SERVICE BULLETIN

Original Issue Date: **1/06**
Model: **6–600 kW**
Market: **Industrial, Mobile, and Rental**
Subject: **Block Heater Inspection and Test Procedure Guidelines**

Introduction

This bulletin provides information for inspecting and testing block heater functionality and failure analysis. In addition, the bulletin provides guidelines for preventing block heater failure during scheduled maintenance and service replacement.

Block heater misuse is frequently the cause for failure during generator set startup and scheduled maintenance procedures. The purpose of this bulletin is to increase user/technician awareness of block heater failure and reduce warranty claims resulting from block heater misuse.

Block heaters use a heating element with a fixed resistance for the desired wattage at a user-selected voltage.

Items Needed

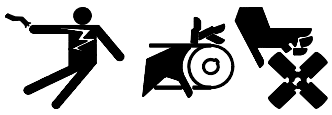
- Phillips® screwdriver
- Needle-nose pliers or nut driver (for removing the connectors from the element pins)
- Ohmmeter
- Thermometer, 0°C–100°C (32°F–212°F)
- Container of water
- Ice (to cool the thermostat and container of water, as needed)
- Heat source (portable cooktop)

Read the entire procedure before inspecting or testing the block heater. Perform the steps in the order shown.

Safety Precautions

Observe the following safety precautions while troubleshooting the generator set. Follow all safety precautions given in the engine literature when performing engine troubleshooting and repairs.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (–) lead first when disconnecting the battery. Reconnect the negative (–) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (–) lead first. Reconnect the negative (–) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

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Initial Here							

Calculating Heater Element Resistance

The General Heater Test Procedure below involves *measuring* the element resistance. Use the following information to *calculate* the element resistance for purposes of comparison. The element resistance varies by different component part numbers. The nominal resistance of each element is determined by the applied voltage squared divided by the known element watts. The tolerance of the nominal resistance reading on a used element should be ±15%.

Formula:

$$\frac{V^2}{W} = R \pm 15\%$$

Example: With an applied voltage of 120 and an element value of 2400 watts, the resistance is 6 ohms or a range of 5-7 ohms based on the ±15% tolerance.

$$\frac{120^2}{2400} = R \pm 15\%$$

$$\frac{14400}{2400} = 6 \pm 15\%$$

General Heater Test Procedure

1. Disconnect the heater from the power source.
2. For heaters without a power cord, go to step 4.

   For heaters with a power cord, check the resistance between the two current-carrying conductors.

   If no continuity exists, continue to step 3.

   If the measured resistance reading matches the calculated resistance value, check each current-carrying conductor to ground. The resistance of any current-carrying conductor to ground should be at least 2 megohms. If the resistance is less than 2 megohms, the heater has failed. Continue to step 3 to determine the cause of failure.
3. Remove the power cord.
4. Isolate the element and any thermostat(s) by removing all wire connections including the high-limit thermostat.
5. Test each element for resistance and each thermostat for continuity.

   a. If the element resistance tests okay based on the calculated value, check each of the element connections to ground for continuity. Use the same 2 megohm rule mentioned in step 2. If the element with power cord to ground test reads less than 2 megohms but the element tests okay, the ground path must be in the power cord.

   b. Check the thermostat when in the "on or closed" temperature range. Thermostats have an 11°C (20°F) temperature band where it can be open (off) or closed (on) during normal use. See Figure 1.

   For instance, if the thermostat temperature is 29°C (85°F) and it is "off" if may have reached the shutoff point of 38°C (100°F) and not be cooled down enough to turn back "on" again. If this is the case, cool the thermostat *beyond* the temperature band and test again.

	27°C (80°F)	**29°C (85°F)**	**38°C (100°F)**
Warming Mode	ON	*ON*	OFF
Cooling Mode	ON	*OFF*	OFF

Figure 1 Thermostat Function by Temperature

   c. If a thermostat is suspect, test by cooling the sensing end of the thermostat. Then place it in a container of water on a heat source while carefully monitoring the temperature of the heat source while checking for continuity. Record the temperature at which the thermostat opens.

   d. Cool the container of water containing the thermostat and monitor the temperature until the thermostat closes. Record that temperature.

   e. Compare the recorded temperatures with the listed range stamped on the thermostat. The tolerance for thermostats is ±4°C (±7°F).
6. Remove the element from the tank assembly. Inspect for scale deposits, evidence of air pockets, or soft or melted elements. Refer to the heater inspection guidelines to identify the cause of any failures.
7. If the element(s), thermostat(s), and cord(s) pass inspection, the heater will function properly.

Determining Cause of Failure

Most engine heater failures are caused in one of the following ways:

1. The heater is installed in a manner that prevents it from properly transferring its heat to the engine. This is primarily only a problem with the tank-style heaters as opposed to direct immersion heaters or heating systems where a pump circulates the coolant (antifreeze).

2. The engine coolant chemical composition causes a scale to form on the heating element(s) resulting in failure. The scale can be caused by minerals (hard water) in the water used in the coolant mix, an over-concentration of coolant relative to water, or an over-concentration of additives used in the coolant.

3. Thermostat failure can be a sign of an improper installation. If a heater is installed in such a manner that the hot coolant flows back toward the thermostat, it will cause the thermostat to cycle on and off rapidly. This frequent cycling can shorten the life of the thermostat.

   Exceeding the maximum ratings of the thermostat can also cause thermostat failure. Never apply a voltage different than the heater rating.

Water Condition

Hard water is one of the most common causes for failure of a heating element. The surface temperature of the heating element causes the minerals in the water to attach to the sheath (outer surface). These minerals collect to form an insulation layer that increases the internal element temperature. As the insulation layer thickness continues to increase, the element temperature eventually increases to the point of failure. See Figure 2 and Figure 3.

Solution

Drain and flush the cooling system. Installing a new heater in this environment will not solve the problem with time it will just ruin another heater. When possible, use only deionized water and low silicate coolant and additives. If this is not available in your area, use only premixed 50/50 low silicate coolant and low silicate supplemental additives. Do not over concentrate. When mixing coolant and water, never exceed a 60/40 mixture.

Because engine coolant reaches its hottest temperature inside the heater, the heater itself can be a great diagnostic tool for cooling system conditions that could have detrimental effects on the water pump, aftercooler, oil cooler, and radiator.

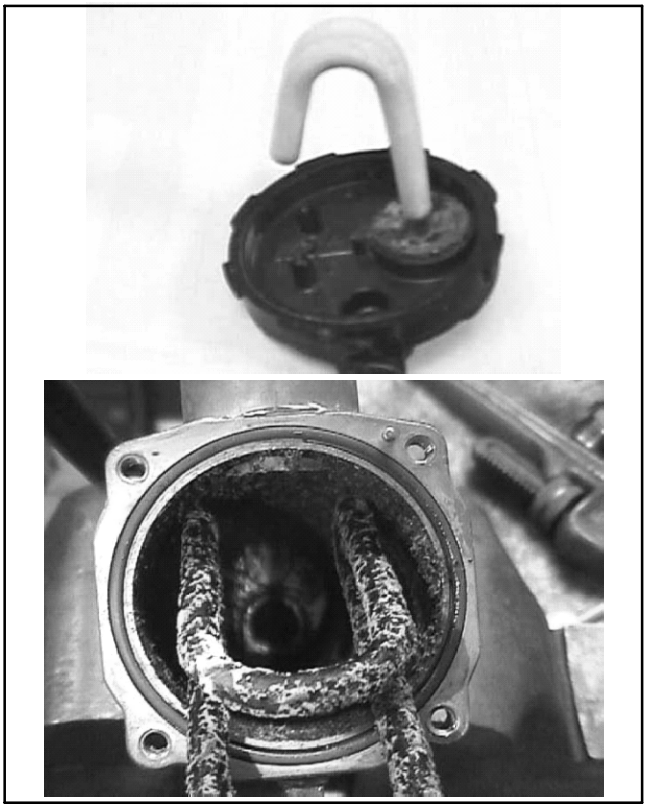


Figure 2 Hard Water Mineral Buildup

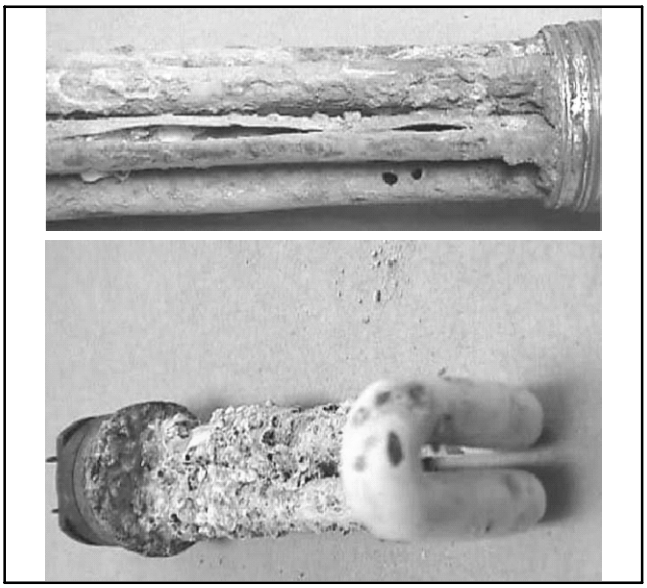


Figure 3 Element Failure Due to Mineral Deposits

Air Pocket(s)

This is a fairly common problem that leads to a false low coolant temperature warning. The heater encounters an air pocket preventing the heated coolant from circulating. Although the heated coolant can't circulate, the heater thermostat continues to turn the heater on and off. The engine will then cool down, activating the low coolant temperature warning. More often than not, the heater is still functional, but it is replaced without being checked. In the most extreme cases, the tank can actually melt or blister. See Figure 4 and Figure 5.

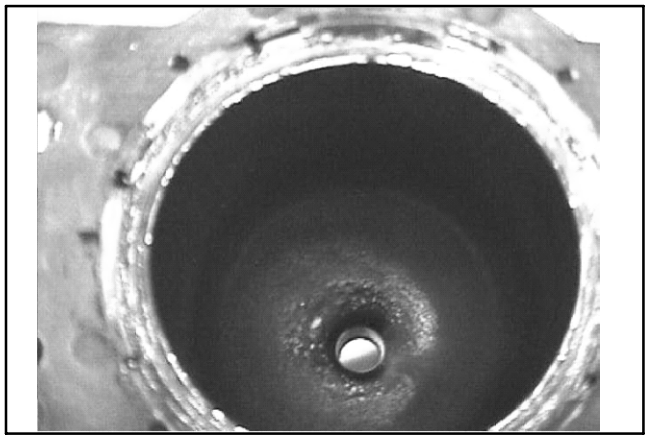


Figure 4 Heater Tank Heat Warpage

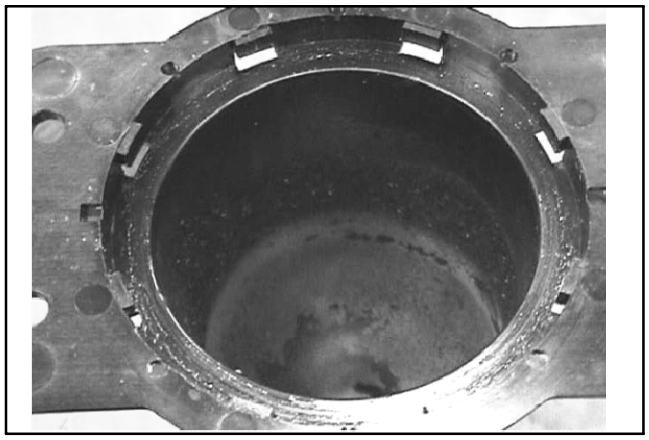
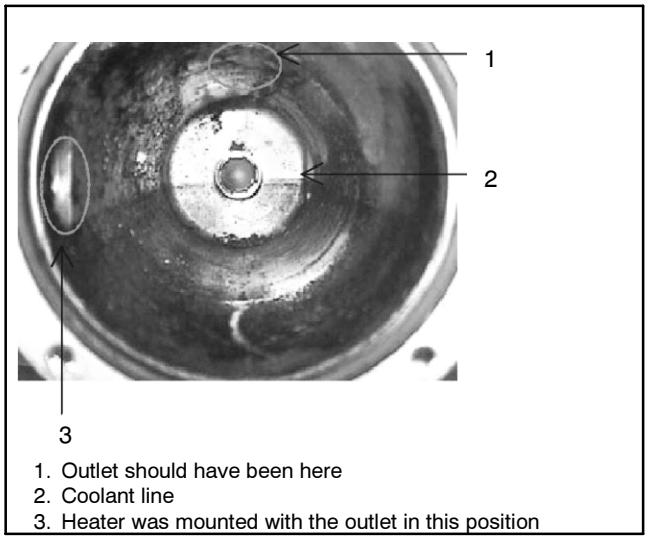


Figure 5 Heater Tank Overheating Damage

Air Pocket Solution

The engine jacket should be thoroughly purged to eliminate any air pockets before the heater is energized. Prior to energizing the block heater, start and run the engine up to the normal operating temperature to open the engine thermostat after the installation. This will ensure that no air pockets remain within the cooling system. Also check the outlet hose to assure there is no point in the line where it sags. Remember that heat rises and a hose dip will stop or at least inhibit the flow of hot coolant.

The heater shown in Figure 6 and Figure 7 was actually mounted with the outlet facing sideways (horizontal). The illustrations show that the coolant never reached the top portion of the tank. This exposes the elements to air and eliminates the heater's ability to pull cold coolant from the engine. It is critical that the heater be completely full of coolant at all times. This means the outlet of the heater must be at the highest point in the cooling system for it to work correctly.



1. Outlet should have been here
2. Coolant line
3. Heater was mounted with the outlet in this position

Figure 6 Improper Heater Mounting Position

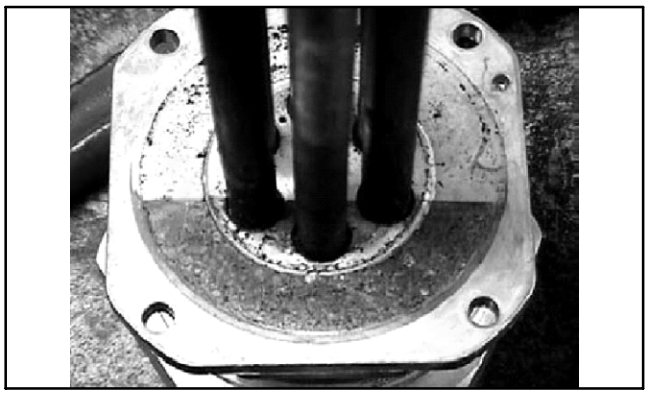


Figure 7 Heater Showing Coolant Line from Horizontal Mounting

Coolant Condition

Correct coolant concentration and additive levels are critical for proper heater and engine function. Always follow the engine manufacturer guidelines for coolant and additive levels. Over-concentration of coolant causes a gel-like slime to accumulate on the element. See Figure 8. Over-concentration of additives will cause a similar slime, but usually with a different color.

In severe cases, it may burn on the element causing a black sludge to form. See Figure 9.

Note: Never add concentrated coolant to an engine without first mixing it with water.

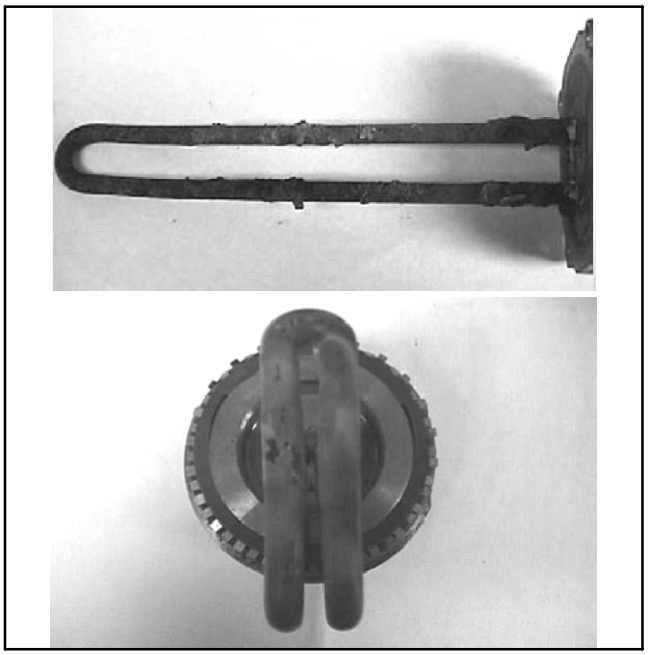


Figure 8 Over-Concentration of Coolant/Additives

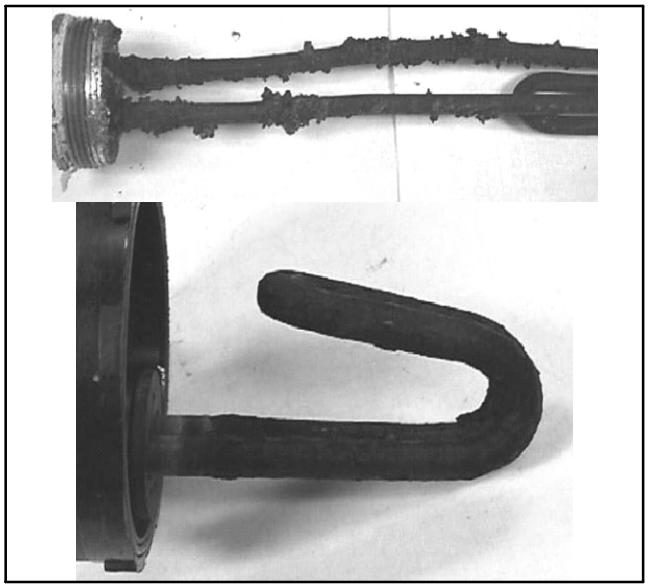


Figure 9 Over-Concentration of Coolant Burned-On the Element

If concentrated coolant is added first before mixing it with the water, it will sit at the bottom of the engine block. Tank heaters are designed to sit at the lowest point of the engine water jacket. If coolant is added without mixing with water first, the heater will be filled with concentrated coolant. If energized in concentrated coolant, scale will form almost immediately.

The water pump will *not* effectively mix the coolant in the engine. The water pump will move a batch of water, then a batch of near concentrated coolant, and it will keep repeating this sequence. The coolant jacket, radiator, and coolant lines are more like a series of pipes than a tank or mixing bowl.