with clean fuel prior to installation, use the fuel primer pump to fill the system. Use caution to avoid fuel spillage.

Fuel Specifications

Diesel fuel is available in No. 1 or No. 2 grades. Your engine is designed to operate on No. 2 grade. No. 2 grade fuel should not be used in colder temperatures because of low-temperature fuel clouding, which thickens the fuel and restricts flow through the hoses, pipes and injectors. No. 1 fuel should be used when operating in very cold temperatures.

NOTICE
Do not fill the fuel tank to the top. Fuel expands as it gets warm and may overflow.

To ensure that the fuel used in your engine meets all requirements, refer to Fuel Specifications in your Caterpillar Operation and Maintenance Manual.

Algae/Bacterial Contamination

Algae/bacterial formation is a danger to the fuel system of a diesel engine. These growths must have water to survive. They multiply rapidly and quickly clog the fuel filters and injector nozzles, stopping fuel flow to the cylinders. To prevent moisture condensation, keep your fuel tank full, especially if the coach will be parked for an extended time. It is also advisable to purchase your fuel from reputable dealers where there is a regular turnover and fuel does not stand for long periods.

Storage fuel tanks should be drained of water and sediment weekly, and/or before refilling. This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If algae/bacterial growth is discovered in the fuel system, commercial products to correct and prevent the problem are available from diesel fuel vendors. The product "Bio-Bar®" is suitable for use to correct this problem. Follow instructions provided on the container.

Governor

The governor adjusts the amount of fuel delivered to the combustion chamber, causing the engine to stabilize at the speed corresponding to the throttle position.

The only adjustment ("On-Engine") to the governor is the low idle setting. All other governor adjustments are performed with the unit removed from the engine. The low idle screw is initially set by the manufacturer. If the low idle setting is not satisfactory refer to Caterpillar Operation and Service Manual for tools required and correct setting specifications.

AIR INLET AND EXHAUST SYSTEM

1. Inlet Manifold
2. Magnetic Switch
3. Inlet Air Heater
4. Inlet (to inlet manifold)
5. Turbocharger Outlet (to after cooler)
6. Turbocharger Inlet (from air fil ter)
7. Turbocharger
8. Turbocharger Outlet (to exhaust)
9. Exhaust Manifold

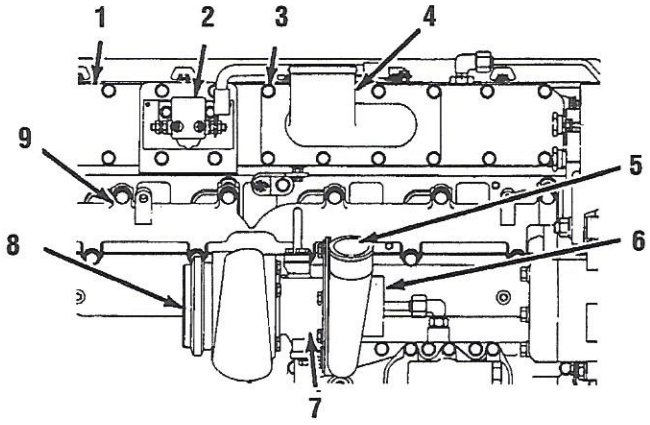

Figure 1.3. Air System Components

The air inlet and exhaust system components control the quality and amount of air available for combustion. These components are the air filter, turbocharger, aftercooler, cylinder head, valves and valve system components, pistons and cylinders, inlet air heater, inlet manifold, and the exhaust manifold (Figure 1.3).

Engine Exhaust

In addition to the components listed in the Air Inlet and Exhaust System section above, the engine exhaust system also includes the muffler, exhaust pipe, and tail pipe. Exhaust gases are routed through the turbocharger to the muffler, are baffled by the muffler and then released into the air through the tail pipe. The muffler is mounted in vibration dampening mounts and muffles the sound of the engine's operation.

If the muffler requires replacement, remove the bolts on the hanger brackets, loosen the clamp which attaches the muffler to the exhaust pipe and drop the disengaged muffler down and away from the vehicle. The tail pipe may then be removed. The new muffler (or other piping) is installed by reversing this procedure.

Air-To-Air Aftercooler

The air inlet and exhaust system incorporates an air-to-air aftercooler. Cooling of the inlet air increases combustion efficiency, which leads to lower fuel consumption and increased horsepower output. To improve the combustion process and performance, a separate air cooler core is installed in front of the engine radiator core. Ambient temperature air is moved across both cores by the engine fan and by the ram effect of the vehicles forward motion. This cools the turbocharger inlet air and the engine coolant.

The air-to-air aftercooling system is designed for reliablility and is easy to maintain. The primary concern with the aftercooler is the integrity of the air piping system. There must not be any leaks or the pressurization caused by the turbocharger will be lost, causing a very noticeable loss of power. A second hazard is the introduction of dirt into the engine, which will cause premature engine failure. In fact, whenever significant reduction in power or performance is experienced, the first item to be checked should be the piping of the aftercooler system.

Air-To-Air Aftercooler Maintenance

Regular maintenance and inspection procedures for the aftercooler system must be developed to include a thorough inspection of the entire air intake system. Injection of pressurized air into the cylinders is the essence of the generation of higher power and torques from the engine. This process also maintains adherence to emission standards. Check the piping, clamps and hoses in the system to ensure air tightness. Because rubber hoses are subject to deterioration over time, the regular check should identify worn hoses so that replacement can be made prior to failure.

The front of the air-to-air aftercooler should be checked regularly for insects and debris. When needed, clean the front of the aftercooler with a stainless steel brush and soapy water.

Radiator Shutters

Caterpillar strongly recommends against the installation of radiator shutters or "winter fronts" on the cooling system of the engine. If extremely cold climates demand the use of one of these options contact a Caterpillar dealer for further technical guidance on the installation so that you are assured of an installation which will not damage the engine or degrade its performance.

Turbocharger

The turbocharger is mounted to the exhaust manifold of the engine (Figure 1.1). Exhaust gases go into the exhaust inlet of the turbocharger and into the exhaust inlet of the turbine housing. The gases push the blades of the turbine wheel, causing the turbine wheel and compressor wheel to turn.

Air from the air cleaner is pulled through the compressor housing air inlet and is compressed and heated. The hot compressed air from the turbocharger is then cooled by the air-to-air aftercooler before going to the inlet manifold of the engine. This compression of air gives the engine more power by making it possible for the engine to burn additional fuel with greater efficiency.

Inlet Air Heater

The 3116 engine is equipped with an electric air heater mounted in the air inlet casting. The air heater aids in starting the engine, especially in cold weather, by warming air for combustion. The heater also helps eliminate excessive engine smoking during startup.

The inlet air heater is designed to provide heat for 30 seconds prior to start-up and during cranking and for seven minutes after the engine has started.

If the inlet air heater system malfunctions, the engine will continue to start and run but may emit more white smoke than previously noticed and may require the use of an alternative starting aid.

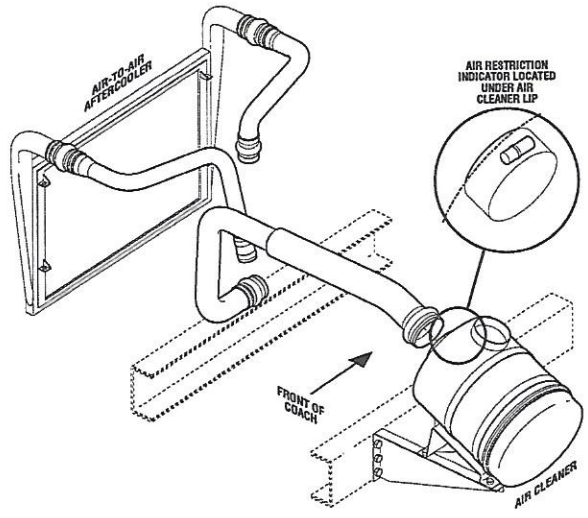

Figure 1.4. Air Intake System and Air Restriction Indicator

Air Filter

The air filter draws fresh air from the right side of the motor home. The filter is equipped with an air restriction indicator, mounted to the air cleaner, which is visible when the engine compartment door is open (Figure 1.4). This indicator should be checked each day during the preoperation inspection while the engine is running at FAST IDLE. If the window in the indicator is red (the normal color is green) the air filter element requires replacement. To replace the element follow steps 1 through 6.

NOTICE (3)
Do not attempt to blow dust off of the filter to wash it for reuse. Engine warranty will not cover "a dusted engine".

1. Loosen the mounting clamp using the thumbscrew.
2. Remove the right end cover from the air cleaner assembly.
3. Remove the old filter.
4. Clean the inside of the filter body and inspect all seals, clamps and hoses for serviceability. Replace worn or damaged seals, clamps, or hoses and tighten any loose clamps.
5. Insert the new element into the body, replace the end cover and tighten the clamp to secure the cover to the filter body.
6. Reset the air restriction indicator by depressing the rubber button on the top of the indicator. Verify that the color in the window of the indicator is green again.

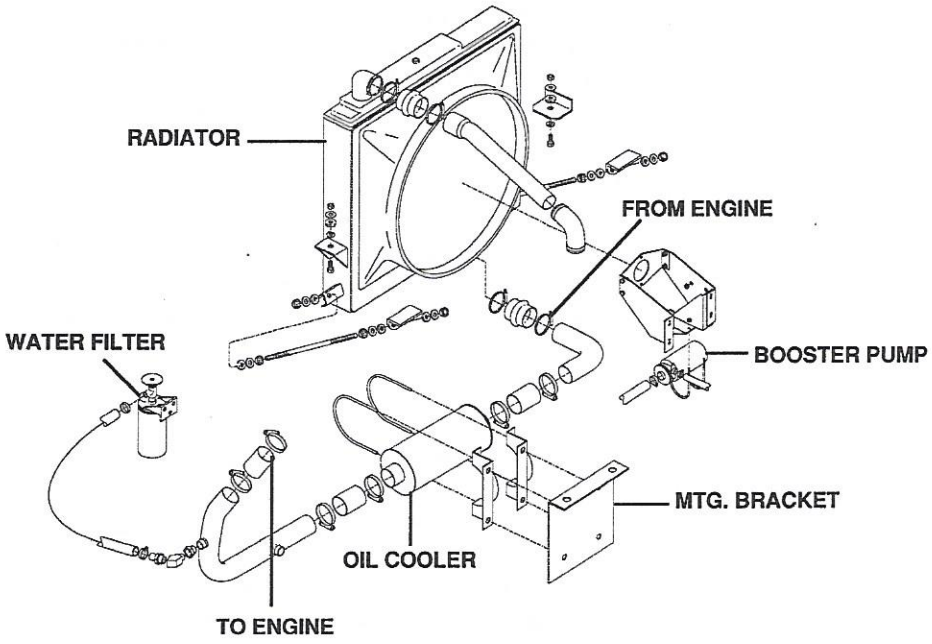

Figure 1.5. Engine Cooling System 01-104-00

COOLING SYSTEM

The Caterpillar 3116 engine has a pressure type liquid cooling system (Figure 1.7) with a shunt line which gives the system two advantages; it allows the system to operate safely at a temperature higher than the normal boiling (steam) point of water and prevents cavitation in the water pump. Components of the cooling system include the water pump, thermostat (water temperature regulator), radiator, hydraulic fan, surge tank, water filter, shunt line and hoses. Maintenance of the hydraulic fan is provided in Chapter 6 - Hydraulic System.

The water pump is mounted on the right side of the cylinder block and is belt driven from the crankshaft pulley. The pump circulates coolant through passages in the engine cylinder block and heads where it (coolant) absorbs heat. The hot coolant flows out of the engine through a pipe to the radiator. In the radiator the coolant loses heat to the outside air circulating around the radiator core tubes. Cooled coolant then flows out of the radiator through a pipe and back to the engine.

NOTICE
The thermostat is a very important part of the cooling system and must be installed for the system to function properly. Without the thermostat coolant will not be distributed properly through the system and the engine will overheat.

The shunt line runs from the top of the water pump to the surge tank, providing a constant flow of coolant to the water pump to keep the pump from cavitation.

The thermostat is positioned on the front left side of the cylinder head and controls the circulation of the coolant flow between the radiator and the bypass by opening and closing at predetermined temperatures.

The engine thermostat is often the first item that is suspected and replaced when engine overheating is encountered. The thermostat is designed to keep the engine operating temperature above the thermostats minimum rated temperature and has no way to control a higher temperature. If an engine is overheating, replacing a thermostat rated at 180°F with one rated at 165°F, for instance, will not reduce the maximum operating temperature by 15°F. If an engine is overheating, it is operating above both 165°F and 180°F and the problem is with another component in the cooling system.

Cooling System Maintenance

Increased engine temperature is generally due to regular inspections of the cooling system not being performed. To prevent serious engine cooling system problems, it is advised that visual inspections of the cooling system be performed on a scheduled basis. Recommendations for maintenance are provided in the Maintenance Schedule section in the Introduction of this manual.

Cooling System Inspection

Hoses

Periodic checks of the cooling system should include checking hose clamps regularly and tightening any that are loose. Inspect the hoses and pipes for cuts or abrasions. If the hoses have become hard and brittle or show signs of cracking as a result of engine heat, they should be replaced. Hoses should also be replaced if soft or spongy due to exposure to oil or grease, or if flaking of the interior lining is evident since this debris can clog the cooling system or reduce it's efficiency.

Coolant Checks

WARNING
To avoid burns, do not open the surge tank cap while the engine and radiator are still hot. Scalding fluid and steam can be blow out under pressure if the cap is opened before the system has cooled sufficiently.

Coolant level and appearance should be checked daily. Additionally, the coolant should be drained at the intervals recommended in the Maintenance Schedule, or sooner if dirty. It is recommended that the system be flushed and the coolant changed at least every two years. The radiator of your motor home was filled with a mixture of at least 30% - 60% ethylene glycol and water prior to leaving the factory. This concentration of water and ethylene glycol will protect the engine from freezing down to temperatures of –34°F and from boil over up to 243°F.

CAUTION
Ethylene glycol concentrations exceeding 60% may cause damage to the radiator and hoses.

Regardless of whether freezing temperatures are expected or not, cooling system protection should be maintained to at least –34°F to provide adequate corrosion protection and loss of coolant from boiling.

NOTICE
Alcohol, methanol-based antifreeze, or plain water will not provide proper corrosion protection and are not recommended for your engine at any time. Use only additives or conditioners recommended by Caterpillar.

If the surge tank on your vehicle has a sight glass installed, coolant level can be checked using the following method:

1. Let the engine cool down from operating temperature.
2. Manually release excess pressure from inside the tank by pressing the pressure relief plunger on the top of the tank.
3. Carefully lift the hatch on the cap only enough to disengage the seal so that any remaining pressure/steam will be released around the edges.
4. Carefully open the bleed screw on the radiator top pipe.
5. With the engine running at normal operating temperature, open the surge tank cap completely and refill until coolant just begins to flow from the opening in the bleed screw. Re-tighten the bleed screw.
6. Continue to add coolant until the level tops the sight glass. Close and latch the sealer cap.

Radiator Checks

The radiator should be checked during daily inspection for leaks and bent fins. Be sure that air flow through the radiator is not restricted. The filler cap and the surface that seals the cap should be clean and should provide an air tight seal when tightened.

Fan and Drive Belts

Periodically inspect the fan and drive belts for cracks, breaks or other damage. Drive belts should be replaced if any damage is found.

Flushing The Cooling System

The cooling system should be cleaned if contaminated, if the engine overheats, if foaming is observed in the radiator, after 3000 service hours or every 2 years. If not using Caterpillar Antifreeze and the supplemental coolant additive as recommended in the manufacturers "Operations and Maintenance" manual, the system should be cleaned after 1500 service hours or once a year.

Various methods and equipment may be used to flush the cooling system. If special equipment is used, such as a back flusher, the equipment manufacturer's instructions should be followed. It is advisable to remove the thermostat before flushing the system.

NOTICE
To prevent the buildup of insoluble chemical compounds in the cooling system, it is recommended that only distilled water or deionized water be used.

LUBRICATION SYSTEM

The oil pan is mounted at the bottom of the engine and acts as a reservoir, holding the oil until it is circulated to lubricate the engine. The oil pump is positioned at the bottom of the cylinder block inside the oil pan and pulls oil from the pan and forces the oil into the oil cooler. The oil then flows through the oil filter to the turbocharger oil supply line and into the main oil gallery in the crankcase where it is distributed to all components of the engine. After being pumped to the critical engine components, the oil drains back into the crankcase and then into the oil pan.

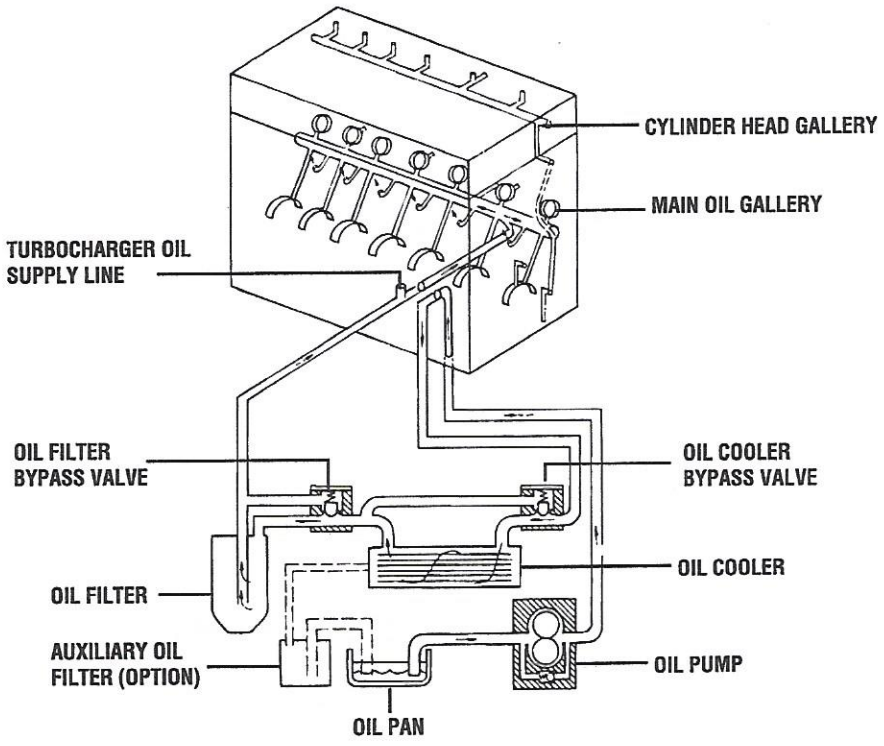

Figure 1.8. Lubrication System

A bypass valve, mounted in the oil pan, controls the flow pressure of the oil as it is pumped from the pan to the engine systems.

A crankcase breather is installed above the oil filter to allow blow-by gases from the cylinders to escape from the crankcase and prevent pressure from building up that could cause the leakage of oil from seals and gaskets.

Oils

Engine oils are labeled on the containers with various American Petroleum Institute (API) designations of quality. Caterpillar requires the use of Cat Engine Oil (EO) or an oil with the API designation of "CE", "CE/SF", or "CE/SG" for the 3116 engine.

Viscosity

Engine oil viscosity (resistance to flow) affects fuel economy. Lower viscosity engine oils can provide better fuel economy; however, higher temperature conditions require high viscosity engine oils for satisfactory lubrication. **Using any oils with a viscosity other than those recommended could cause engine damage.** When choosing an oil, consider the range of temperature your vehicle will be operated in before the next oil change.

Information currently available on synthetic oils does **not** justify any additional lengthening of the oil change interval. Any engine part failures caused by using an oil beyond the recommended change intervals **will not** be covered under the chassis warranty.

Lubrication System Maintenance

To provide proper lubrication for the engine and to help prevent engine damage, the oil level should be checked daily to insure that there is an adequate supply of oil. The engine oil must be drained and replaced with fresh oil and the filter replaced at the intervals recommended in the Maintenance Schedule in Appendix D.

Checking The Oil Level

The oil level should be checked daily while the engine is shut down. **Do not** check the oil level with the engine running; you will not obtain an accurate oil level reading. The oil level should be maintained between the ADD and the FULL RANGE marks on the dipstick.

WARM - The best time to check the engine oil level is when the oil is warm , such as during a fuel stop. Allow a minimum of ten minutes for the oil to drain back to the oil pan.

COLD - If you check the oil level when the oil is cold, do not run the engine first. The cold oil will not drain back to the oil pan fast enough to give a true oil level. Use the following method to check the engine oil when cold.

1. Pull the dipstick out slightly from the tube at the end of the day's driving so that the tube is not sealed by the cap at the top of the dipstick.

2. Leave the dipstick in this position overnight.

3. Before starting the engine again the following day, seat the dipstick and check the oil level.

This method allows the oil to drain down easily to provide an accurate reading.

Changing The Oil

Oil can be drained from the engine through the drain hole in the bottom of the oil pan. Replacement oil is added through the tube at the top rear of the engine. The recommended oil change interval is every 250 service hours, every 6,000 miles or every 6 months, whichever occurs first. More frequent intervals are recommended if any of the following severe operating conditions are encountered:

- Frequent long runs at high speeds and high ambient temperatures.
- Operation in dusty areas.
- Towing a trailer, boat or car.
- Idling or low speed operation for extended periods.
- Operating when outside temperatures remain below freezing and when most trips are less than four miles.

Changing The Oil Filter

The oil filter is the spin-on type which can be removed using a band filter-wrench. The replacement filter should be installed following the manufacturer's instructions.

Calibrating The Engine Oil Dipstick

It is recommended that the calibration of the dipstick be verified at the time of the first oil change to prevent filling the engine to an incorrect level. The crankcase capacity is 21 quarts (20 liters), which includes only the crankcase and not any of the auxiliary filters, cooler, or accessory plumbing. Overfilling results in burning of the excess oil, which is wasteful, while under-filling can result in oil starvation with possible subsequent damage to the engine.

To verify proper calibration of the dipstick the crankcase should be drained and the oil filters removed, just as for a routine oil change. After replacing the drain plug and installing new filters, the operator should add 21 quarts (20 liters) of oil to the engine. Do not start the engine yet.

Allow at least five minutes for the new oil to drain to the oil pan. Now check the dipstick to verify that the oil level is at the "Full" mark on the dipstick. If this is not the case, calibrate the dipstick so that the oil is between the ADD and FULL RANGE marks on the dipstick by following one of the methods provided below:

1. Using a tube cutter, cut away enough of the dipstick tube to allow the dip stick to extend down far enough into the tank so that the oil, when full, comes to the "Full" mark on the dipstick.

2. Etch a mark onto the dipstick to indicate where the "Full" mark should be.

After calibration is verified or adjusted as appropriate, start and run the engine for a few minutes to check for leaks and to circulate oil thru the filters, cooler and associated plumbing. Then stop the engine and add enough oil to refill the crankcase to the proper level. The topping off should take 3 to 4 quarts of oil.

Lube-finer Oil Bypass Filter (Option)

The Lube-finer 750-CT bypass oil filter is mounted on an outrigger to the right of the engine. This filter helps keep the oil free of minute contaminants which are not normally filtered out by the primary oil filter.

The bypass filtering system requires a continuous operating pressure of 65 psi to function properly. A portion of the oil is bled from the oil pressure system, through a check valve, into the bypass filter. The filtered oil is then returned directly to the engine crankcase sump. To filter the oil effectively, the engine's oil system must be kept full. The bypass filter (Lube-finer 750-CT) requires 3-1/2 gallons of oil in addition to the quantity required to fill the crankcase.

A thermostatic control is designed into the filter pack hold down assembly (T-handle) which enables the filter pack to reach operating temperatures quickly, thus it is able to filter oil as soon as the engine is ready to begin normal operation.

To bled air from the bypass system, the cover vent plug should be loosened slightly to allow the air to escape. Retighten the vent plug before operating the engine.

The filter element should be changed at every oil change. If engine operating conditions cause a high contamination rate in the oil, the filter element should be changed more often.

The bypass filter should be checked for leaks at the O-ring seal at every oil change and the seal replaced if any leakage is found.

BLOCK HEATER

A block heater, powered by 110 volt AC current, is installed to aid in cold weather starting. A plug is included in the engine compartment to accept outside power for the heater. Plug the heater into an outside source of 110 volt AC power to run the block heater. Unplug the heater before starting the engine.

CAUTION
DO NOT attempt to operate the engine and the block heater at the same time.

ENGINE MOUNTING

The engine is mounted at the rear of the chassis in the exact opposite orientation of a conventional, front-mounted engine. The crankshaft pulley used for driving the various belts is at the rear of the chassis. The output flexplate, which drives the transmission torque converter, is on the end of the engine toward the front of the chassis.

A detailed illustration of the mounting configuration is shown in figure 1.7. Routine maintenance should include a check of the isolators to be sure that the rubber has not deteriorated, cracked or become swollen from exposure to oil. If the mounts have become unserviceable, they should be replaced. The mounting hardware should also be checked for proper torque (see Appendix A).

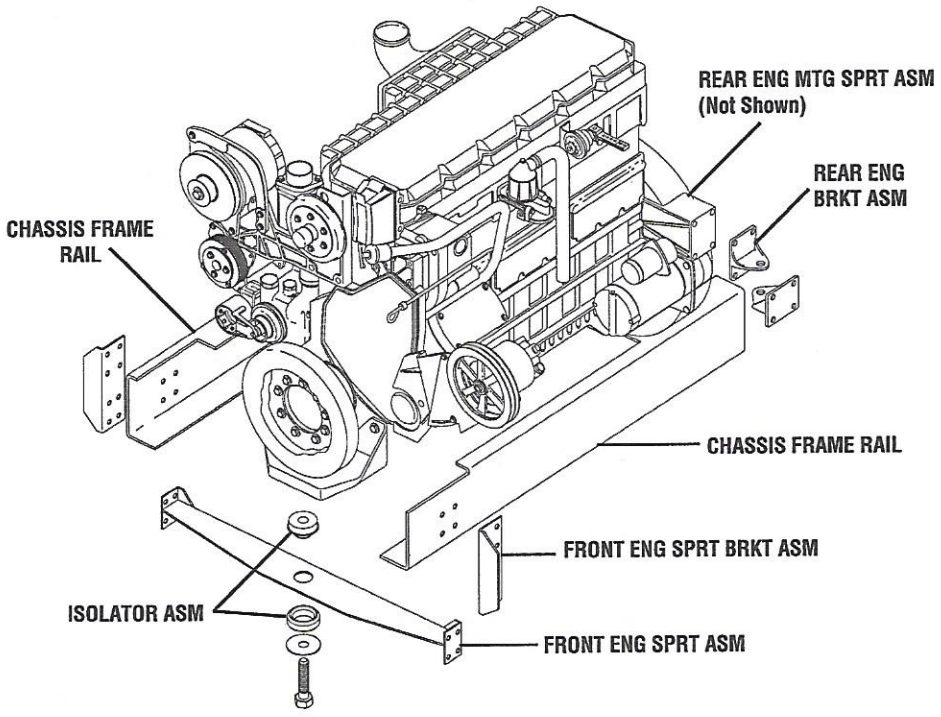

Figure 1.7. Engine Mounting

ENGINE PROTECTION MODULE (EPM)

The Gillig Corporation has designed and installed an Engine Protection Module (EPM) with an automatic engine shutdown feature to help protect your coach and your capital investment in case of undetected road damage to the engine oil pan or coolant system. In the event of low coolant level (as indicated by a probe at the bottom of the radiator tank), coolant level above upper temperature limits, or low oil pressure, the EPM will allow 20 seconds to correct the errant condition before shutting down the engine. By depressing the EPM OVERRIDE button during the 20 second interval and holding the button down, the engine will run long enough for the driver to move the coach to a safe stopping place.

In coaches without the EPM OVERRIDE button, turn the ignition to "Off", then to "On" and restart. This will provide 20 seconds of continued operation.

The EPM has an additional 7 second delay to compensate for coolant system water slosh which will affect the tripping of the sensor when cornering or stopping the vehicle. The 20 second shut down interval will begin after the 7 second delay.

CAUTION
Twenty seconds is the longest the engine should be run unless the vehicle is in eminent danger. Running longer than 20 seconds in some conditions can potentially damage the engine.

Refer to Chapter 7-Electrical, for further information regarding the EPM unit.

Notes