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General Method for Determining Heater Requirements

Most electrical heating problems can be readily solved by determining the heat required to do the job. To do this, the heat requirement must be converted to electrical Power and the most practical heater can then be selected for the job. Whether the problem is heating solids, liquids or gases, the method, or approach, to determining the Power requirement is the same.
All heating problems involve the following steps to their solution:

Step 1: Define the Heating Problem
•Gather application information
•Sketch problem for visual reference
Step 2: Calculate Power Requirements
•System start-up power requirement
•System maintenance power requirements
•Operating heat losses
Step 3: Review System Application Factors
•Operating temperature
•Operating efficiency
•Safe/permissible watt densities
•Mechanical considerations
•Operating environment factors
•Heater life requirements
•Electrical lead considerations
Step 4: Select Heater
•Type
•Size
•Quantity
Step 5: Select Control System
•Type of temperature sensor and location
•Type of temperature controller
•Type of power controller

Defining the Problem

Your heating problem must be clearly stated, paying careful attention to defining operating parameters. Take these into consideration:

•Minimum start and finish temperatures expected
•Maximum flow rate of material(s) being heated
•Required time for start-up heating and process cycle times
•Weights and dimensions of both heated material(s) and containing vessel(s)
•Effects of insulation and its thermal properties
•Electrical requirements — voltage
•Temperature sensing methods and location(s)
•Temperature controller type
•Power controller type
•Electrical limitations
•And since the thermal system you're creating may not take into account all the possible or unforeseen heating requirements, don't forget a safety factor. A safety factor increases heater capacity beyond calculated requirements.

Calculations for Required Heat Energy

When performing your own calculations, refer to Equations for values of materials covered by these equations.

The total heat energy (kWh or Btu) required to satisfy the system needs will be either of the two values shown below depending on which calculated result is larger.

•Heat required for start-up
•Heat required to maintain the desired temperature

The power required (kW) will be the heat energy value (kWh) divided by the required start-up or working cycle time.

The kW rating of the heater will be the greater of these values plus a safety factor.

The calculation of start-up and operating requirements consist of several distinct parts that are best handled separately. However, a short method can also be used for a quick estimate of heat energy required.

Safety Factor Calculation

You should always include a safety factor of varying size to allow for unknown or unexpected conditions. The size of the safety factor is dependent on the accuracy of the wattage calculation. Heaters should always be sized for a higher value than the calculated figure. A factor of 10% is adequate for small systems that are closely calculated; 20% additional wattage is more common. Safety factors of 20% and 35% are not uncommon, and should be considered for large systems, such as those containing doors that open or are large radiant heat applications. You'll also want to predict how long your system will operate without failure, so examine the amount of heater life you'll be needing. And because electricity costs money, take efficiency factors into account so your system will cost as little as possible to operate.

With these considerations in mind, carefully review them all to be sure you do, in fact, have definitive information to decide on a particular solution to your heating problem. Some of this supporting information may not be readily available or apparent to you. You may find it necessary to consult the reference tables and charts in this reference data section, or reference a book that deals with the particular parameter you need to define. At the minimum, the thermal properties of both the material(s) being processed/heated and their containing vessel(s) will be required.
Figuring a safety factor requires some intuition on your part. The list of possible influences can be great. From changing ambient operating temperatures, caused by seasonal changes, to a change in material or material temperature being processed, you must carefully examine all the influences. Generally speaking, the smaller the system with fewer variables and outside influences---the smaller the safety factor. Conversely, the larger the system and the greater the variables and outside influences — the greater the safety factor.

Here are some general guidelines:
•10% safety factor for small systems with closely calculated power requirements
•20% safety factor is average20% to 35% for large systems
The safety factor should be higher for systems that have production operations that contain equipment cycles subjecting them to excessive heat dissipations, e.g.: opening doors on furnaces, introducing new batches of material that can be of varying temperatures, large radiant applications and the like.