White Paper: Heating Emergency Diesel Generators
Prepared for Geo-Thermal Systems by Mercury bps, April 2007

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Background

Emergency Power Systems (EPS) were first introduced by the military during World War II. Navy planners feared that combat fire would disable electrical operations and leave ships dead in the water. EPS was essentially invented when redundant diesel engines were connected to ship power grids as a back-up measure. Since then, most emergency power systems have included diesel generators. After the war, this technology was widely adopted by facilities with mission-critical up-time requirements. Occasionally, emergency generators failed and investigators determined that a key problem was engine temperature at start-up. Subsequently, the National Fire Protection Association issued codes recommending that emergency diesel generators be heated at all times.

Manufacturers of diesel generators responded by adding block heaters to emergency diesel generators. Today, most of these heaters operate as they did in 1950, using resistance heaters to convert electricity into heat with an coefficient of performance of 1 to 1. This is a low cost solution from a manufacturing perspective, and the increased energy cost has been small enough to escape notice – until recently.

Emergency diesel generators are found in large public buildings like hospitals, jails, and airports that need fail-safe back-up systems. This is also true in the private sector where business administration has become dependent on digital technology and on EPS to protect their businesses. But whether public or private, all emergency diesel generators have one or two resistance heaters which use legacy technology to operate over 60% of the time, 24/7, and there is no built-in redundancy if the resistance heater fails.
Why Emergency Diesel Generators Need to be Heated

Sometimes called the “forgotten energy consumer,” stand-by diesel generator installations typically consume energy over 60% of the time. While the generator itself is inactive, the block heater itself is still operating in order to maintain the recommended engine temperature. This issue has not received much attention because energy conservation has only become a corporate issue in the past 15 years, and because easy solutions were not available. However emergency diesel generator installations have always wasted energy.

Diesel generator engines start-up based on the compression ignition principle. The temperature of the air in the cylinder increases in direct proportion to the compression ratio (i.e. if the compression ratio is 18:1, the air is compressed eighteen-fold, and the temperature increase is also eighteen-fold). Emergency diesel generators start when the air in the cylinder is compressed to the temperature needed to ignite the diesel fuel. When the engine is cold, this process is not as effective.

Diesel engines were originally designed for vehicles. In this application, they are equipped with a starting aid (glow plugs or ether). Operating manuals for diesel vehicles recommend the engines be allowed to idle until warm. This warm-up period is needed to allow dissimilar metals in the engine to expand to proper operating tolerances.

Unlike a vehicle, when there is a power failure, there is no opportunity to warm-up: it needs to carry a load immediately. Thus almost all emergency diesel generators are installed with inexpensive resistance heaters to maintain the generator at a consistently warm temperature. This is needed to insure a safe and reliable split-second start-up, and to prevent 'cold start wear.'

Depending on the size and environment of the emergency diesel generator, more than one resistance heater may be needed. In engines with two resistance heaters, one heater usually carries more of the load, running longer than the second heater.

Factory specifications typically recommend that heaters engage at 90°F and turn off at 110°F. Installation specifics such as engine location, make, and model effect starting characteristics, so the optimal temperature range may vary, however there is no redundancy built in these systems.

In an age of heightened energy-use awareness, the emergency diesel generator heater should no longer be a forgotten consumer.
Alternative Heating Solutions

Resistance heaters have been standard equipment for over 50 years, and the technology has not changed much. The coefficient of performance (COP) for resistance heaters was, and is, 1 to 1: meaning that for every $1 of energy used, $1 of heat is produced. For example, heat pumps have a COP of 4.2 to 1, delivering over four units of heat for each unit of electricity used. Meaning for every $1 of energy consumed by the heat pump there is $4.20 worth of heat generated.

It takes less energy to move heat than it does to make it. Heat pump technology takes heat out of ambient air and efficiently transfers it to the engine coolant system by using refrigerant under pressure. There are thousands of patented Geothermal Systems (GTS) heat pump units operating in the field providing back-up insurance — this is a robust commercial technology.

Resistance heaters usually operate 60-90% of the time, while heat pumps typically run about 50-80% of the time. However, the energy savings are far greater than the 10% time difference because resistance heaters are inefficient. The three key variables for how much time a heating solution is active are:

1) Make and model of generator
2) Environment around the generator
3) Type of heating solution installed

The GTS alternative to emergency diesel generator heating is increasingly popular because it offers a cash positive method for reducing energy consumption and for complying with the Environmental Protection Agency's (EPA) Greenlights Program to reduce the pollutants released into the atmosphere. Environmental initiatives offer good public relations value, and in this case, make good financial sense. GTS has documented that diesel generators usually save between 75% and 85% on electricity charges. This technology is only available through GTS.

The addition of a heat pump provides another key advantage: redundancy. If a single resistance heater is used as the emergency diesel generator heating source, there is no back-up. The redundancy provided by installing heat pumps in series with block heaters provides increased system reliability. Without a heat pump however, a failed block heater is, potentially, a failed emergency power system.

Specifications

Heat Pump Model DH-12

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Capacity</td>
<td>19,800 BTU/Hr*</td>
</tr>
<tr>
<td>Cooling Capacity</td>
<td>15,200 BTU/Hr*</td>
</tr>
<tr>
<td>Voltage</td>
<td>208/230 phase 1</td>
</tr>
<tr>
<td>Circuit Ampacity</td>
<td>40 AMP</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>1.4 KW/Hr</td>
</tr>
<tr>
<td>C.O.P.</td>
<td>4.2*</td>
</tr>
<tr>
<td>Dimensions</td>
<td>24” x 24” x 39”</td>
</tr>
<tr>
<td>Weight</td>
<td>160 Lbs.</td>
</tr>
</tbody>
</table>

* 90°F entering air and 100°F entering water

Typical Heat Pump Specifications

813-251-1477
Finally, heat pumps last longer than resistance heaters. The expected useful life of the electric resistive block heater is 10 years based on results published by ASHRAE Insulation for Mechanical Systems Technical Committee 1.8, and 15 years for heat pumps. However, heat pump technology is continuing to improve. A 2005 study reported in *Air Conditioning/ Heating/Refrigeration News*, called Increasing Consumer Confidence in Heat Pumps, found that the observed median service life of a heat pump—when removed because of failure—was 26 years.

With a back-up system for your mission-critical EPS, your electricity is wired for success.

The patented GTS heat pump process operates with dual control thermostats and two contacts. The existing block heaters are wired to the secondary contactor, and controlled by the second stage of the thermostat. The heat pump becomes the primary heater unless the temperature drifts down to the block heater set-point. When the set-point is reached, the patented process shuts off the heat pump to avoid a freeze-up of the unit, and the block heaters kick into operation. Should the unit fail, the temperature will drift down to the set point for the block heaters. The block heaters and the alarm will also be activated, signaling there is a failure in the heat pump.

There are two possible causes for an alarm. The first is that the environment surrounding the emergency diesel generator does not have enough heat for the heat pump to operate properly. In this case, the heat pump will automatically resume operation as the primary heater when the ambient air temperature rises above 40°F. The second and less likely cause is that the heat pump may have failed.

At installation, heat pumps are wired in series with the existing block heaters, but installing a GTS heat pump system causes minimal disruption to the emergency power system. The actual installation of the heat pump, once electricity is available to connect the system, seldom takes longer than 90 minutes. The engine is only off-line a few minutes during this period. Once installed, it becomes a simple turn-key operation with an expected life over twenty years.

About Geo-Thermal Systems

GTS heat pumps save thousands of dollars annually for each installation while significantly reducing greenhouse emissions. GTS acquired patent rights to the process of connecting heat pumps to emergency diesel generators. Since that time, GTS has installed thousands heat pumps to save money, energy, and provide redundant heating for emergency diesel generators.

Sources


Emergency and Backup Power Sources: Preparing for Blackouts and Brownouts, Hordeski, Michael F.: Fairmont Press. 2005