

TechTopics No. 84

Space heater - sizing and application principles

Use of space heaters in metal-clad switchgear and in outdoor distribution circuit breakers is a frequent topic of discussion. These discussions make it clear that there is little understanding of why space heaters may be needed in enclosed switchgear, and what function they are intended to serve. Especially in these days of energy conservation, there is a strong temptation to de-energize space heaters or use adjustable thermostats set to a relatively low temperature, which keeps the space heaters turned off when they are needed most. Use of adjustable thermostats with low "off" temperature-settings greatly increases the likelihood of condensation.

The three most critical concepts to keep in mind with respect to space heaters are:

1. Space heaters are intended to reduce the likelihood of condensation on insulation.
2. See item 1.
3. See item 1.

The key point is that space heaters have nothing to do with human comfort.

The fundamental goal is to reduce the chance that condensation will occur on insulating surfaces, and condensation is, perhaps, the number one problem with electrical installations. When users experience insulation problems in switchgear or in outdoor circuit breakers, more often than not the root cause can be traced to moisture (condensation), sometimes exacerbated by the presence of dirt and other contamination.

Siemens viewpoint is that space heaters are intended to minimize condensation, and must be energized at all times. When space heaters are furnished in equipment, our standard practice is to continuously energize the space heaters. When the user requires thermostatic control, Siemens furnishes a non-adjustable thermostat in each vertical section of the equipment. The thermostat turns the space heaters "on" when the temperature inside that vertical section is lower than approximately 40 °C (104 °F).

How did Siemens arrive at this practice? The goal of using space heaters is to raise the temperature inside the enclosure so that the temperature is high enough to prevent condensation in most reasonable circumstances. The basic tool for this discussion is the psychrometric chart, which is available at many websites, such as www.uigi.com/UIGI_IP.pdf, www.truetex.com/psychrometric_chart.htm, and others. An example of a psychrometric chart is included on page two, but the reader is encouraged to search for these charts on the internet, where charts with a greater level of detail are readily available.

In the psychrometric chart (refer to page two of this issue), the curved line that is the upper limit on the chart is the line that indicates 100 percent relative humidity. Condensation is probable when the air inside the enclosure is saturated with water vapor, which is the situation with 100 percent relative humidity. The goal is to raise the temperature inside the enclosure to decrease the relative humidity to a point where condensation is unlikely. Siemens considers that if the relative humidity is reduced to 80 percent or lower, then the likelihood of condensation occurring is reduced to a reasonable degree.

PSYCHROMETRIC CHART

Normal Temperatures
Barometric Pressure
29.92 Inches of Mercury

Air Conditions/Quantity
O.A. _____ DB _____ WB _____ CFM
R.A. _____ DB _____ WB _____ CFM

Total CFM = _____
$$t_{ea} = \frac{(CFM\ OA \times t_{oa}) + (CFM\ RA \times t_{ra})}{Total\ CFM}$$

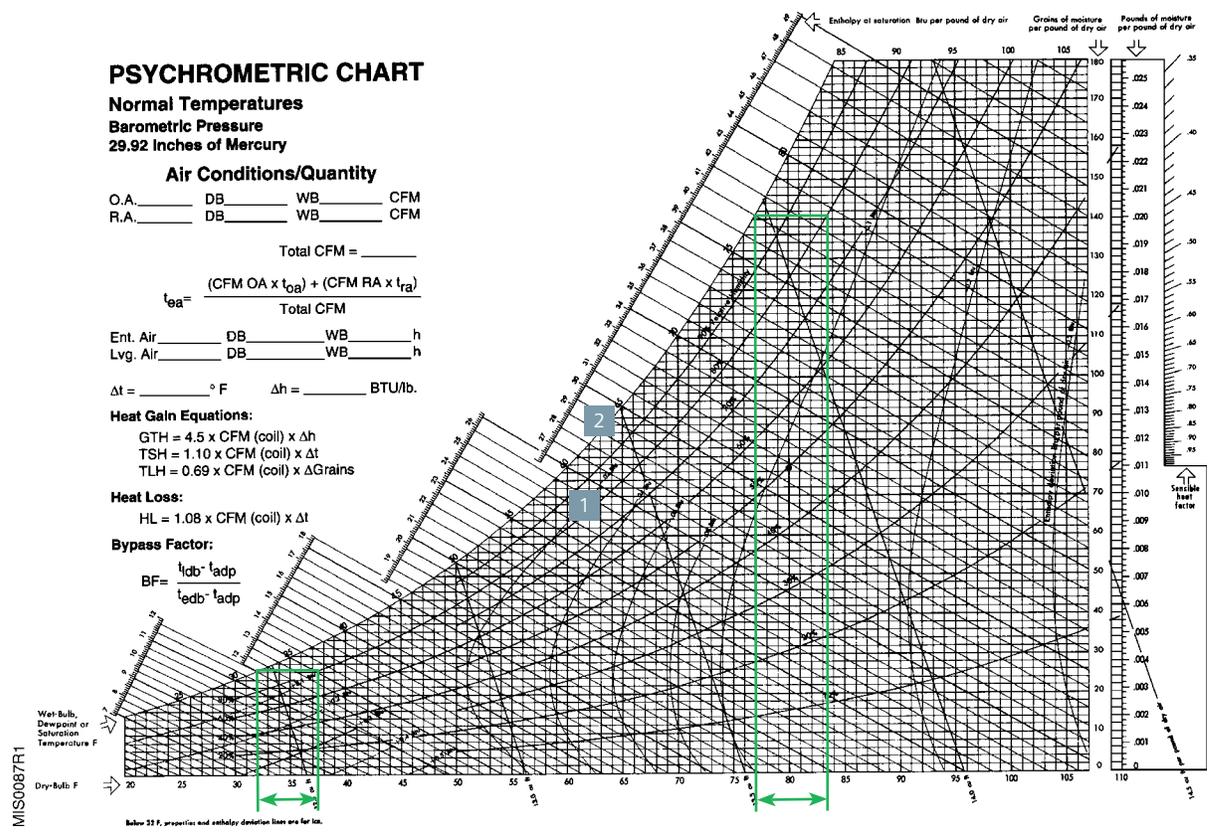
Ent. Air _____ DB _____ WB _____ h
Lvg. Air _____ DB _____ WB _____ h
 $\Delta t = \text{_____ } ^\circ F$ $\Delta h = \text{_____ } BTU/lb.$

Heat Gain Equations:
GTH = 4.5 x CFM (coil) x Δh
TSH = 1.10 x CFM (coil) x Δt
TLH = 0.69 x CFM (coil) x $\Delta Grains$

Heat Loss:
HL = 1.08 x CFM (coil) x Δt

Bypass Factor:
$$BF = \frac{t_{db} - t_{adp}}{t_{db} - t_{adp}}$$

Psychrometric Chart



5.2 °F
(2.9 °C)



Engineering

6.3 °F
(3.5 °C)

- 1. Relative humidity 80%
- 2. Relative humidity 100%

Again, looking at the psychrometric chart, consider an example of a temperature of 32 °F (0 °C) and 100 percent relative humidity. To reduce the relative humidity to 80 percent, the temperature inside the enclosure would have to be increased by 5.2 °F (2.9 °C), as shown by the lines plotted on the chart.

For a second example, consider a temperature of 77 °F (25 °C) and 100 percent relative humidity. To reduce to 80 percent relative humidity would require an increase in the temperature inside the enclosure of 6.3 °F (3.5 °C).

Two conclusions arise from these examples. First, only a moderate increase in temperature is needed to reduce the likelihood of condensation occurring. Second, the absolute temperature is irrelevant. If the relative humidity is 100 percent inside the enclosure, regardless of the temperature inside the enclosure, supplemental heating is needed to drive the relative humidity down to a reasonable value, or there will be a strong likelihood of condensation. It is this last point that leads to our conclusion that space heaters must be energized at all times to minimize the likelihood of condensation occurring.

All of this assumes the worst case, in which the equipment is not carrying substantial current. In olden days, some engineers argued that if the equipment were energized, the losses in the equipment would be sufficient to prevent condensation. The reality is that, in many cases, this is valid. However, in many cases, it is not valid.

A very simple example will illustrate the dilemma. Suppose there is a 1,200 A circuit breaker unit, and suppose that this unit is carrying 200 A.

If the circuit breaker unit meets the ANSI/IEEE C37.20.2 limits on temperature rise, the highest temperature rise at 1,200 A would be 65 °C. In many instances, it would be lower, but we can use 65 °C for this discussion.

What would the highest temperature rise of the buses and connections in this example unit be with a current of 200 A instead of 1,200 A? Heating is a function of the square of the current and the resistance. For a given unit, resistance is constant, so the temperature rise of the 1,200 A unit at 200 A actual current would be $(200^2/1,200^2) \times 65 \text{ } ^\circ C = 1.8 \text{ } ^\circ C$ (3.2 °F).

Also, this level of temperature rise in the conductors would be considerably higher than the resulting increase in temperature of the air inside the enclosure. From the psychrometric chart calculations performed earlier, this would not be sufficient to reduce the likelihood of condensation to the extent that Siemens would feel comfortable with.

The example above assumes a modest current of 200 A, one-sixth of the circuit breaker rating for this example. It should be clear that the situation is more severe in the case of a circuit that is not carrying current, such as for a normally-open tie circuit breaker, where the heat generated during normal operation is essentially none.

From the examples discussed, a rule-of-thumb was selected that the air temperature inside the enclosure should be raised about 4 °C (7.2 °F) in order to have reasonable confidence that the relative humidity will be reduced to 80 percent, and the risk of condensation mitigated.

From this discussion, one can understand why Siemens position is that space heaters should be energized at all times. The exception to this would be when the load being carried in the unit is high enough to produce significant heating of the air in the enclosure so as to reduce the relative humidity to 80 percent or less. This level of temperature rise on bus and connections is likely to be significantly higher than just 4 °C, as all of the heat in the bus bars would not convert into heating of the air in the enclosure.

Siemens often receives requests for adjustable thermostats from users. We speculate that the desire for an adjustable thermostat comes from confusion between personnel comfort and the need to minimize condensation. The use of an adjustable thermostat is an invitation for the user to reduce the thermostat setting to save energy, in the process, significantly increasing the likelihood of condensation. As the likelihood of condensation increases, so also does the likelihood of ultimate catastrophic failure due to condensation.

Siemens practices and recommendations are:

- Space heaters are a highly recommended option for any installation, especially any application where the likelihood of condensation is relative high. Space heaters are a standard component of any outdoor switchgear or outdoor circuit breakers that we supply.
- As standard, we prefer to continuously energize space heaters, and no thermostat is provided.
- When thermostatic control is required, a non-adjustable thermostat should be used in each vertical section. Our standard thermostat is selected to open at 110 °F +/- 5 °F and close at 100 °F +/- 5 °C temperature inside the enclosure. This keeps the space heaters “on” at all times unless the temperature inside the enclosure exceeds 110 °F +/- 5 °C.

- If adjustable thermostats are used, they should be set to keep the space heaters “on” in line with the values given above for our non-adjustable thermostat.
- A single thermostat for an entire lineup **should not** be used. The amount of heat generated by current in each vertical section differs, and space heating may be needed in some vertical sections, but not in others.
- The need for heat to minimize condensation is higher at higher temperatures than it is for lower temperatures. In the 32 °F (0 °C) example, a temperature increase of 2.9 °C is needed to bring relative humidity down to 80 percent, whereas at 25 °C, an increase of 3.5 °C is needed.

This discussion does not deal with the need to reduce the likelihood of condensation in low-voltage compartments (for example, in control and protective relay compartments). The focus of this discussion is on the high-voltage components.

Space heaters are often not specified for use in indoor switchgear, as indoor switchgear is often in a climate controlled area in which the relative humidity is maintained at levels at which condensation is unlikely to occur.

One last observation before this discussion is closed. The possibility always exists that the rate of change of outside temperature and humidity can exceed the rate at which the equipment can respond in reducing relative humidity inside the enclosure. In such instances, condensation can occur. The object of using space heaters is to reduce the likelihood of condensation occurring, but no system can fully eliminate the possibility.

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Order No.: E50001-F710-A460-V1-4A00
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