10 Tips on Maximizing Heater Performance

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Many plant engineers do not give much thought to the heaters operating within their processes and applications - unless those heaters fail, require significant maintenance or cause other problems. Unfortunately, heaters play an integral role in many applications. Therefore, heater problems can easily snowball and lead to much larger headaches.

Following a few simple guidelines will not only reduce the likelihood of heater-related issues, but can actually have a significant positive impact on the efficiency of systems and reduce maintenance requirements and costs. Below are 10 ways to maximize a heater's service life and performance.

Tip 1: Guard against heater contamination
Contamination is the most frequent cause of heater failure (see images). As heaters expand and contract during cycling, they often draw in organic or conductive materials. This can lead to an arcing failure between individual heater windings or between heater windings and the electrically grounded outer heater sheath. When allowed to collect at the lead end of a heater, contaminants can also cause electrical shorts between power pins or terminals. Therefore, it is important to keep lubricants, oils, low-temperature tapes or processing materials out of contact with the lead end of the heater. Employing seals will help.

Tip 2: Protect leads and terminations from high temperatures and excessive movement
Standard fiberglass-insulated lead wire may be used in applications with ambient temperatures up to approximately 260°C (500°F). If a lead is exposed to higher temperatures, high-temperature lead wire or ceramic bead insulation should be used. An unheated section of the heater, extending away from the heated region of the system, enables the leads to run at a beneficially cooler temperature.

When heaters are mounted in moving machinery, it is essential to anchor the leads to prevent them from being damaged. A lead protection option should be specified and used for optimum protection against lead damage.

Tip 3: Heater selection and sizing are important
A heater's wattage should be matched as closely as possible to the application's actual load requirements to limit ON/OFF cycling (see tip 6). For fitted-part applications, specify the hole or an alternative application feature size to ensure an optimal fit between the heater and application feature. A tight fit minimizes air gaps and reduces the instances of hot spotting.

Tip 4: Ground the equipment
It is common sense and safe practice to electrically ground all equipment on which the heater is used. Grounding equipment helps protects plant and personnel in the event of an electrical failure in the heating system. TOP

Tip 5: Regulating voltage ensures the rated heater voltage matches voltage supply
It is essential to ensure a heater's rated voltage matches the available voltage supply because wattage increases (or decreases) at the square of the change in voltage

applied to a heater. For example, if a heater is rated for 120V/1000W and is connected to a 240V supply, it will generate four times the rated wattage output or 4000W. This will cause a heater to fail relatively quickly and can also cause significant damage the attached equipment.

Tip 6: Prevent excessive heater cycling
Excessive temperature cycling is very detrimental to the life of a heater. The most detrimental is the cycle rate that allows full expansion and contraction of the heater resistance wire at a high rate (30 to 60 seconds' power ON and power OFF). This causes severe stress and oxidation of the resistance wires inside a heater. A bad temperature cycle is typically found when thermostats are used. Thermostats respond slowly to temperature changes and have large switch ON/OFF temperature differentials. An improvement, but a somewhat more expensive solution, is to use ON/OFF or PID controllers with mechanical relays. It is crucial to not switch the frequency or cycle time too rapidly (somewhere between 3 to 10 seconds), because the relay contacts can wear out quickly.

The most effective way to minimize heater element temperature cycling, and the most expensive solution, is to use solid state relays (SSRs) and SCR power controllers coupled to PID temperature controllers. This combination provides the best performance for both your thermal system as well as for the heater itself. Solid state switching devices cycle power to the heater very rapidly (from one second with a SSR, down to milliseconds with phase-angle fired SCRs). This fast-power cycling dramatically reduces heater element wire temperature excursions and substantially extends heater life.

Tip 7: Ensure that the sheath material and watt density ratings are compatible with the material being heated
This is absolutely critical to ensure long heater life and healthy processing equipment. When heating solids, such as metals, the operating temperature and heater-to-part fit drive sheath material and watt density choices. Carbon steels, aluminum, silicone rubber sheath materials are fine for lower temperatures (a few hundred degrees). However, as temperatures increase beyond this point, sheath material choices become limited to galvanized or stainless steels and other higher temperature metal alloys. As temperature also increases, the watt density must decrease accordingly to prevent internal resistance wires from oxidizing quickly and failing prematurely. A good heater-to-part fit ensures proper heat transfer and does not force the resistance wires to overheat.

When heating gases, the operating temperature and flow rates dictate what sheath material and watt density can be used. For example, you can run higher watt densities when heating hydrogen versus nitrogen, but hydrogen requires Incoloy 800 sheaths, whereas 304 Stainless Steel will work for many nitrogen applications.

Increasing flow and turbulence across the heater elements means better heat transfer, which raises watt density values. For liquid heating, the prime driver for materials and watt density selection is the fluid material and flow rate. Water can easily handle 42.52 to 70.87W/cm^2 (60 to 100W/in^2) using a copper sheath, whereas a 50/50-water/glycol mix can only handle 21.26 W/cm^2 (30 W/in^2) and must use a steel sheath.

Tip 8: Mount immersion tank heaters horizontally near the tank bottom
Heaters should be placed horizontally and near tank bottoms to maximize convective circulation. Vertical mounting is only advisable when limitations, such as space restrictions, prohibit horizontal placement. Regardless of whether a heater is mounted horizontally or vertically, it is essential to place it high enough to avoid any sludge and debris buildup in the bottom of the tank. Likewise, for both mounting methods, the entire heated length of the heater must be immersed at all times - one reason vertical mounting is rarely recommended. It is also important to avoid placing heaters in restricted spaces that limit convective flow and/or where free boiling or steam traps can occur.

Tip 9: Prevent build-up and sludge on the heater elements
Scale, coking and sludge build-up on heater sheaths must be minimized. Any accumulation should be periodically removed or at least minimized, to avoid inhibiting heat transfer to the liquid. Periodic cleaning prevents heater elements being forced to operate at higher temperatures, which can lead to early heater failure. Extreme care should also be taken to avoid getting silicone lubricant on the heated section of a heater. Silicone will prevent the "wetting" of the sheath by the liquid, act as an insulator, and possibly cause the heater to fail.

Tip 10: Ensure proper, tight temperature control and safety limit protection
Matching the appropriate temperature control system to the heater is imperative to strong heater performance and life. Each process application should, at the very least, include a process temperature sensor (to sense the material being heated) and a limit sensor (to sense the heater sheath temperature). The process sensor should be directly immersed into the material to be heated, or snugly inserted into a thermowell inside the fluid itself. For safety reasons, two separate control systems should be used - one for process temperature control and one for high limit control. PID type process temperature controllers offer more stable control and faster response than ON/OFF switching controls or thermostats. The trade off is that PID control is often more expensive than ON/OFF types and not always necessary for applications that do not require highly accurate temperature control.

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