How To Safely Select Electric Immersion Heaters

Prevent injuries and property damage by selecting the right immersion heater and then maintaining it . . .

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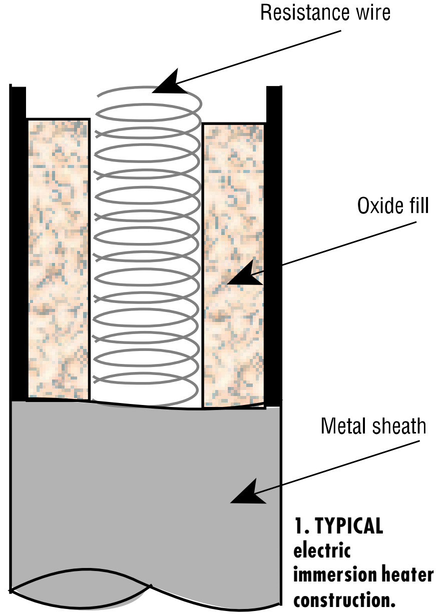

1. TYPICAL electric immersion heater construction.

Electric immersion heaters use high-voltage and therefore pose hazards to personnel working with them as well as equipment and facilities. Care is needed to properly select, install and service electric immersion heaters.

Modern electric immersion heaters are constructed using an alloy-resistance wire encased in a corrosion-resistant metal sheath. The resistance wire is surrounded by an electrically insulating, thermally conductive metal oxide powder. The wire and the powder fill are encased in a metallic sheath and then reduced to compress the oxide film and optimize its insulating and conductive properties.

Electric immersion heaters of this

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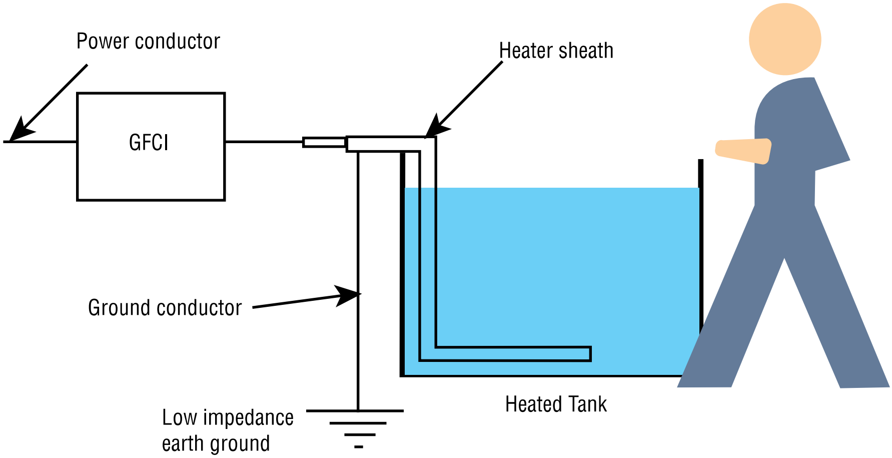

2. TYPICAL finishing tank setup with immersion heaters and ground-fault circuit interrupter.

type, when manufactured in accordance with UL, CSA or other recognized standards, are subjected to a high-voltage-withstand test (twice the rated voltage, which is + 1,000 volts for one min) to assure that the resistance wire is centrally located and that the compacted powder has reached an adequate dielectric strength. A current leak as little as two mA can be cause for rejection.

Since only the outer metal sheath contacts a potentially corrosive substance, a variety of metals (stainless steel, titanium) and combinations of metals and polymers such as Teflon® are available to resist or eliminate the effects.

Grounding. The outer metal sheath can serve as a continuous-grounding conductor when connected to a suitable earth ground. Without a grounding conductor, any mechanical or corrosive penetration of the heater sheath could permit a current path from the electrically energized resistance wire through the solution and potentially through an operator contacting the solution or tank. A properly connected ground shunts this power away and improves the safety for operating personnel.

The earth ground should be installed in accordance with the National Electric Code, section 250-84, latest edition. A high-impedance earth ground permits the heater to continue operation with the ground fault acting as a power conductor. This ground-fault current flow may be insufficient to trip the primary circuit breaker or fuse.

A GFCI (ground fault circuit interrupter) provides additional safety. Where a ground fault is detected, power is removed in milliseconds, reducing operator exposure to potential electrical shock. Specify a UL listed/CSA certified, groundable, electric immersion heater and install it using a tested earth ground and properly sized GFCI.

A second and equally important consideration is potential property loss resulting from overheating. Electric immersion heaters can achieve temperatures above 6,000F (the minimum temperature of an electric arc), but are more likely to fail at 2,000F (the melting point of the resistance wire). This potential temperature is higher than the ignition temperature for most plastics commonly used for equipment in corrosive applications.

Over temperature due to solution loss. Over temperature is typically the result of solution loss. The solution is a heat sink that conducts the heat generated by the immersion heater away from the heater. A small loss of liquid will cause an over-temperature condition to occur. This is because air is less conductive than liquid.

Conductivity varies from liquid to liquid, with ultrapure water being the most conductive and solidified oil being one of the least conductive. Conductivity can be approximated using the specific heat of the solution and its viscosity. The lower a solution's specific heat and/or higher viscosity, the less heat conductive is the solution.

Encrustation on the heater surface inhibits the conductivity of the heater. Encrusted heaters operating in air have the highest surface temperatures, while heaters operating in ultrapure water have the lowest surface temperatures. A heater's surface temperature when operating in water is approximately 50 deg F higher than the water. Similar measurements in air indicate upwards of 1,000 deg F higher differentials. Similar values have been seen on encrusted heater surfaces.

Installation. To control the surface temperature, a practical approach towards heater selection and installation is needed.

First, ensure that the heater is completely immersed in the solution at all times. This is usually accomplished using a level switch that is electrically interlocked with a heater's power circuit. A good level switch withstands mechanical abuse and will "fail safe," disconnecting heater power if damaged or disabled. Solids buildup and the effects on the level switch must be considered. If buildup renders the switch inoperable, the switch should be eliminated from consideration.

Second, select a heater that is equipped with a sheath-responsive over-temperature switch. These switches can be eutectic (one-shot fusible link or pellet) style, bimetallic style or sensor-remote controllers. The response temperature should be selected based on the thermal properties of the solution (conductivity/viscosity) but never higher than the lowest ignition temperature of the tank material or the thermal decomposition products of the tank materials.

Third, know the properties of the solution to be heated. If the conductivity is poor and/or the viscosity is high, select a "derated" heater. These

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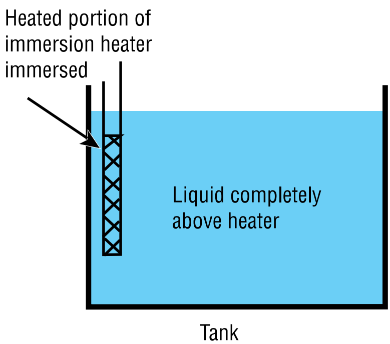
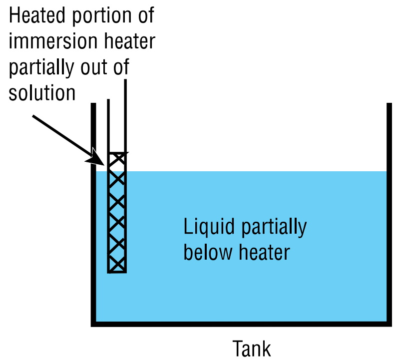




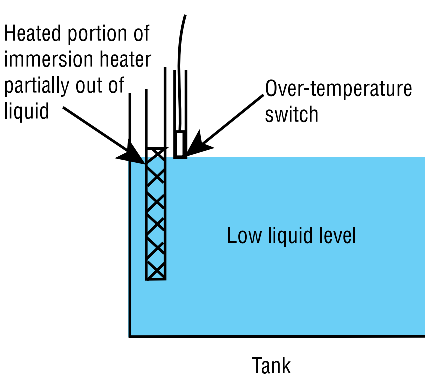
3. OVER-TEMPERATURE often results from solution loss.

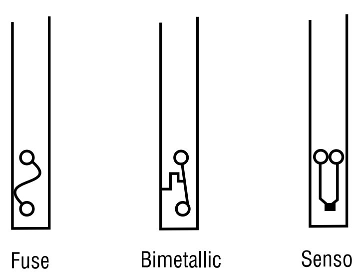
heaters have a higher surface-area-to-power input ratio. This ratio is commonly referred to as watt density and expressed in terms of watts per sq inch. Usual watt densities range from 40 for average aqueous solutions to 10 for oils.

Watt Density vs. Btu/hr/sq ft
one watt(hr) = 3.412 Btu(hr)
one watt/sq in = 490 Btu/hr/sq ft

The lower watt densities result in lower sheath temperatures, when the sheath is clean. Encrustation will result in higher sheath temperatures at any watt density. If a heater becomes encrusted, clean it. However, be careful how you clean the heater. Hammering the encrustation will disturb the compacted oxide fill and shorten heater life. Scraping will remove the sheath's passive film or cut the heater's polymer covering, resulting in exposure to corrosives. If possible, use chemical removal methods that will leave or remove the passive film on the heater sheath. If scraping is the only way, exercise caution and, when through, passivate the heater sheath to restore its corrosion-resistant properties.

4. SHEATH TYPES with over-temperature switch





Over-temperature Switch Types

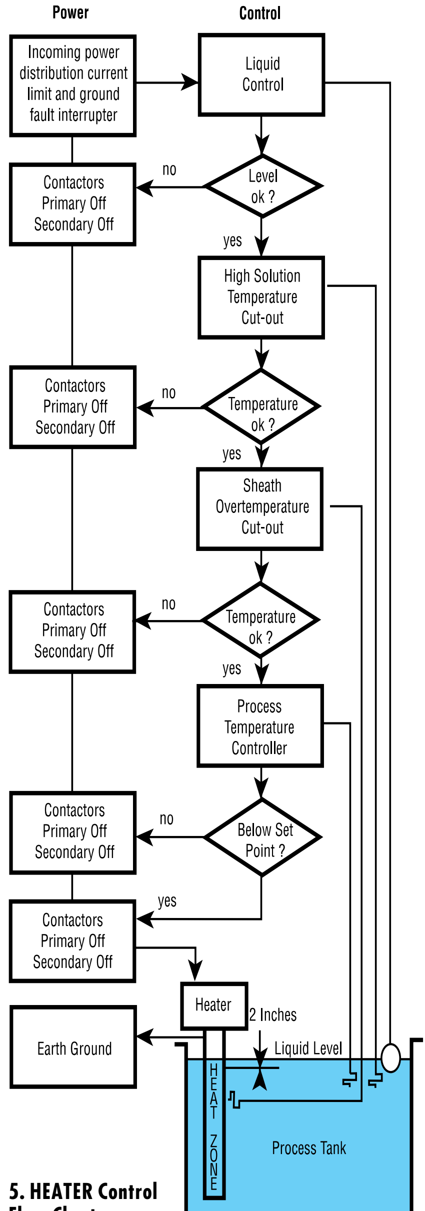
In extremely difficult heating situations it is often justifiable to install a closed-loop recirculating heating system where heating solution is pumped from a remote electric heater through an immersed heat exchanger. The surface temperature of the immersed exchanger will not exceed the temperature of the circulated solution. The electric recirculating heater must be equipped with low-liquid-level switches, sheath over-temperature switch, high-solution-temperature switch and recirculating-pump flow-rate interlocks. A GFCI is also recommended.

Temperature Controllers. Once you have selected the proper immersion heater, you must select the proper accessories to assure safe operation.

There are two basic types of temperature controllers: mechanically operated, such as filled bulb and capillary systems and bimetallic systems; and electrically operated systems. Mechanical systems are inexpensive but are prone to inaccuracy and do not "fail safe." Electronic systems cost more and can be installed "fail safe," but are prone to occasional noise malfunctioning. "Fail safe" is defined as any component failure that will result in the heater de-energizing.

When selecting a controller ask the following four questions. Will the heater shut off if:

1. The sensor is disconnected (sensor bulb severed)?
2. The sensor is short circuited (sensor bulb crushed)?
3. Control power is interrupted?
4. A control component fails?



5. HEATER Control Flow Chart

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If the answer to any question is no, carefully consider the consequences if you select that controller.

Installation of an additional temperature control to serve as a "high-temperature cut-off" is encouraged, since the usual cause of an over-temperature condition is liquid loss. The addition of this second control, set five to 10 degrees above the normal operating temperature, will shut off heater power if the liquid temperature is accidentally or intentionally increased. Many operators are under the mistaken notion that increasing the set-point temperature setting will increase that tank heating rate. If the operator is distracted after making such an adjustment, and the tank operates at this higher set point, a dangerous over-temperature condition can result.

The selected temperature controller must be combined in a package that will:

- Handle the power requirements
- Permit the use of the sheath-responsive over-temperature switch
- Permit the use of the low-liquid-level switch
- Permit the use of a GFCI
- Permit the use of the high-temperature cut-off
- Meet the safety requirements of the National Electric Code and other jurisdictional requirements.

Careful selection of an immersion heater, as well as regular maintenance, proper use and operator awareness will lessen the possibility of accidents in the plating shop. It will also provide you with a heater that lasts and performs consistently. **PF**

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