Ferrium® M54™ Chemical Composition (nominal wt. %)

<table>
<thead>
<tr>
<th></th>
<th>Fe</th>
<th>C</th>
<th>Co</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>W</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bal.</td>
<td>0.3</td>
<td>7</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>1.3</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Ferrium M54 Mechanical Properties (typical)

<table>
<thead>
<tr>
<th>YS (ksi)</th>
<th>UTS (ksi)</th>
<th>El (%)</th>
<th>Ra (%)</th>
<th>Hardness (HRC)</th>
<th>CVN (ft-lb)</th>
<th>Klc (ksi√in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>251</td>
<td>293</td>
<td>15</td>
<td>64</td>
<td>54</td>
<td>24</td>
<td>118</td>
</tr>
</tbody>
</table>

Materials by Design® Objective

The design objective of Ferrium® M54® was to create a cost effective ultra high-strength, high fracture toughness material with high resistance to stress corrosion cracking material for use in structural applications.

Description

Ferrium® M54® is an ultra high-strength steel for structural applications. Ferrium® M54® was designed to provide mechanical properties equal to, or better than ultrahigh-strength steels such as Aermet® 100. Ferrium® M54® has high resistance to stress-corrosion cracking (SCC) over conventional ultra high-strength steels.

Ferrium® M54® utilizes an efficient M2C strengthening dispersion precipitated through tempering while avoiding other carbides. This maximizes strength, wear resistance, and toughness; resulting in a unique combination of mechanical properties.

Ferrium® M54® also has high hardenability, permitting less severe quench conditions for a given section size and resulting in less distortion during heat treatment.
Processing

Processing of Ferrium® M54® is similar to other quench and tempered martensitic secondary-hardening steels. Vacuum heat treatment and vacuum tempering is recommended to avoid surface decarburization. After quenching to room temperature, Ferrium® M54® is subjected to cryogenic treatment to assure a complete martensitic transformation. Ferrium® M54® is typically tempered around 960°F (516°C) and has excellent thermal resistance approaching this temperature. This allows for higher grinding speeds without risk for grinding burns and more reliability in service.

Heat treatment recommendation: Test specimens should be hardened by heating to 1940°F ±27 (1060°C ±15), holding at heat for 60 - 90 minutes, quenching in oil (or equivalent), cooling to -100°F (-73°C) or lower, holding at temperature for 1 hour +2, -0, and warming in air to room temperature; and tempered by heating to 960°F ±12 (516°C ±7), holding at heat for 10 hours +2, -2, and cooling in air (or equivalent).

Application Environment

Ferrium® M54® is not considered corrosion resistant. Therefore, users should consider the specific environment when determining surface treatment.

Product Forms

Ferrium® M54® may be manufactured in typical ingot, bar, and billet forms. Sheet and plate also available upon request.

Other

U.S. Patent Number 9,051,635 B2