

## SPECIFICATIONS

Commercial	416
EN	1.4005

A martensitic machining bar with machinability enhanced through the addition of Phosphorus and Sulphur.

Grade 416 has the highest machinability of any stainless steel, at about 85% of that of a free-machining carbon steel. As for most other free-machining stainless steels the improvement in machinability is achieved by addition of sulphur which forms manganese sulphide inclusions; this sulphur addition also lowers the corrosion resistance, weldability and formability to below that of its non-free machining equivalent Grade 410.

Grade 416 is sometimes used in the unhardened or hardened and highly tempered condition because of its low cost and ready machinability.

Martensitic stainless steels are optimised for high hardness, and other properties are to some degree compromised. Fabrication must be by methods that allow for poor weldability and usually also allow for a final harden and temper heat treatment. Corrosion resistance is lower than the common austenitic grades, and their useful operating temperature range is limited by their loss of ductility at sub-zero temperatures and loss of strength by over-tempering at elevated temperatures.

## CHEMICAL COMPOSITION

EN 10088-3:2005 1.4005 Steel	
Element	% Present
Chromium (Cr)	12 - 14
Manganese (Mn)	1.5 max
Silicon (Si)	1 max
Molybdenum (Mo)	0.6 max
Sulphur (S)	0.15 - 0.35
Carbon (C)	0.06 - 0.15
Phosphorous (P)	0.04 max
Iron (Fe)	Balance

## ALLOY DESIGNATIONS

## SUPPLIED FORMS

- Bar

## GENERIC PHYSICAL PROPERTIES

Property	Value
Density	7.75 g/cm <sup>3</sup>
Thermal Expansion	9.9 x10 <sup>-6</sup> /K
Modulus of Elasticity	200 GPa
Thermal Conductivity	24.9 W/m.K
Electrical Resistivity	0.57 x10 <sup>-6</sup> Ω .m

## MECHANICAL PROPERTIES

EN 10088-3:2005 Bar Up to 160mm Dia or Thickness	
Property	Value
Proof Stress	450 Min MPa
Tensile Strength	650 - 850 MPa

*Mechanical properties vary greatly according to the heat treatment that the material has undergone.*

*Material in the annealed condition shall have a hardness reading of 220 HB Max and a Tensile test reading of 730 MPA Max*

## APPLICATIONS

Typical applications include:  
 Valve Parts  
 Pump Shafts  
 Automatic Screw Machined Parts  
 Motor Shafts  
 Washing Machine Components  
 Bolts and Nuts  
 Studs  
 Gears

### CORROSION RESISTANCE

Corrosion resistance is lower than the common austenitic grades.

Useful resistance to dry atmospheres, fresh water and mild alkalis and acids, but less resistant than the equivalent non-free-machining grades. Less corrosion resistant than the austenitic grades and also less than 17% chromium ferritic alloys such as Grade 430. High sulphur content free machining grades such as 416 are totally unsuitable for marine or other chloride exposure.

Maximum corrosion resistance is achieved in the hardened condition, with a smooth surface finish.

### HEAT RESISTANCE

Fair resistance to scaling in intermittent service up to 760°C and up to 675°C in continuous service. Not recommended for use in temperatures above the relevant tempering temperature, if maintenance of mechanical properties is important.

### FABRICATION

Fabrication must be by methods that allow for poor weldability and usually also allow for a final harden and temper heat treatment.

### COLD WORKING

Not recommended - Suitable only for minor deformation. Severe deformation will result in cracking.

### HOT WORKING

All hot work procedures should commence following uniform heating to 2100-2250 F (1149-1232 C). Hot work below 1700 F (927 C) may result in cracking.

### MACHINABILITY

Grade 416 offers exceptionally good machinability, the highest of any of the commonly available stainless steels. Best machinability is in the sub-critical annealed condition.

### HEAT TREATMENT

Full Annealing - Heat to 815-900°C for ½ hour per 25mm of thickness. Cool at 30°C per hour maximum to 600°C and air cool.

Sub-Critical Annealing - Heat to 650-760°C and air cool.

Hardening - Hardened by heating to 925-1010°C, quenching in oil, and tempering to suit the mechanical requirements. See accompanying table.

Condition: Tensile Strength Range (N/mm<sup>2</sup> or MPa) QT  
650: 650 - 850  
QT 700: 700 - 850  
QT 800: 800 - 950  
QT 850: 850 - 1000  
QT 900: 900 - 1050

### WELDABILITY

Grade 416 has poor weldability. If welding is necessary use Grade 410 low hydrogen electrodes. Pre-heat to 200-300°C. Follow immediately with annealing or re-hardening, or a stress relief at 650-675°C.

A better option if the weld is not required to be hard is to use a Grade 309 austenitic stainless steel filler rod

## CONTACT

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## REVISION HISTORY

Datasheet Updated	13 March 2020
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