

DIESEL FUELS & DIESEL FUEL SYSTEMS

3600 • C175 • 3500
C32 • 3412E • 3400 • 3126B
C18 • C-16 • C-15 • C15
C13 • C-12 • C11 • C-10
C9 • C-9 • C7

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specifications will result in optimum engine performance and durability. Depending on fuel costs and availability, the proper use of alternative fuels such as crude oil, blended oil or residual oil can also provide cost competitive engine operation.

Diesel Fuel Types

Crude Oil

The term crude oil is used to describe petroleum-based oils/fuels that are not yet refined. They are essentially in the same state as when they were pumped from the earth.

Certain types of crude oils can be burned in Caterpillar Engines. In some cases, crude oil is a practical and economical fuel for diesel engines. Crude oils are evaluated individually and special equipment may be needed to condition the fuel. Minimum guidelines have been established to determine the suitability of crude oils as shown in **Appendix 2**.

Residual Oil or Blended Heavy Fuel Oil (HFO)

Residual fuel (which resembles tar and contains abrasive and corrosive substances) is composed of the remaining elements from crude oil after the crude has been refined into diesel fuel, gasoline, or lubricating oil.

After the more desirable products have been refined, residual fuel can be combined or diluted with a lighter fuel to produce a mixture that can flow. This mixture is called blended or heavy fuel. Heavy fuels tend to

create more combustion chamber deposit formations which can cause increased cylinder and ring wear.

Blending may improve fuel density; however, adding alcohol (ethanol, methanol) or gasoline causes an explosive atmosphere in the tank and is not recommended.

Caterpillar 3600 diesel engines, in general EPG applications only, can be modified to run on blended fuels, but extreme PREVENTIVE MEASURES MUST BE TAKEN, including following a thorough maintenance program and use of high quality fuel treatment equipment. For any other applications including marine, petroleum, industrial, etc. that require the burning of blended fuels, MAK Engines should be considered.

Blended fuel can lower fuel cost, but there are often significant trade-offs. Fuel price must be weighed against the following.

- Fuel containment effects
- Reduced engine component life
- Higher maintenance and personnel costs
- Reduced warranty

Distillate Fuel

Distillate fuels are refined from crude oil and are commonly referred to as diesel fuel, furnace oil, gas oil, or kerosene.

Marine Diesel Oil

Many different names are used for marine diesel fuels, which can often cause a misunderstanding. Four types of marine diesel fuel are generally recognized and available at

Installation Example with Main and Auxiliary Fuel Tanks

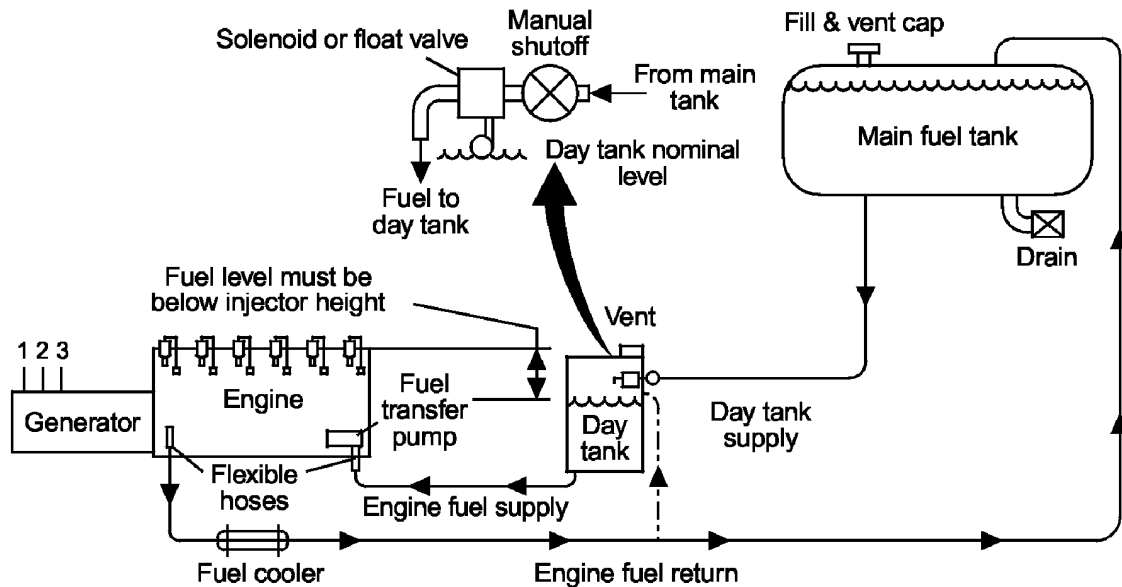


Figure 3

Auxiliary Fuel Tanks

Auxiliary fuel tanks, service tanks and day tanks are secondary fuel tanks located between the main fuel tank and the engine. These tanks are required in the following situations.

- The main fuel tank is located on the same level but more than 15 m (50 ft) away.
- The main fuel tank is located 3.7 m (12 ft) or more below the engine.
- The main fuel tank is located above the engine fuel injectors.

Any of the above conditions can cause unsatisfactory engine starting and operation. The purpose of an auxiliary tank is to relieve the fuel

pressure "head" from the fuel transfer pump and injection equipment for efficient fuel flow.

A manual fuel priming pump, offered as an attachment, or an electric motor-driver boost pump may allow operation under conditions more severe than those previously described; but where starting dependability is required, Caterpillar recommends the use of an auxiliary fuel tank.

Auxiliary tanks offer convenient and ready fuel storage while providing a settling reservoir for water, sediment and sludge. An example of an auxiliary fuel tank is shown in **Figure 4**.

extremely harmful to the engine's internal components.

Pipes, hoses and fittings must be mechanically strong and resistant to deterioration due to age or environmental conditions. They must also be airtight to avoid entry of air into the suction side of the fuel system. A joint, which is leak-tight to fuel, can sometimes allow air to enter the fuel system, causing erratic running and loss of power.

Sizing

Sizing of pipes, hoses and fittings must be adequate to minimize flow loss.

Sizing for a particular application is determined by the supply and return line restrictions. This can be estimated with help from the Piping System Basic Information section of the Application & Installation Guide. The maximum allowable restrictions are published in the TMI.

Generally, the supply line carrying fuel to the fuel transfer pump and the return line carrying excess fuel back to the tank should be no smaller in size than the connection fittings on the engine. In addition, the return line should be at least as large as the supply line.

If the fuel tank supplies multiple engines over 9.14 m (30 ft) from the tank, or ambient temperatures are low, larger fuel supply and return lines should be considered to ensure adequate flow. The overflow line from the day tank (or, if no day tank is used, the engine fuel return line) should be one size larger than the supply and return lines.

Routing

Fuel lines should be well routed and clipped with flexible hose connections where relative motion is present. Lines should be routed away from hot surfaces, like manifolds and turbochargers, to avoid fuel heating and potential hazard if a fuel line should fail.

Fuel lines should be routed to avoid formation of traps, which can catch sediments, or pockets of water, which will freeze in cold weather.

Whenever possible, route fuel lines down low, so any potential leakage will be confined to the fuel tank base or floor space. Leaks from overhead fuel system components may fall onto hot machinery, increasing the likelihood of fire danger.

Route fuel lines to avoid crossing paths and walkways. Protect fuel lines from abrasion and damage. Whenever possible, route fuel lines so they are visible for leak checking.

Fuel Filtration Systems

Clean fuel that meets Caterpillar fuel recommendations provides outstanding engine service life and performance. The use of lesser fuels is a compromise and the risk is the user's responsibility. Dirty fuel and fuels not meeting Caterpillar's minimum specifications will adversely affect:

- The perceived performance of the combustion system and fuel filters.

Partial Load Operation

Extended operation at low idle or at reduced load may cause increased oil consumption and carbon buildup in the cylinders. Carbon buildup results in a loss of power and/or poor performance. When possible, apply a full load at least on an hourly basis. This will burn excess carbon from the cylinders.

Burning Used Crankcase Oil

With legislation and ecological pressures, it is becoming increasingly difficult to dispose of used oil. The burning of used crankcase oil in 3600 engines is not recommended due to the detrimental effects on exhaust emissions. However, if ancillary methods of reducing exhaust emissions to acceptable limits are used, or if emissions are not a problem, burning crankcase oil in 3600 engines is possible with the following guidelines.

- It is necessary to collect, store, and dispose of used crankcase oil from engines correctly. It is not acceptable to dump used crankcase oil into the oceans, rivers, and harbors from vessels or offshore drilling and production platform installations. It may be necessary for engine operators to consider burning crankcase oil in their Caterpillar engines. This can be done, providing the precautions below are carefully followed:

- Only diesel engine crankcase oils can be mixed with the diesel engine fuel supply. The ratio of used oil to fuel must not exceed 5%. Premature filter plugging will occur at higher ratios. Under no circumstances should gasoline engine crankcase oil, transmission oils, special hydraulic oils not covered by Caterpillar recommendations, grease, cleaning solvents, etc., be mixed with the diesel fuel. Do not use crankcase oils containing water or antifreeze from engine coolant leaks or poor storage practices.
- Adequate mixing is essential. Lube oil and fuel oil, once mixed, will combine and not separate. Mix used filtered crankcase oil with an equal amount of fuel, then add the 50-50 blend to the supply tank before new fuel is added (maintaining the 5% used oil-to-fuel ratio). This procedure should normally provide sufficient mixing. Failure to achieve adequate mixing will result in premature filter plugging by slugs of undiluted oil.

Step 4

Calculate the heat transferred between the fuel in the day tank and the atmosphere, the ΔT of the fuel in the day tank due to the heat transfer, and the resulting fuel day tank temperature.

- a. Heat transferred between the day tank and the atmosphere:

$$Q_{TK} = \left[U \times [(H \times (2L + 2W) + (L \times W)) \times \left[T_{AMB} - \frac{(T_{MIX} + T_{DT})}{2} \right] \right] \times t$$

Where:

Q_{TK} = Heat transfer to/from atmosphere (Btu)
This considers 6mm (0.25 in.) steel plate forming the tank boundaries, and the film coefficient for air and oil. The air side film coefficient is predominant when compared to the oil side film. The tank thickness has a negligible effect.

U = Coefficient of heat transfer, (0.0424 Btu/min •ft²•°F)

L = Day tank length (ft)

W = Day tank width (ft)

T_{AMB} = Ambient temperature (°F)

T_{MIX} = Mix temperature of return fuel and fuel in tank (°F)

T_{DT} = Day tank temperature resulting from heat transfer to/from day tank (°F)

T = Incremental time step (min)

H = Fuel height for specific time step (ft)

- b. Temperature change in the day tank resulting from heat to/from day tank:

$$\Delta T_{DT} = \frac{Q_{TK}}{M_{DT} \times C_p}$$

Where:

ΔT_{DT} = Temperature change of fuel in the day tank (°F)

Q_{TK} = Heat transfer to/from atmosphere (Btu)

M_{DT} = Mass of fuel in day tank (lb)

C_p = Specific heat of #2 MDO = 0.5 Btu/lb •°F

- c. Day tank temperature resulting from heat transfer to/from day tank:

$$T_{DT} = T_{MIX} + \Delta T_{DT}$$

Where:

T_{DT} = Day tank temperature (°F)

T_{MIX} = Mix temperature of return fuel and tank fuel (°F)

ΔT_{DT} = Temperature change of day tank (°F)

These three calculations are interdependent in nature. First, Q_{TK} is determined for the first incremental

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