Centralloy® ET 45 Micro
MATERIAL DATA SHEET

Designation: GX45NiCrSiNb45-35
Centralloy® ET 45 Micro is an air melted nickel-base alloy consisting essentially of a Ni-Cr-Fe-Si matrix. The high chromium level, rare earth additions and primary carbide formation provide the best compromise between good high temperature corrosion resistance and high temperature creep rupture strength.

The presence of carbon leads to the formation of a series of carbides:

a) Intergranularly occurring primary carbides, nitrides or carbonitrides of general form M(C,N) where M is usually niobium, titanium and zirconium. These greatly affect the generation of good high temperature properties. The phase is visible in unetched micro specimens, its color varying from the orange/yellow of the nitride to the grey/mauve of the carbide.

b) Chromium-rich intergranular carbides of the $M_7C_3$ and $M_23C_6$ types. These carbides have a profound influence on properties due to the decomposition and re-precipitation reactions in service producing secondary carbides in a rather uniform dispersion. By this mechanism dislocation movement is impeded with the result of significant strengthening at elevated temperatures.

Product Forms

Centralloy® ET 45 Micro was designed as centrispun tube material to meet specific design criteria in terms of carburisation and oxidation resistance, creep rupture strength and weldability. It is available as centrispun tubes, vertically spun, statically cast and investment cast product forms.

Other forms may be supplied upon request. Further information regarding these topics and maximum und minimum sizes, may be obtained from the sales department.

Chemical Composition (*)

<table>
<thead>
<tr>
<th>Element</th>
<th>Mass Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.45</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.60</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.00</td>
</tr>
<tr>
<td>Chromium</td>
<td>35.00</td>
</tr>
<tr>
<td>Iron</td>
<td>16.00</td>
</tr>
<tr>
<td>Niobium</td>
<td>Additions</td>
</tr>
<tr>
<td>Titanium</td>
<td>Additions</td>
</tr>
<tr>
<td>Zirconium</td>
<td>Additions</td>
</tr>
<tr>
<td>Rare earth elements</td>
<td>Additions</td>
</tr>
<tr>
<td>Nickel</td>
<td>Balance</td>
</tr>
</tbody>
</table>

(*) This is a typical composition which may be slightly modified according to the application.

Applications

Tubular systems requiring superior carburisation and oxidation resistance combined with high creep rupture strength and high creep resistance. No heat treatment is required for most applications of this alloy. Main high temperature applications for the material are:

<table>
<thead>
<tr>
<th>Process</th>
<th>Max. operating temperature, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam cracking</td>
<td>1150</td>
</tr>
<tr>
<td>Direct reduction of iron ore</td>
<td>1150</td>
</tr>
</tbody>
</table>
Physical Properties

Density: 8.1 g/cm³
Thermal Conductivity (20°C): 14.0 W/mK
Centralloy® ET 45 Micro

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: 245 MPa
- Ultimate tensile strength: 450 MPa
- Elongation (l = 5d):
  - 6% for centricast tubes
  - 3% for static castings

Typical Tensile Strength and 0.2% Yield Strength vs. Temperature

Temperature, °C

Strength, MPa

0 100 200 300

0 50 100 150 200

700 750 800 850 900 950 1000

Ultimate Tensile Strength
0.2% Yield Strength

Typical Tensile Test Elongation vs. Temperature

Temperature, °C

Elongation (l=5d), %

0 10 20 30 40 50

700 750 800 850 900 950 1000
Carburisation Resistance

Increase in Carbon Content vs. Temperature after Pack Carburisation for 260 Hours at Indicated Test Temperature

Oxidation Resistance

Oxidation Weight Loss vs. Temperature for 10 Thermal Cycles in Air Between Indicated Temperature and Room Temperature

7 hours hold time per cycle at test temperature
Parametric Stress Rupture Strength

LMP = Larson Miller Parameter

LMP = T (19.3 + log tr)/1000

Where T: temperature [K] and tr: rupture time [h]

Lower Scatter Band represents 95% confidence level
Parametric Minimum Creep Rate

Manufacturing Characteristics

Machining
In general terms the machinability of Centralloy® ET 45 Micro is similar to that of other heat resistant alloys.

Welding
For critical, highly stressed and corrosion resistant joints coated electrodes, flux cored wire and bare filler material are commercially available. These welding consumables have high strength properties at elevated temperatures with good retained ductilities. Besides fillerless PAW, TIG and MAW have been used satisfactorily for component fabrication or repair welding. Pre-heating and postweld heat treatment of the joint is not necessary. For dissimilar weld joints to austenitic materials the same filler materials are recommended. Further information will be supplied upon request.

Health and Safety Information

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

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

Nickel- and iron-base materials may contain, in varying concentrations, elemental constitutions of chromium, iron, manganese, molybdenum, cobalt, nickel, tungsten and aluminium. Inhalation of metal dust from welding, grinding, melting and dross handling of these alloy systems may cause adverse health effects.
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- Petrochemicals
- Iron-ore direct reduction

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- Training of customer personnel
- Welding supervision

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