Tf = Final Temperature
Ti = Initial Temperature
Li = Initial Length

Linear Thermal Expansion Formula: $\Delta L = \text{Li} \times \alpha \times (T_f - T_i) \times 10^{-6}$

- $\Delta L$ = Change in Length
- $\text{Li}$ = Initial Length
- $\alpha$ = Coefficient of Linear Thermal Expansion
- $T_f$ = Final Temperature
- $T_i$ = Initial Temperature

### Material Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Classification</th>
<th>Max. Surface Temperature °F (°C)</th>
<th>Density (lb/in³)</th>
<th>Coefficient of Linear Thermal Expansion (in/in/°F × 10⁻⁶)</th>
<th>Specific Heat Capacity (BTU/lb-°F)</th>
<th>Thermal Conductivity (BTU-in/hr-ft²-°F)</th>
<th>Melting Point (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum 319</td>
<td>Aluminum 319.0</td>
<td>700 (371)</td>
<td>0.101</td>
<td>12.7 @ 68° – 572°F</td>
<td>0.23</td>
<td>754</td>
<td>960 – 1120</td>
</tr>
<tr>
<td>Aluminum 356</td>
<td>Aluminum 335.0</td>
<td>750 (399)</td>
<td>0.0968</td>
<td>12.9 @ 68° – 572°F</td>
<td>0.23</td>
<td>1160</td>
<td>1030 – 1140</td>
</tr>
<tr>
<td>Bronze</td>
<td>UNS C95300</td>
<td>1350 (732)</td>
<td>0.272</td>
<td>9 @ 68° – 572°F</td>
<td>0.0896</td>
<td>437</td>
<td>1900 – 1913</td>
</tr>
<tr>
<td>Yellow Brass</td>
<td>UNS C85700</td>
<td>1200 (649)</td>
<td>0.304</td>
<td>12.2 @ 68° – 500°F</td>
<td>0.0899</td>
<td>582</td>
<td>1660 – 1690</td>
</tr>
</tbody>
</table>

### Heating Element Electrical Specifications

- Tubular Heater Diameter: .260" .315" .375" .430"
- Maximum Volts: 240 277 480 600
- Maximum Amps Per Element: 15 30 40 40
- Maximum Watt Density: Aluminum Alloy—35 W/in² on the element

- Aluminum Alloy—45 W/in² on the element
- Resistance Tolerance: +10%, -5% Wattage Tolerance: +5%, -10%
- Three Phase available depending on casting size.
- Ground Studs can be added to most cast-ins.

### Cooling Tube Materials for Castings with Liquid Cooling

- Tube Material | Tube OD and Wall Thickness |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel (Standard)</td>
<td>1/4&quot; O.D. × .028 wall</td>
</tr>
<tr>
<td>Stainless Steel (Standard)</td>
<td>3/8&quot; O.D. × .035 wall</td>
</tr>
<tr>
<td>Stainless Steel (Standard)</td>
<td>1/2&quot; O.D. × .049 wall</td>
</tr>
<tr>
<td>Stainless Steel (Optional)</td>
<td>5/8&quot; O.D. × .049 wall</td>
</tr>
<tr>
<td>Incoloy®-804 (Optional)</td>
<td>1/2&quot; O.D. × .049 wall</td>
</tr>
</tbody>
</table>

- Tubing with heavier wall thickness is available upon request.

### Options for Cast-In Thermal Components

- **Casting Surface Treatments**
  - Special surface finishes are required in some applications:
    - Electroless Nickel Plating
    - Anodizing
    - Hard-Coat Anodizing
    - Magnaplate

- **Lab Services**
  - Computerized Infrared Heating Profiles
  - Life Cycle Testing
  - X-Rays to confirm heating element location and casting density
  - Heating Ramp Rate Testing

### Notes:
- Tempo-Pak mineral insulated cable heaters can be used in place of tabular heating elements to fit physical constraints not possible with conventional heating elements. See catalog Section 5 for more details.
- Cast-In thermal components can be made in any practical size, weight and geometric shape.

### Agency Approvals
- Cast-In Heater Elements are UL recognized under UL File Number E90771.

### If you require UL Agency Approval, please specify when ordering.