Designation: G-NiCr25Fe10Al
Features

Centralloy® 60 HT R is a nickel-based cast alloy containing chromium, iron, aluminium, tungsten, and niobium. The alloy shows excellent creep rupture strength. Due to the formation of an α-aluminium oxide scale, outstanding resistance in oxidizing and carburizing atmospheres is observed up to very high temperatures.

Microstructure

In the as-cast condition the microstructure of Centralloy® 60 HT R consists out of an austenitic NiCrFe matrix with primary M₇C₃ and MC carbides precipitated on the interdendritic boundaries. Within the dendrite cores extremely fine γ’ precipitates (Ni₃Al) can be detected by TEM investigations. At service temperature these particles are dissolved.

Chemical Composition (*)

<table>
<thead>
<tr>
<th>Element</th>
<th>Mass Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.3 – 0.6</td>
</tr>
<tr>
<td>Chromium</td>
<td>24 – 30</td>
</tr>
<tr>
<td>Iron</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Aluminium</td>
<td>3 – 5</td>
</tr>
<tr>
<td>Tungsten</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Niobium</td>
<td>0.4 – 1</td>
</tr>
<tr>
<td>Nickel</td>
<td>Balance</td>
</tr>
</tbody>
</table>

(*) This is a typical composition which may be slightly modified.

Applications

Centralloy® 60 HT R may be used as furnace rollers, rotary kilns, retorts, radiant furnace tubes, combustion boats, grates, walking beams. The maximum application temperature is 1250°C.
Physical Properties

Density at 20°C: 8.0 g/cm³

Typical physical properties

<table>
<thead>
<tr>
<th>δ, °C</th>
<th>α, 10⁻⁶/K</th>
<th>λ, W/m K</th>
<th>c_p, J/kg K</th>
<th>E, GPa</th>
<th>ρ, μΩm</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>-</td>
<td>13.1</td>
<td>446</td>
<td>178</td>
<td>1.32</td>
</tr>
<tr>
<td>100</td>
<td>12.6</td>
<td>14.3</td>
<td>467</td>
<td>175</td>
<td>1.34</td>
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<tr>
<td>200</td>
<td>13.0</td>
<td>15.7</td>
<td>494</td>
<td>170</td>
<td>1.37</td>
</tr>
<tr>
<td>300</td>
<td>13.4</td>
<td>17.1</td>
<td>523</td>
<td>165</td>
<td>1.39</td>
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<tr>
<td>400</td>
<td>13.8</td>
<td>18.5</td>
<td>554</td>
<td>159</td>
<td>1.41</td>
</tr>
<tr>
<td>500</td>
<td>14.2</td>
<td>19.9</td>
<td>588</td>
<td>154</td>
<td>1.43</td>
</tr>
<tr>
<td>600</td>
<td>14.8</td>
<td>21.4</td>
<td>626</td>
<td>148</td>
<td>1.44</td>
</tr>
<tr>
<td>700</td>
<td>15.4</td>
<td>22.9</td>
<td>670</td>
<td>142</td>
<td>1.44</td>
</tr>
<tr>
<td>800</td>
<td>16.2</td>
<td>24.4</td>
<td>743*</td>
<td>134</td>
<td>1.44</td>
</tr>
<tr>
<td>900</td>
<td>17.4</td>
<td>26.2</td>
<td>809*</td>
<td>124</td>
<td>1.41</td>
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<tr>
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<td>28.2</td>
<td>886*</td>
<td>113</td>
<td>1.38</td>
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<tr>
<td>1100</td>
<td>19.2*</td>
<td>30*</td>
<td>980*</td>
<td>100*</td>
<td>1.37*</td>
</tr>
</tbody>
</table>

*: extrapolated
δ: Temperature
α: Mean coefficient of linear thermal expansion
λ: Thermal conductivity
c_p: Mean specific heat
E: Young’s modulus (dynamic)
ρ: Electrical resistivity

Young’s Modulus (dynamic) vs. Temperature

![Graph showing Young’s Modulus (dynamic) vs. Temperature](image)
Mechanical Properties
(only for wall thickness less than 25 mm, in the as cast condition)

Tensile properties
Minimum tensile properties at 20°C: 0.2% Yield strength: 650 MPa
Ultimate tensile strength: 800 MPa
Elongation, (l=5d): 3%

Typical Tensile Strength and 0.2% Yield Strength vs. Temperature

Typical Tensile Elongation and Reduction of Area

Elongation at Fracture, Reduction of Area, %

Temperature, °C
**Oxidation Behaviour**

**Cyclic oxidation resistance**
Cycle: 2 h @ \( T_{\text{max}} \) – 15 min @ 20°C
(performing by FZ Jülich)

**Creep Rupture Behaviour**

**Comparison to heat resistant steels**
Larsson-Miller-Plot
Creep Rupture Strength Data

1%-Creep Limit and Creep Rupture Strength
(Mean values of the scatter band evaluated so far)

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>( R_{p1%} ) (MPa)</th>
<th>( R_m ) (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000 h</td>
<td>10000 h</td>
</tr>
<tr>
<td>1000</td>
<td>13.3</td>
<td>-</td>
</tr>
<tr>
<td>1025</td>
<td>12.8</td>
<td>-</td>
</tr>
<tr>
<td>1050</td>
<td>12.0</td>
<td>-</td>
</tr>
<tr>
<td>1075</td>
<td>11.0</td>
<td>-</td>
</tr>
<tr>
<td>1100</td>
<td>9.8</td>
<td>7.8</td>
</tr>
<tr>
<td>1125</td>
<td>8.5</td>
<td>6.4</td>
</tr>
<tr>
<td>1150</td>
<td>7.3</td>
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<td>4.2</td>
<td>2.9</td>
</tr>
<tr>
<td>1250</td>
<td>3.7</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Manufacturing Characteristics

Machining
Due to the very fine γ’ precipitates the machinability of Centralloy® 60 HT R is harder than that of other heat resistant alloys.

Welding
Centralloy® 60 HT R should be welded preferentially by shielded metal arc welding (SMAW) processes. Depending on size and shape of the components gas tungsten arc (GTAW) and plasma arc (PAW) welding are also applicable.

Approved filler materials are bare welding rods and electrodes. Further information will be supplied upon request.

Health, Safety and Environmental Information

The operation and maintenance of welding equipment should conform to the provisions of relevant national standards for the protection of personnel and environment.

Mechanical ventilation is advisable and under certain conditions in confined spaces, it is necessary during welding operations to prevent possible exposure to hazardous fumes, gases or dust that may occur.

Nickel- and iron-base materials may contain, in varying concentrations, the elements chromium, iron, manganese, molybdenum, cobalt, nickel, tungsten and aluminium. Metal dust from welding, grinding, melting and dross handling of these alloy systems may cause adverse environmental and in case of inhalation health effects.
Industries
• Petrochemicals
• Iron-ore direct reduction

Industries
• On- and Offshore

Industries
• Power technology
• Industrial furnace construction
• Separation technology
• Pump manufacturing
• Machine and plant construction

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Services
• Metallurgy and material engineering
• Material analysis and examinations
• Metallurgical defect analysis
• Process and material consulting
• Design of tubes and tube systems
• Material welding services
• Mechanical machining
• Heat treatment
• Convection zones
• Site services and logistics

Production sites
Germany, Spain, United Kingdom, Czech Republic, Malaysia, Saudi Arabia