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Power Generation

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Ambient temperature vs. air on core (AOC) temperature

White Paper

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ENERGY DISTRIBUTION IN A GENERATOR SET

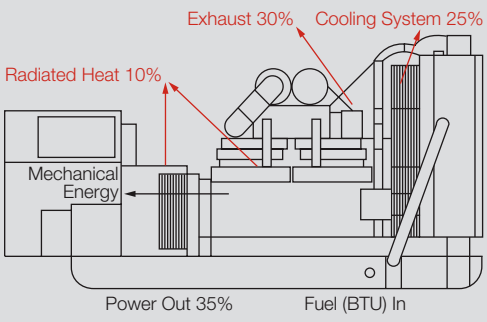

Figure 1: Typical heat rejections from a generator set

The demands of these power systems require a means of regulating engine temperature by taking away unused heat. The radiator is one of the primary means of regulating temperature, in essence functioning as a heat exchanger to transfer thermal energy from one medium to another.

As engines operate, they become hotter, as does the engine coolant. In order to cool an engine, radiators pass hot coolant though tubes exposed to a cooler ambient atmosphere and lose heat through radiation.

There are several ways of rating and classifying radiators, based on a variety of factors, including:

- Where they are installed (set mounted radiators versus remote radiators)
- What temperatures they are designed for (standard rating versus high ambient rating)
- How these ratings are achieved (ambient temperature versus air on core temperature)

This paper aims at differentiating between the ambient temperature vs. air-on-core (AOC) method of rating the performance of a cooling system used on a generator set.

Energy balance

Before we go into detail about rating a cooling system, it is worth exploring the energy distribution in a typical generator set.

Energy can neither be created nor destroyed, but it can be transformed. As we see in this schematic, the fuel we feed the generator set is the energy going in, and from this energy less than 40% (dependant on type of engine, combustion process, fuel used, type of the alternator, etc) is available as electrical output after accounting for typical diesel engine and alternator inefficiencies.

Much of the energy is lost as it simply transforms into heat. Most modern day diesel engines use turbochargers to utilize some of the energy from the exhaust, which otherwise would be lost to heat generation. However, there is still a considerable amount of heat radiated to the surrounding environment via hot surfaces and through coolant.

Ventilation

When designing a site for generator set installation, one factor to attend to is air flow. A ventilation design should account for the following:.

- Combustion air for the engine
- Cooling air for the alternator
- Removing room heat
- Cools engine (via radiator)

In Figure 2, ideal engine construction allows cool air to arrive from the inlet side, picking up heat around the generator set through the radiator, and leaving the other side as warm air.

VENTILATION LAYOUT

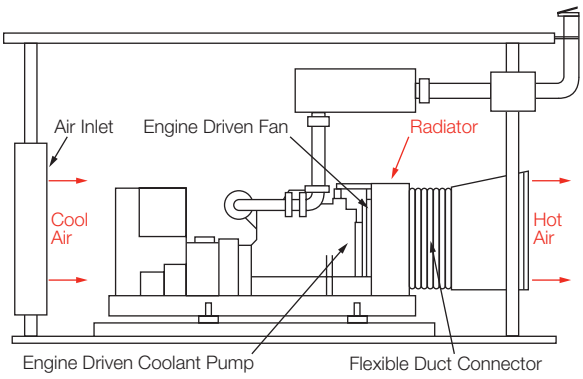

Figure 2: A typical ventilation layout for a genset mounted cooling system

Note that there is a significant temperature rise (from around 10 C) in the air as it moves across the system. This is a consequence of air heating as it comes in contact with the hot components in it's way to the radiator (alternator, engine and may be even the exhaust muffler which is another significant source of heat and should be insulated).

TOP VIEW OF A GENERATOR SET

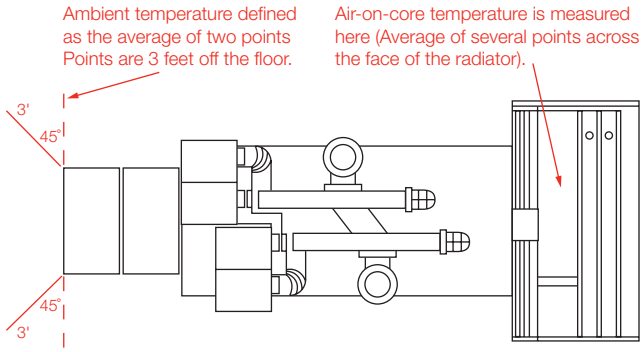

Figure 3: Measurement locations for ambient temperatures

Cooling systems rated for ambient temperatures

When a cooling system is rated for ambient temperatures, it is the temperature of air on the inlet side of the system, before it picks up heat from the alternator and engine components, that is being measured. This temperature is typically measured as an average of two points, which are at a distance of three feet from the alternator end of the generator set at an angle of 45 degrees and three feet above the ground as shown in Figure 3. In case of housed generator sets or generator sets in an enclosure, this temperature is typically measured at the air inlet louver.

The air flowing through the radiator, then, is significantly warmer than the air entering the system. In other words, the actual air on core temperature is higher than the cooling system temperature rating when the cooling system is rated at ambient.

About the author

Aniruddha Natekar started with Cummins Power Generation in 2007. As a Sales Application Engineer, he provides technical recommendations on installations, engineering support to customers, technical training to the sales force, and support for technical seminars.

Aniruddha has an M.S. in Automotive Engineering from Lawrence Technological University (Southfield, MI) and a B.S. in Mechanical Engineering from University of Pune (India). He has held positions in research & development, market research, engineering, and product development with various automotive companies.

Factory tested cooling system

There is no alternative to a tried and tested product coming straight from a manufacturer. A factory test, along with documented results, eliminates surprises and fault-finding that can arise from putting an engine and a cooling system together on site for the first time.

A good factory test will simulate the typical air flow in a power room, along with dedicated instrumentation. Ambient temperature will be measured at various points in the air so the cooling system is tested to the true ambient temperature environment.

A thermo cycle test is also recommended to evaluate radiator cores for mechanical stress relief. This will drastically reduce the possibility of premature failures, such has leaks. Additional use of mathematic simulation during radiator design will further enhance the compatibility of the cooling system with the generator set. Besides performance testing, endurance testing is recommended to estimate the lifespan of the equipment.

Conclusion

It should be noted that, even though there is more than one way to call out a cooling system, the purpose of ventilation at a generator set installation site is to account for air requirements to the following systems:

- Combustion air for engine
- Cooling air for alternator
- Room heat:
  including generator set surfaces and accessories as well as any additional sources of heat
- Heat rejection:
  from jacket water and charge air cooler

A factory provided cooling system will typically account for the entire system, and therefore will be well suited to the generator set. Take care when sourcing radiators by themselves, as the working temperatures mentioned for ‘loose radiators’ may not take into consideration the heat rejections from the rest of the system.

Take, for example, a factory tested generator set with a cooling system rated at 50 C ambient. Remember that, by the time the air actually reaches the core of the radiator, the temperature of the air could be around 60 C. So if a loose radiator is bought for this same generator, a 50 C rated radiator will refer to 50 C limiting temperature of the air contacting the core, and will fall short on performance.

For additional technical support, please contact your local Cummins Power Generation distributor. To locate your distributor, visit www.cumminspower.com.

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