industry: energy processes
authors: scott boehmer & mike bange

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subject:

Determining Temperature Class for Electric Process Heaters

summary:

Electric process heaters that interface with flammable materials in explosive environments need to be properly evaluated to protect the equipment against catastrophic failures. There are several possible protection methods that may be employed to protect from a potential explosion. A temperature class requirement will be provided by the user based on the explosive gases that may be present in the installation area. The maximum surface temperature of the process heater must then be evaluated to assure compliance.

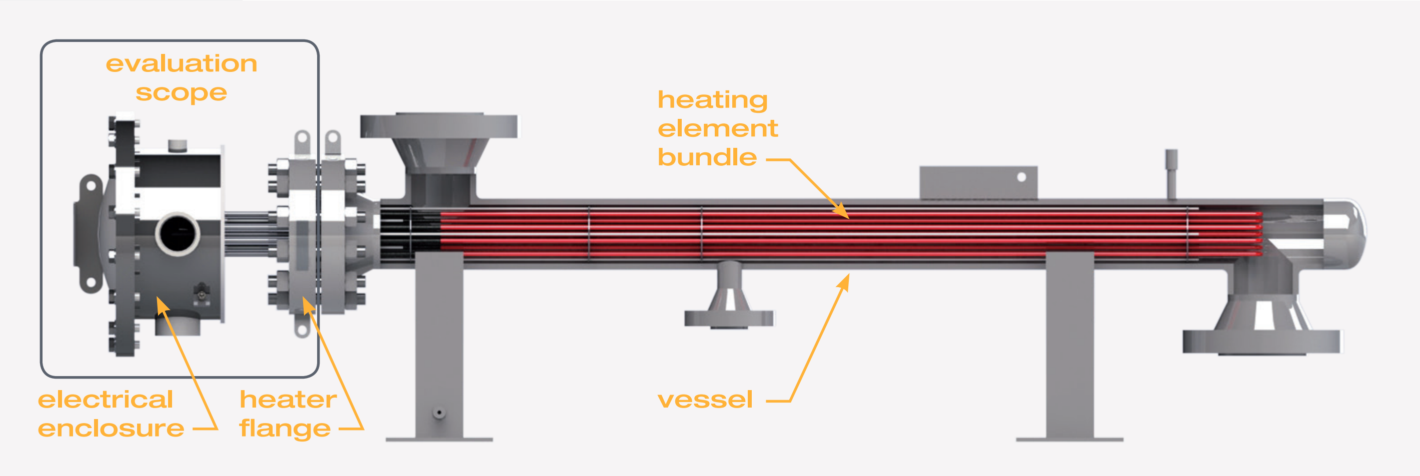
Temperature classes that are based on the maximum operating temperature for heaters prescribe the level of safeguards. Determining the temperature class for a specific electric process heater is unique compared to other electrical components installed in classified locations. The temperature code, or T-code, is highly dependent on the process conditions of the heating application. Global Temperature Classes/Codes are broken down into the following various levels.

codes:

Zones	Divisions	Temperature
Temperature Class IECEx, ATEX, U.S., CA	Temperature Code U.S., CA	Maximum Surface Temperature (°C)
T1	T1	450
T2	T2	300
	T2A	280
	T2B	260
	T2C	230
	T2D	215
T3	T3	200
	T3A	180
	T3B	165
	T3C	160
T4	T4	135
	T4A	120
T5	T5	100
T6	T6	85

system details:

Some end users may believe and request that the temperature classification be based solely on the temperature of the terminal enclosure. However, current standards for the general requirements of equipment to be installed in explosive atmospheres state that an external source of heating must be considered in the product evaluation. If end users do not factor in temperatures from the flange to the electrical enclosure, the wrong T-code could be used, which could mean a heater may not be properly certified and fail inspection thereby increasing delays and costs for end users.



definitions & envelope boundary:

The first step is to understand the primary definitions and envelope boundary for the temperatures of interest.

Per EN/IEC 60079-0, Section 3, Terms and Definitions

Maximum Surface Temperature: The highest temperature attained during service under the most adverse conditions (but within the specified operating tolerances) by any part or surface of the heater bundle that is exposed to the atmosphere. NOTE: For electrical equipment in an explosive gas atmosphere, this temperature may occur on an internal component (internal to the enclosure) or on the external surface of the enclosure/heater flange/standoff, etc., depending upon the type of protection employed.

Enclosure Service Temperature: The maximum or minimum temperature reached at specific points of the equipment when the equipment is operating at rated conditions, including ambient temperature and any external sources of heating or cooling.

Enclosure Internal Temperature: The maximum air temperature reached inside the terminal enclosure when the equipment is operating at rated conditions, including ambient temperature and any external sources of heating or cooling.

certification requirements:

Next, we need to understand the requirements of the applicable codes, which typically are determined by the country where installation happens. North American regulations (NEC Article 500 and CSA C22.2) are different than European regulations (EN 60079-0) as well as international regulations (IEC 60079-0). However, each of these standards specify that influence from an external source of heating must be included in the determination of the maximum surface temperature. For an electric process heater assembly, this means that the heat generated inside the terminal enclosure needs to be considered as well as the temperature of the flange and other exposed surfaces. The temperature impact of this entire area must be included in the evaluation of maximum surface temperature.

Per EN/IEC 60079-0 section 5 references below:

5.1.2 External source of heating or cooling	
Where the equipment is intended to be physically connected to or influenced by a separate external source of heating or cooling, such as a heated or cooled process vessel or pipeline, the ratings of the external source shall be specified in the certificate and in the manufacturer's instructions.	
NOTE 1	The external source of heating or cooling is frequently referred to as the "process temperature."
NOTE 2	The way in which these ratings are expressed will vary according to the nature of the source and the installation. For sources generally larger than the equipment, the maximum or minimum temperature will usually be sufficient. For sources generally smaller than the equipment, or for heat conduction through thermal insulation, the rate of heat flow may be appropriate. Alternatively, the rating is often expressed by specification of a temperature at a defined accessible point on the equipment.
NOTE 3	The influence of radiated heat may need to be considered on the final installation. See IEC 60079-14

5.3.1 Determination of maximum surface temperature
Maximum surface temperature shall be determined according to 26.5.1 considering the maximum ambient temperature and, where relevant, the maximum rated external source of heating.

procedure:

1. The first step in calculating a preliminary T-code is to determine the maximum surface temperature and internal enclosure air temperature based on the heater design operating in the most demanding conditions while remaining within design specifications. These conditions include: maximum process temperature influence, full power/amperage operation, maximum ambient temperature for installation location and solar load if applicable.

   As Watlow engineers have proven, the internal enclosure air temperature is impacted by the pins that attach heating elements to the electrical termination. With enough amperage flowing through them, the pins and other electrical supply connections can act as individual "small" heaters and could dramatically increase the temperature within the enclosure. (See Watlow's "Better Predicting Terminal Enclosure Temperature to Improve Heater Reliability" white paper)

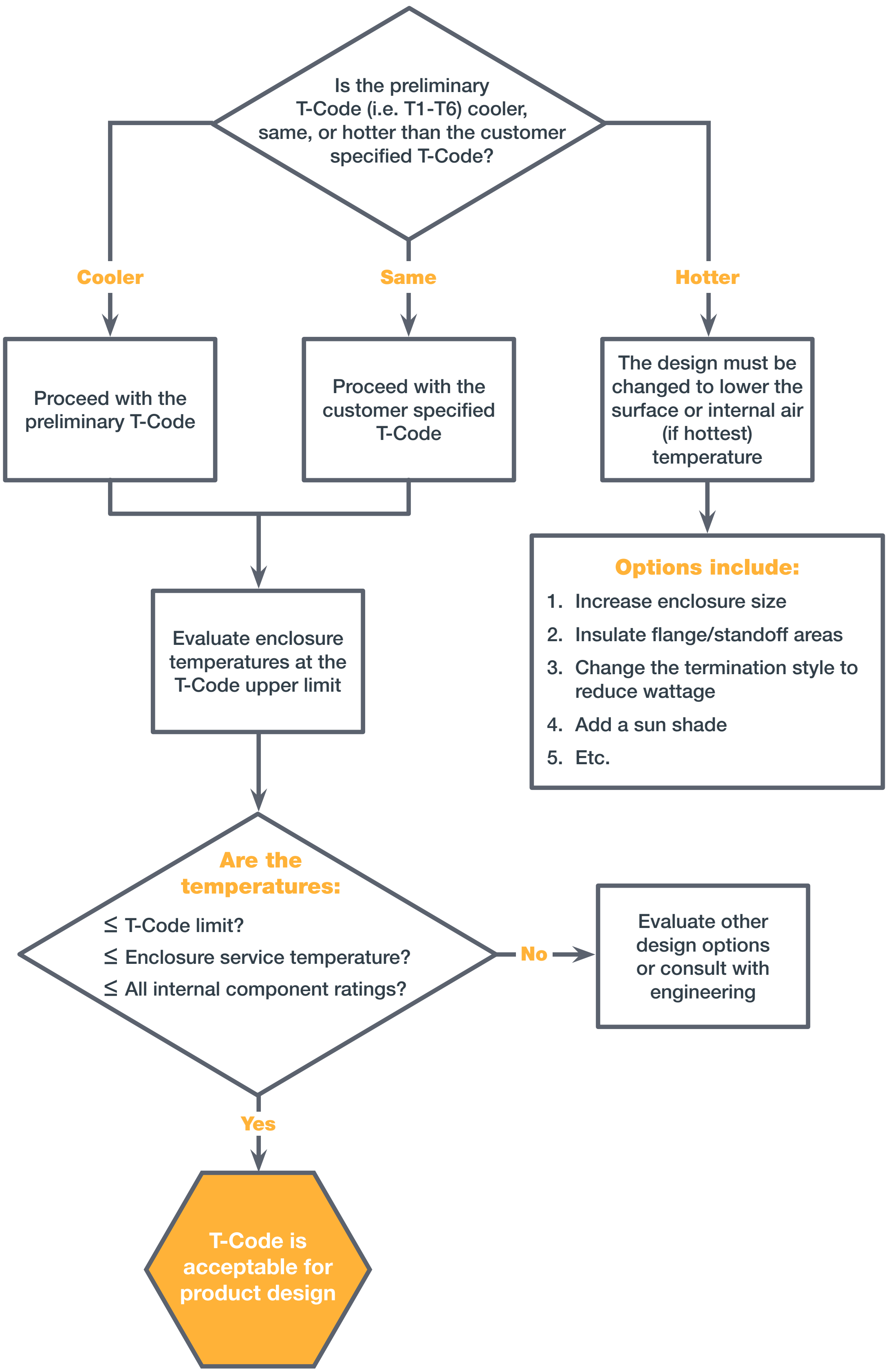
2. Once the preliminary T-code is determined, electric process heater designers must answer an important question: Is the preliminary T-code cooler, same or hotter than the customer specified T-code? The answer to that question is an important guide in the development of the heater.

   If it is cooler than specifications, then proceed with the cooler T-code. If it is the same, then proceed with the customer specified T-code. If the preliminary T-code is hotter, then the proposed design does not meet the customer requirement. At that point, design changes must be considered to meet the customer specified T-code.

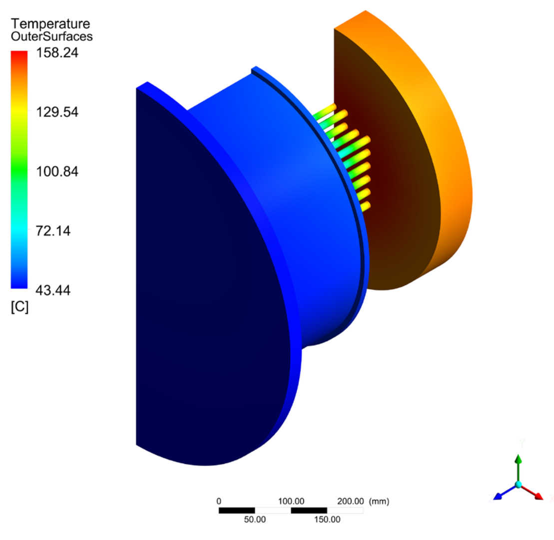
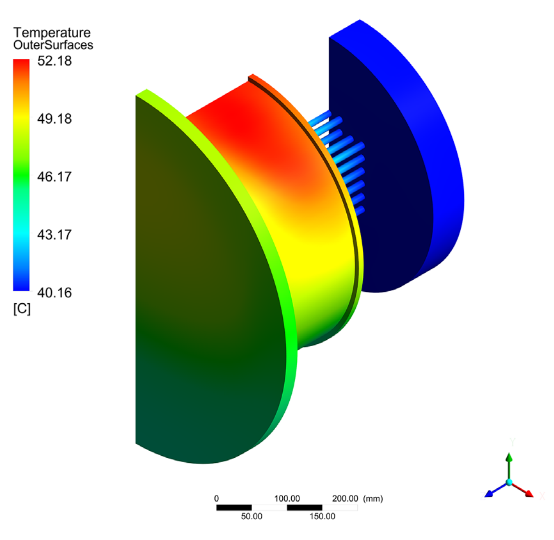
3. The last step is to verify that the enclosure service temperature rating will not be exceeded. The maximum surface temperature is evaluated such that even if it were to reach the assigned T-code temperature limit, the enclosure service temperature rating will not be exceeded. This will ensure that all of the internal enclosure components are suitable for the expected worst-case temperatures.

   An enclosure operating with a service temperature in excess of the maximum could cause two problems. First there is a potential safety risk as the heater will be operating at service temperatures beyond its rated temperature. If ignition happens at that elevated temperature, the integrity of the enclosure may fail and not contain an explosive event. Additionally, if the temperature exceeds internal component ratings, there is a higher chance of component degradation and an increased chance of early equipment failure.

evaluation process chart:



examples:

<table>
<tr>
<th>1. Flange (heat source) has the hottest surface temperature and is the basis for the T-Code evaluation</th>
<th>2. Electrical enclosure has the hottest surface temperature and is the basis for the T-Code evaluation</th>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>The 158°C flange surface temperature would be classified as T3</td>
<td>The 52°C enclosure surface temperature would be classified as T6</td>
</tr>
</table>

takeaway:

It is very important to comply with the current standards that define the evaluation scope to be from the flange (heat source) to the electrical enclosure, as well as fully accounting for all the heat generated inside and outside the enclosure. Failing to do so could mean an unsafe situation or could result in the authority having jurisdiction (AHJ) not approving the equipment installation, causing potential schedule delays and/or cost overruns.

For more information contact Watlow at www.watlow.com

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