COOLING SYSTEM

Engines using a liquid for cooling have jackets or passages around each cylinder and throughout the cylinder head. Coolant enters the jacket under pressure, and on its way to the outlet, absorbs heat from the engine. Water cooling systems are designed so the engine inlet and outlet temperature differential is maintained at a desirable level, usually not more than 15° F or 8° C.

CAUTION **High Engine Temperature Cutoff will shut down engine in an overheat condition only if coolant level is sufficiently high to physically contact shutdown switch. Loss of coolant will allow engine to overheat without protection of shutdown device, thereby causing severe damage to the engine. Adequate engine coolant levels must be maintained to ensure operational shutdown protection capability of engine cooling system.**

At the outlet the coolant may enter a radiator or heat exchanger, be tempered in a standpipe, or dumped into a drain. Consider initial cost, operating cost, space, ambient temperature, ventilation, noise and availability of satisfactory water. Note the advantages and disadvantages of each.

OPERATION PRINCIPLES

Radiator Cooling

A radiator is comprised of small finned tubes through which engine coolant passes. These fins provide a large surface area for transfer of heat from the coolant to the air stream. The air stream in Onan generator sets is produced by a pusher-type radiator fan which draws air over the engine and pushes it through the radiator. Radiator cooling provides low initial cost, is completely independent of any interruptible utility (as in contrast to city water cooling) and it can be freeze protected with antifreeze solution. However, radiator cooling requires large ventilation ducts and the radiator fans are relatively noisy.

CAUTION **For Onan generator sets having cooling system corrosion resistors, do not use antifreeze solutions with an antileak formula. The antileak formula will clog the element.**

Remote Radiator Cooling

Some installations require the radiator and fan mounted separately from the generator set. While these systems offer more versatility, require less power room ventilation, and can use low-noise fans, these systems are more expensive in original cost than the other cooling systems discussed. There are three categories of remote radiator designs (see *"Remote Radiator System Designs"*).

City Water Cooling

This type of cooling uses an external water source to cool the engine. It offers quieter operation than radiator cooling (no radiator fans) and less required ventilation, but it cannot be freeze protected throughout the system, it is dependent on the utility water source (unless independent source used), and operating cost is higher due to cost of supplying cooling water. Three types of city water cooling are available (see *"City Water Cooling Designs"*).

REMOTE RADIATOR SYSTEM DESIGNS

General Information

Pipe Sizing: When water flow is produced by the engine-driven water pump, total piping pressure drop must not exceed 7 psi (48.3 kPa) at rated engine water flow. If water flow is assisted by an auxiliary pump, piping pressure drop must be matched to pump capacity at desired water flow.

Refer to table on water pressure drop in PSI for standard DDV radiators. *(See Index of Tables).*

Remote Radiator Airflow: Remote radiators are designed for installations where no external airflow restrictions occur. If the remote radiator will ventilate a room, has any ducting, or its airflow is opposed by prevailing winds, the cooling capacity is reduced.

Deaeration: Because air enters the cooling system during generator set operation a radiator top tank or surge tank must be installed at the highest point in the system. This point is the only place where air is adequately separated from the system (Figure 8 shows plumbing). A top tank or surge tank must have adequate volume so the inlet and outlet are below the normal running water level, and the air space provides not less than eight percent of the total volume of the engine water jacket, piping, and radiator.

CAUTION **If the radiator top tank or surge tank is not at the highest point in the system, high sections of plumbing can cause air pockets which prevent water flow and result in engine overheating.**

Auxiliary Pumps: The auxiliary pumps listed show the pumping capacity with approximately a 40-foot (12.2 m) head pressure. *(See Table on Auxiliary Water Pumps.)*

CAUTION **The 40-foot (12.2 m) head pressure limit is the maximum allowable for a single Onan pump and tank system. If vertical distance creates greater head pressures, add secondary pumps or higher capacity pumps and tanks. This type of system requires a qualified consulting engineer with hydraulic cooling system design experience.**

Proper pump and motor selection is based on pump duty, capacity and head loss. A restriction or gate valve may be required on the auxiliary pump outlet to maintain pump pressure head loading and prevent motor overloading. Check proper pump operating and loading by operating the entire system. If coolant is discharged from the radiator overflow or at the vent system outlet, slowly close the gate valve or increase the restriction in the pump outlet until the overflow action stops. Do not increase pump outlet loading so much that the pump overloads.

Electrical: Make connections of fans and auxiliary pumps to the generator set power distribution panel so the fans and pumps operate whenever the generator set operates. Special voltages are available.

Flexible Hoses: Install flexible hoses to isolate vibration at the engine and radiator water inlets and outlets.

Drain Valve: At the lowest point in the cooling system, install a drain valve for cleaning and flushing.

Heat Rejection: The heat rejection to coolant figures of Onan generator sets are listed separately for gasoline and diesel powered systems (refer to *Index of Tables*).

Radiator Selection

Remote radiators for Onan generator sets are available from the Perfex Corporation, Milwaukee, Wisconsin; or, from Young Radiator Company, Racine, Wisconsin. Sizing is determined by the particular generator set. (Refer to *Index of Tables* for a list of Perfex radiator models. Gasoline and diesel models listed separately).

Radiator sizes are based on 190°F (88°C) engine water outlet temperatures. Maximum operating radiator inlet temperatures are indicated at the top of the table and are rated at a maximum altitude of 1200 feet (366 m) above sea level. Operating at higher altitudes requires derating the cooling capacity 2 percent for each 1000 feet (305 m) above the first 1200 feet (366 m).

Consider radiator noise levels for each installation. Lower noise levels require lower speed fans but also require larger radiators (Table 8).

Short Remote Radiator Installation

The sum of the vertical distance from the engine centerline to the radiator top and the horizontal distance from the engine front to the radiator centerline must not exceed 15 feet (4.6 m). Figure 7 shows a typical schematic of the installation. The engine water pump provides adequate coolant circulation through the entire cooling system with proper plumbing.

Size the pipe the same as the engine inlet and outlet fittings throughout the entire system. (Refer to table on *Type DDV Radiators - Low and High Speed Fans - Column J* for minimum pipe size recommended. See *Index of Tables*.)

Long Remote Radiator Installation

The sum of vertical distance from the engine centerline to the radiator top and horizontal distance from engine front to the radiator centerline exceeds 15 feet (4.6 m), but the vertical distance alone does not exceed 15 feet (4.6 m). Figure 8 shows a typical schematic of the installation.

A surge tank and auxiliary water pump (in conjunction with engine water pump) in the system provide adequate coolant circulation. See "*General Information.*"

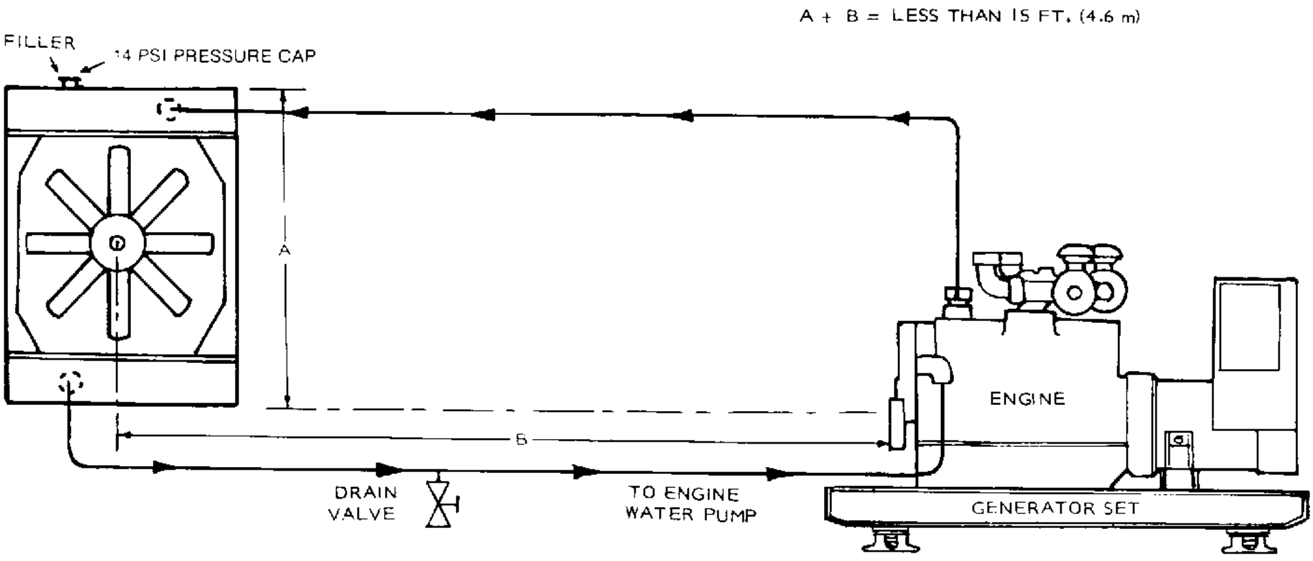


FIGURE 7. SHORT REMOTE RADIATOR INSTALLATION

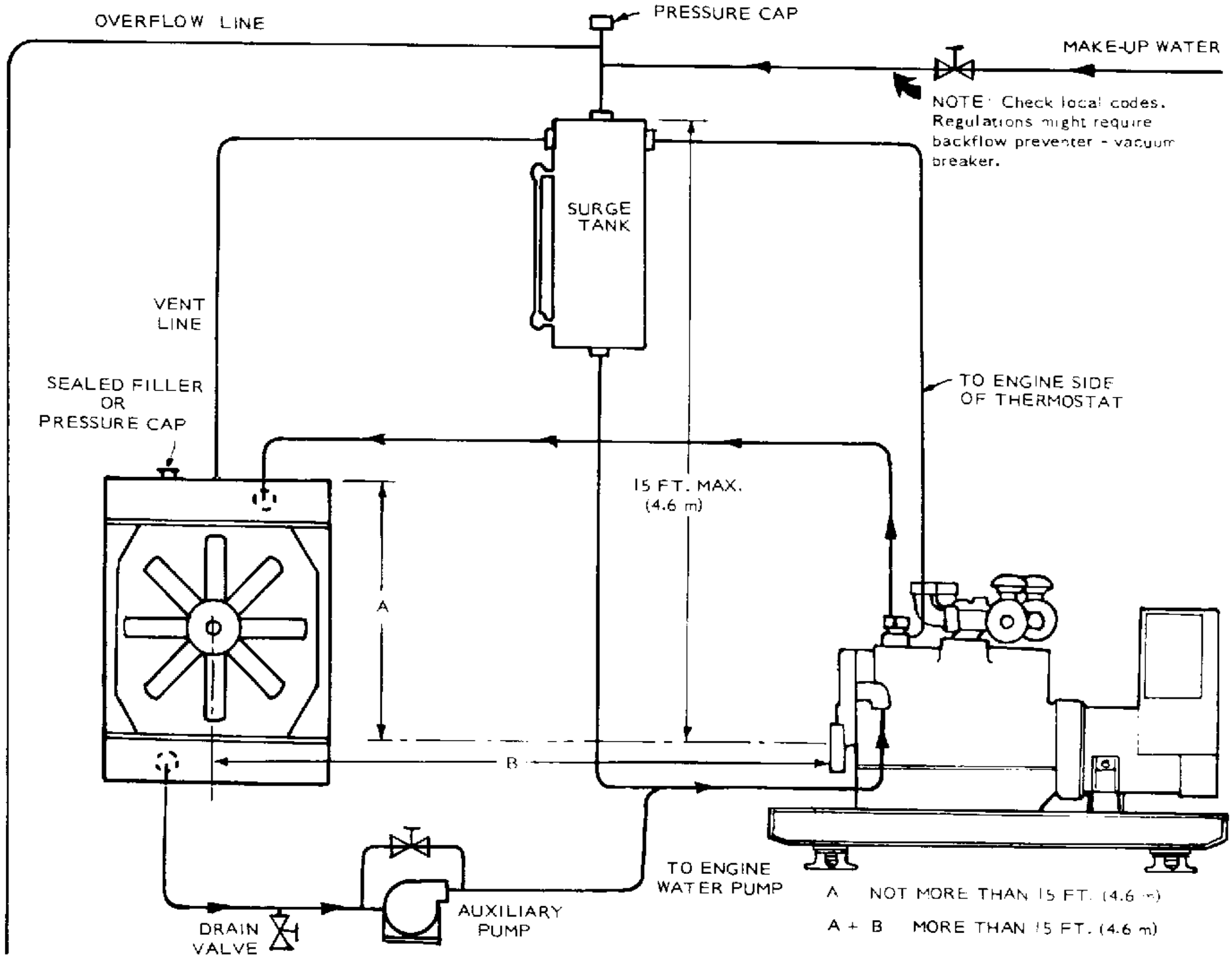


FIGURE 8. LONG REMOTE RADIATOR INSTALLATION WITH SURGE TANK

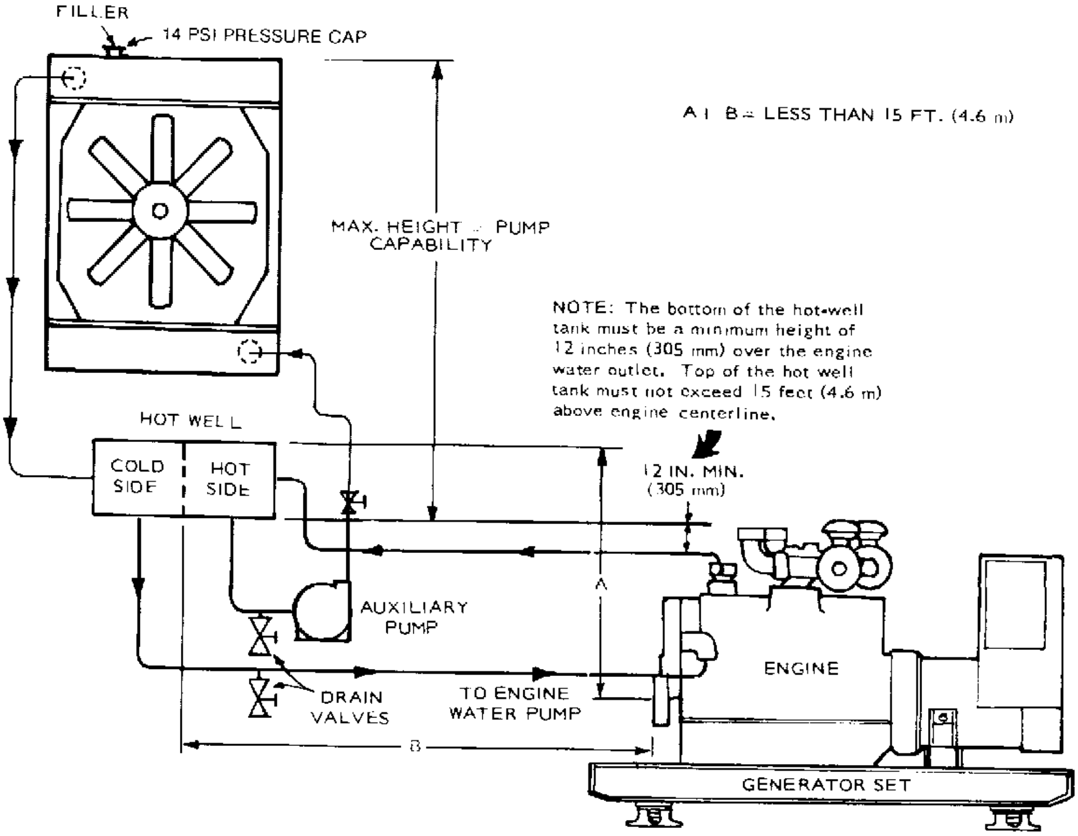


FIGURE 9. HIGH REMOTE RADIATOR INSTALLATION

High Remote Radiator Installation

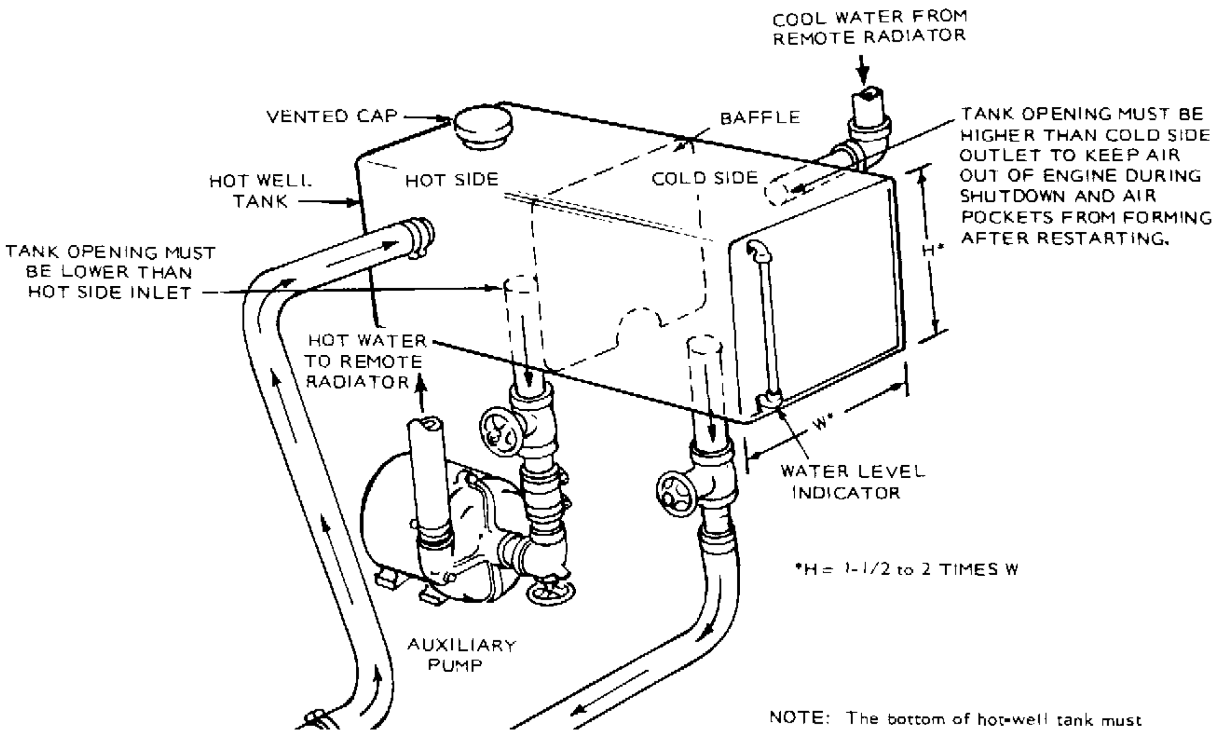
If the radiator top is more than 15 feet (4.6 m) above the engine centerline, a hot-well tank and auxiliary pump between the engine and the radiator are required. See Figure 9. The tank is a storage tank which reduces the water head pressure on the engine to acceptable limits. It is a two-section tank with a partial baffle to separate the hot side (from engine outlet) and the cold side (to engine inlet).

The engine pump circulates water between the engine and hot-well tank, and the auxiliary pump circulates water between the hot-well tank and remote radiator (Figure 9). If the radiator is selected from the Tables (see *Index of Tables*), the auxiliary pump must supply the same water flow as the engine water pump. If not, a larger radiator is required.

Size the hot-well tank so it can contain the full-water capacity of the engine, piping, radiator, volume needed to keep inlets and outlets submerged, and eight percent of total for expansion. Inlets to the tank must be higher than the outlets, with both lower than the lowest possible operating water level. Because the radiator drains into the cold side of the hot-well tank after generator set shutdown, the baffle between the hot and cold side must have an opening large enough to allow free water passage up to the flow rate of engine or auxiliary pump, whichever is larger. As shown in Figure 10, the hot-well tank is vented to the atmosphere.

Maximum water level in the hot-well tank must never exceed 15 feet (4.6 m) above the engine centerline. The bottom of the tank must be a minimum of 12 inches (.305 m) over the engine water outlet. Vertical height between the bottom of the hot-well tank to the top of the radiator is limited by auxiliary pump capability. Supports for the hot-well tank must withstand the weight of the water plus 60 percent of the cooling system capacity (when the generator set is not running).

Mount the auxiliary pump at the tank hot side outlet below the running water level to prevent air from entering the pump during operation. If the proper pump and water line sizes are used, adequate water flow is maintained. For information on the pumps, see "Auxiliary Pumps."


COOL WATER FROM
REMOTE RADIATOR
VENTED CAP
BAFFLE
TANK OPENING MUST BE HIGHER THAN COLD SIDE OUTLET TO KEEP AIR OUT OF ENGINE DURING SHUTDOWN AND AIR POCKETS FROM FORMING AFTER RESTARTING.
HOT WELL TANK
HOT SIDE
COLD SIDE
H*
TANK OPENING MUST BE LOWER THAN HOT SIDE INLET
HOT WATER TO REMOTE RADIATOR
W*
WATER LEVEL INDICATOR
*H = 1-1/2 to 2 TIMES W
AUXILIARY PUMP
NOTE: The bottom of hot-well tank must

:AUTION 1. Since the incoming water enters the engine cooling passages, the water must be clean and have very low corrosion levels to prevent clogging ne passages. Otherwise, engine overheating and damage will lt.

/ith standpipe cooling, the entire cooling system must be ned during freezing conditions to prevent equipment damage.

w rate of the city water supply must be adequate to l the engine. Water flow rate can be controlled by a nual valve (set for proper cooling of engine at full d) or by an automatic valve which uses the engine lant outlet temperature as an adjustment erence.

an uses a solenoid shutoff valve before the control ve in the incoming city water line (Figure 11). It ps city water flow when the generator set is pped. More importantly, it ensures an automatic d water supply when the generator set starts.

at Exchanger Installation

e heat exchanger consists of tubing within a rounding "shell." Engine water in the shell side of heat exchanger does not mix with city or raw ter within the tubes (Figure 12). Raw water passing ough the tubes absorbs engine heat from the arated engine coolant in the heat exchanger. cause the engine coolant is not mixed with the city raw cooling water, the engine coolant can include ifreeze and anti-corrosion solutions for engine tection.

CAUTION **While you can protect the engine coolant from freezing with antifreeze solution, cool- raw water cannot be protected. If freezing temperatures are ountered, the heat exchanger's raw water system must be ined.**

w rate of cooling raw water is controlled either by a nual or automatic valve. A manual valve must be usted for proper engine cooling while running der full load. If an automatic valve is used, the gine coolant outlet temperature must be used as an justment reference. A solenoid valve is included in

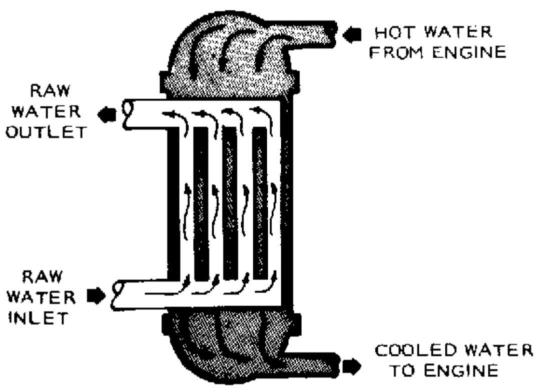


FIGURE 12. TYPICAL HEAT EXCHANGER

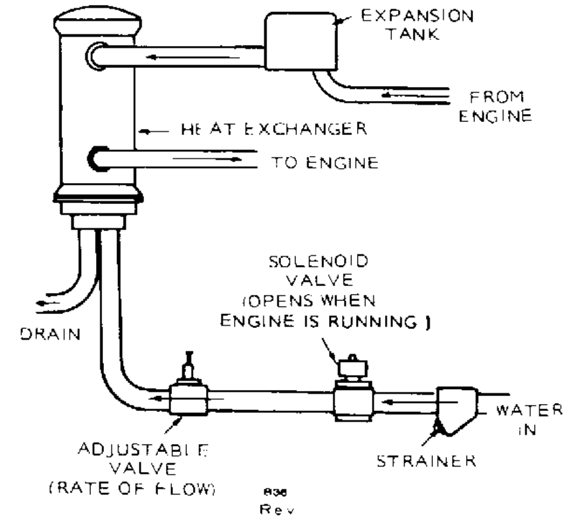


FIGURE 12A. HEAT EXCHANGER SYSTEM

the incoming raw water line and opens during generator set operation. Figure 12A shows a heat exchanger system.

Direct Flow Installation

With this sytem, a city or raw water cooling supply under pressure forces water directly into the engine, through the engine and to the outlet. An adjustable valve controls the incoming water flow rate to obtain correct engine water temperature, as measured at engine coolant water outlet while the generator set is operating under full load. A solenoid valve is coordinated with the generator set system to open during set operation. (See Figure 13 on next page).

CAUTION **Restrict inlet water pressure to a maximum of 7 psi or 48.3 kPa, otherwise engine gaskets and seals will leak.**

Raw water cooling is often undesirable because:

1. The water supply must be very clean or engine deposits will result.
2. A high temperature differential between the cold incoming water into the engine and warm discharged water can put damaging stresses on engine components (no overall uniform engine temperature).

COOLANT HEATERS

Engine coolant heaters with thermostats, available from Onan, are important for any unattended, standby application. They increase:

1. Starting reliability,
2. Engine life,
3. Unit ability for load acceptance.

Due to starting difficulty of diesel generator sets in cold temperatures, Onan recommends coolant