### 1.4016 Stainless ferritic, chromium steel

<table>
<thead>
<tr>
<th>C max.</th>
<th>Cr 16.00 – 18.00</th>
</tr>
</thead>
</table>

#### General comments
Although the corrosion resistance of 1.4016 is inferior to the austenitic grades of stainless steels, its ferritic microstructure makes it resistant to the effects of stress corrosion cracking, a form of corrosion to which most of the conventional austenitic stainless steels are susceptible to. Despite this beneficial characteristic, the use of 1.4016 is limited by its poor weldability.

#### Relevant current and obsolete standards
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>EN 10088-3</td>
<td>1.4016</td>
<td>X6Cr17</td>
</tr>
<tr>
<td>AISI</td>
<td>430</td>
<td></td>
</tr>
<tr>
<td>BS</td>
<td>430S17</td>
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<tr>
<td>JIS</td>
<td>430</td>
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<tr>
<td>AFNOR</td>
<td>Z8C17</td>
<td></td>
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<tr>
<td>DIN 17440</td>
<td>1.4016</td>
<td></td>
</tr>
<tr>
<td>SIS</td>
<td>2320</td>
<td></td>
</tr>
</tbody>
</table>

#### Special grade for particular use
- cold heading grade
- cold forming grade
- wire drawing grade

#### General properties
- corrosion resistance: good
- mechanical properties: average
- forgeability: good
- weldability: poor
- machinability: average

#### Special properties
- ferromagnetic grade
- suitable for use up to 650 °C

#### Physical properties
- density (kg/dm³): 7.70
- electrical resistivity at 20 °C (Ω mm²/m): 0.60
- magnetizability: yes
- thermal conductivity at 20 °C (W/m K): 25
- specific heat capacity at 20 °C (J/kg K): 460
- thermal expansion (K⁻¹):
  - 20 – 100 °C: 10.0 x 10⁻⁶
  - 20 – 200 °C: 10.0 x 10⁻⁶
  - 20 – 300 °C: 10.5 x 10⁻⁶
  - 20 – 400 °C: 11.0 x 10⁻⁶
  - 20 – 500 °C: 11.0 x 10⁻⁶

#### Typical applications
- building industry
- electronic equipment
- mechanical engineering
- decorative applications
- food and beverage industry

Note: supplied in accordance with the Z-30.3-6 building regulation. Dimensional limits can be agreed on.

#### Processing properties
- automated machining: seldom
- machinable: seldom
- hammer and die forging: yes
- cold forming: yes
- cold heading: yes
- suited to polishing: yes

#### Conditions
- annealed

#### Demand tendency
- sharply rising

#### Corrosion resistance (PRE = 16.0 – 18.0)
As a result of its higher chromium content, 17 %, 1.4016 is more corrosion resistant than 1.4003 and other 13 % chromium stainless steels. Good corrosion resistance is displayed in moderately corrosive media/environments with low chloride ion concentrations, such as natural waters, soap and detergent solutions. It must be noted that 1.4016 is not resistant to sea water. 1.4016 is resistant to intergranular corrosion in the as-delivered condition, but is not resistant to intergranular corrosion after welding or elevated temperature forming process.
1.4016 may be annealed by holding in the temperature range 750 °C to 850 °C, followed by cooling in air. Since this grade of steel is prone to rampant grain growth, a temperature of 850 °C should not be exceeded. In the annealed condition, the following mechanical properties may be attained when testing in the longitudinal direction:

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield strength (N/mm²)</td>
<td>R_{y,0.2}</td>
<td>≥ 240</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>R_{m}</td>
<td>400 – 630</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>A₆</td>
<td>≥ 20</td>
</tr>
<tr>
<td>Hardness (HB)</td>
<td></td>
<td>≤ 200</td>
</tr>
</tbody>
</table>

A typical work hardening curve for 1.4016.

The mechanical properties (d ≥ 160 mm) have to be agreed on for thicker dimensions, or the delivered product is based on the values given.

### Elevated temperature properties

Minimum tensile properties at various temperatures, shown in the diagram, are specified in the EN 10088-3.

### Welding

1.4016, like most ferritic stainless steels, is prone to rampant grain growth when exposed to elevated temperatures which result in the formation of a coarse grained heat affected zone on each side of the weld bead. Since ferritic stainless steels also have a very limited solubility for interstitial elements such as carbon and nitrogen, the formation of chromium carbides and nitrides in the heat affected zone are also not uncommon. Arc welding of 1.4016 is thus not recommended. If welding is unavoidable, then the use of carbon or nitrogen containing shielding gasses must be avoided.

The detrimental effects of grain growth and formation of precipitates can be controlled to some extent by limiting the heat input during welding to less than 1kJ/mm, avoiding preheating, avoiding weaving during welding and ensuring that the workpiece is clean, i.e. free from grease, oil or any other form of hydrocarbon. Resistance and friction welds are easier to produce than arc welds. When the application of a filler metal is required, then Novonit® 4316 or Novonit® 4502, can be used.

### Forging

The work-piece is usually heated to temperatures between 1100 °C and 1130 °C, with forging taking place at temperatures between 1130 °C and 750 °C followed by cooling in air.

### Machining

As a result of its ferritic microstructure, 1.4016 tends to smear when machined resulting in a build-up of material on the cutting tool and the production of longer swarf. This phenomenon can be counteracted to some extent by using coated hard metal cutting/machining tools combined with adapted cutting/machining parameters. The following machining parameters can be used as a guideline when machining 1.4016.

<table>
<thead>
<tr>
<th>Description</th>
<th>Annealed R₆, 450 – 550 N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of cut (mm)</td>
<td>6 3 1</td>
</tr>
<tr>
<td>Feed rate (mm/r)</td>
<td>0.5 0.4 0.2</td>
</tr>
<tr>
<td>Cutting speed (m/min)</td>
<td>160 190 260</td>
</tr>
</tbody>
</table>