FERRITIC AND MARTENSITIC STEELS, INCL. PRECIPITATION HARDENING STEELS

Available Product Shapes

- Long Products
- Open Die Forgings
- Plates

Product Description

Martensitic precipitation hardenable chromium-nickel-copper steel possessing high strength and toughness. Further strength increments can be obtained by cold forming, followed by a precipitation hardening treatment.

Properties

- Aircraft and rocket engineering, mechanical engineering, power generation, measuring and control technique

Applications

- Aerospace
- Comp. for Chemical plants (incl. LNG, FGD, Urea, LDPE, etc.)
- Custom Hand Knives
- Electronic Industry
- General Components for Mechanical Engineering
- Mechanical Engineering / Machine Building General
- Other Automotive components (Turbochargers, Piston Rings, Sensors, etc.)
- Other Oil and Gas + CPI comps.
- Power Generation (Gas/Steam/Nuclear)
- Structural parts (Aerosp)
- Unknown Components Application
- Well Completion Tools
- CPI (incl. LNG, Urea)
- Automotive
- Comp. for Industrial Gas Compressors
- Distributors for Component Applications
- Food processing Industry
- Industry gear boxes
- Medical
- Other Aerospace Comps.
- Other Power Generation Components
- Pumps and High Pressure Components
- Tubular Products, Flanges, Fittings
- Valves and Actuators
- Well Logging Tools
- Blades & Shafts for Turbines and Compressors
- Comp. for Food processing and Animal Feed
- Distributors or producers of standard parts without knowledge of final applications
- Forging Applications
- Injection Components
- Medical Instruments & Implants
- Other Components
- Packaging
- Shafts
- Turbine and Engine Parts (Aerosp)
- Wear parts
- Wellhead, X-mas trees and Manifolds (incl. Tubing hangers), BOPs
### Chemical composition

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Ni</th>
<th>Cu</th>
<th>Nb</th>
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<tbody>
<tr>
<td></td>
<td>0.04</td>
<td>0.25</td>
<td>0.40</td>
<td>15.30</td>
<td>4.50</td>
<td>3.25</td>
<td>0.30</td>
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### Material designation

<table>
<thead>
<tr>
<th>Material designation</th>
<th>Standards</th>
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<tbody>
<tr>
<td>1.4542 SEL</td>
<td>A564</td>
</tr>
<tr>
<td>1.4548</td>
<td>ASTM</td>
</tr>
<tr>
<td>S17400 UNS</td>
<td>5643</td>
</tr>
<tr>
<td>X5CrNiCuNb16-4 EN</td>
<td>5604</td>
</tr>
<tr>
<td>X5CrNiCuNb17-4-4</td>
<td>5622</td>
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<td>EZ6CNU17.04 EN</td>
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</tr>
<tr>
<td>AISI: 630</td>
<td>AISI</td>
</tr>
<tr>
<td>17-4 PH Market grade</td>
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</table>
Service temperatures

High-temperature applications:
Suidet up to 350°C (660°F)
For short periods, may be used at temperatures up to 50°C (120°F) max. below the precipitation hardening temperature.

Cryogenic applications:

Condition H900 (480°C):
If the steel also has to fulfil specific toughness requirements, this condition should not be used for subzero applications.

Condition H925 (500°C):
For general use down to -18°C (-0.4°F).
If no specific impact strength requirements are imposed, this condition is suidet for temperatures down to -196°C (-320°F) (e.g. for valve seats).

Condition H1150 (620°C): [P930]
possible temperature up to -79°C (-110°F).

Condition H1150-M (620°C-M): [P800]
possible temperature up to -196°C (-320°F).

Principally, precipitation hardening temperatures below 550°C (1020°F) are not recommended for components subject to specific impact strength requirements at low temperatures.

For critical cryogenic applications we recommend our BÖHLER N701 (15-5PH) grade, which exhibits elevated impact energy values.

[ P...] Heat treatment condition to DIN EN 10088-3
**Hot forming, Heat treatment**

**Hot forming**

Forging:
1150 to 900°C (2100 to 1650°F), Air cooling

**Heat treatment**

Solution annealing:
1000 to 1050°C (1830 to 1920°F), Oil, air

Age hardening:
- **Condition H900 (480°C):**
  480°C (900°F) / 1 h / Air
- **Condition H925 (500°C):**
  500°C (925°F) / 4 h / Air
- **Condition H1025 (550°C):** [P1070]
  550°C (1025°F) / 4 h / Air
- **Condition H1075 (580°C):**
  580°C (1075°F) / 4 h / Air
- **Condition H1100 (600°C):** [P960]
  600°C (1100°F) / 4 h / Air
- **Condition H1150 (620°C):** [P930]
  620°C (1150°F) / 4 h / Air
- **Condition H1150-M (620°C-M):** [P800]
  760°C (1400°F) / 2 h / Air +
  620°C (1150°F) / 4 h / Air

_ P..._ Heat treatment condition to DIN EN 10088-3

**Structure as solution annealed:**
Martensite + austenite + ferrite

**Structure as precipitation hardened:**
Martensite + austenite + ferrite + intermetallic phases
### Mechanical properties at room temperature to DIN EN 10088-3

<table>
<thead>
<tr>
<th>Condition</th>
<th>Product</th>
<th>Dimension L x Q mm</th>
<th>Hardness HB (average values)</th>
<th>0.2% proof stress N/mm²</th>
<th>Tensile strength N/mm²</th>
<th>Ductility</th>
<th>Deformation Aₕ</th>
<th>Erosion</th>
<th>Impact strength E₂ (J/100 mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>St</td>
<td>≤ 100</td>
<td></td>
<td>520</td>
<td>890 - 950</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>720</td>
<td>930 - 1100</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>750</td>
<td>900 - 1160</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1100</td>
<td>1070 - 1270</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<tr>
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<th>Ductility</th>
<th>Deformation Aₕ</th>
<th>Erosion</th>
<th>Impact strength E₂ (J/100 mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Bl</td>
<td>≤ 50</td>
<td></td>
<td>620</td>
<td>890 - 1050</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>800</td>
<td>930 - 1150</td>
<td>12</td>
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<td>1100</td>
<td>1070 - 1270</td>
<td>10</td>
<td></td>
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</tr>
</tbody>
</table>

1) Not valid for inspection purposes for which tensile strength is the ruling property.
2) Sheet or plate ≥3 mm thickness

### High temperature properties

- L = Longitudinal, Q = Transverse
- St = Bars, Bl = Sheet or plate
- P = Precipitation hardened
- SR = Stress relieving annealed

### Mechanical properties at room temperature to ASTM A564

<table>
<thead>
<tr>
<th>Condition</th>
<th>Product</th>
<th>Dimension L x Q mm</th>
<th>Hardness HB (average values)</th>
<th>0.2% proof stress N/mm²</th>
<th>Tensile strength N/mm²</th>
<th>Ductility</th>
<th>Deformation Aₕ</th>
<th>Erosion</th>
<th>Reduction of area</th>
<th>Impact strength E₂ (J/100 mm²)</th>
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</thead>
<tbody>
<tr>
<td>L</td>
<td>St</td>
<td>max. 300</td>
<td></td>
<td>380</td>
<td>1170</td>
<td>10</td>
<td></td>
<td></td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>375</td>
<td>1170</td>
<td>10</td>
<td></td>
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<td></td>
<td>391</td>
<td>1170</td>
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<td>311</td>
<td>1000</td>
<td>12</td>
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<td>302</td>
<td>785</td>
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<td>277</td>
<td>715</td>
<td>16</td>
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<td>50</td>
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<td></td>
<td></td>
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<td>205</td>
<td>520</td>
<td>18</td>
<td></td>
<td></td>
<td>55</td>
<td>75</td>
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</tbody>
</table>

Bars up to 200 mm diameter

1) Not valid for inspection purposes for which tensile strength is the ruling property.

The values for other products and dimensions shall be established by agreement.
Precipitation hardening chart

1. I....Tensile strength, in N/mm²
2. II....0.2% proof stress, in N/mm²
3. III....Impact strength (ISO-V), in J
4. IV....Elongation A₅, in %

1, II, III, IV
Minimum values for bar measuring up to 300mm (longitudinal values)
1, 2, 3, 4 ... Typical values

High temperature strength chart

1....Tensile strength, in N/mm²
2....0.2% proof stress, in N/mm²
3....Reduction of area, in %
4....Elongation A₅, in %

Typical values
^ ----- ^ Condition H900 (480°C)
○ --- ○ Condition H1025 (500°C)
• • • Condition H1150 (620°C)
**Dimensional change**

During solution annealing:
Contraction in longitudinal direction approx. 0,2%

During precipitation hardening:
Contraction at different precipitation hardening temperatures compared with the as solution annealed condition.

**Surface treatment**

**Nitriding:**
The nitriding process reduces the steel's corrosion resistance. It is applied in cases where increased friction and wear resistance is required (e.g. for pump shafts).

**Plasma nitriding:** in combination with precipitation hardening;
Hardness penetration depth: 0.1 - 0.15 mm
Obtainable surface hardness: approx. 67 HRC (converted).

**Descaling:**
The method most frequently employed is that of sandblasting.
**Pickling** after solution annealing or after hot forming may be performed by the same methods as are employed for stainless austenitic standard steel grades.

**Passivation or slight pickling** can be carried out in a 10% nitric acid, 2% hydrofluoric acid at 40 to 60°C (105 to 140°F), with a holding time of a few minutes.
This treatment also removes the surface discoloration caused by solution annealing. These stains may reduce the material's corrosion resistance.
Removal is also possible be electropolishing.
Descaling according to the salt bath method exerts an ageing effect.
### Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit 1</th>
<th>Unit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C / °F)</td>
<td>20 / 68</td>
<td></td>
</tr>
<tr>
<td>Density (kg/dm³ / lb/in³)</td>
<td>7.8 / 0.28</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity (W/(m.K) / BTU (IT) ft/hr/ft²/F)</td>
<td>16 / 9.24</td>
<td></td>
</tr>
<tr>
<td>Specific heat (J/(kg.K) / BTU (IT) lb/F)</td>
<td>500 / 119.42</td>
<td></td>
</tr>
<tr>
<td>Specific electrical resistance (Ohm.mm²/m / Ohm.inch²/ft)</td>
<td>0.71 / 0</td>
<td></td>
</tr>
<tr>
<td>Modulus of elasticity (10³N/mm² / 10³ksi)</td>
<td>200 / 29.01</td>
<td></td>
</tr>
</tbody>
</table>

### Thermal Expansions

<table>
<thead>
<tr>
<th>Temperature (°C / °F)</th>
<th>100 / 212</th>
<th>300 / 572</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion (10⁻⁶ m/(m.K) / 10⁻⁶ inch/(inch.F))</td>
<td>10.9 / 6.056</td>
<td>11.1 / 6.167</td>
</tr>
</tbody>
</table>

For more information see www.voestalpine.com/bohler-edelstahl