

# Stainless Steel Grade 316 / 1.4401

Stainless steel types 1.4401 and 1.4404 are also known as grades 316 and 316L respectively. Grade 316 is an austenitic grade second only to 304 in commercial importance.

316 stainless steel contains an addition of molybdenum that gives it improved corrosion resistance. This is particularly apparent for pitting and crevice corrosion in chloride environments.

316L, the low carbon version of 316 stainless steel, is immune to grain boundary carbide precipitation (sensitisation). This makes it suited to use in heavy gauge (over about 6mm) welded components.

For elevated temperature applications the high carbon variant, 316H stainless steel and the stabilised grade 316Ti stainless steel should be employed.

The austenitic structure of 316 stainless steel gives excellent toughness, even at cryogenic temperatures.

Property data given in this document is typical for flat rolled products covered by ASTM A240/A240M. ASTM, EN or other standards may cover products sold by Aalco. It is reasonable to expect specifications in these standards to be similar but not necessarily identical to those given in this datasheet.

## Applications

Initially developed for use in paper mills 316 stainless steel is now typically used in:

- ◆ Food processing equipment
- ◆ Brewery equipment
- ◆ Chemical and petrochemical equipment
- ◆ Laboratory benches & equipment
- ◆ Coastal architectural panelling
- ◆ Coastal balustrading
- ◆ Boat fittings
- ◆ Chemical transportation containers
- ◆ Heat exchangers
- ◆ Mining screens
- ◆ Nuts and bolts
- ◆ Springs
- ◆ Medical implants

## Typical Chemical Composition

| %  | 316     | 316L    | 316H   |
|----|---------|---------|--------|
| C  | 0.08max | 0.03max | 0.1max |
| Mn | 2.0     | 2.0     | 2.0    |
| Si | 0.75    | 0.75    | 0.75   |
| P  | 0.045   | 0.045   | 0.045  |
| S  | 0.03    | 0.03    | 0.03   |
| Cr | 16-18   | 16-18   | 16-18  |
| Mo | 2-3     | 2-3     | 2-3    |
| Ni | 10-14   | 10-14   | 10-14  |
| N  | 0.1     | 0.1     | -      |

## Typical Mechanical Properties

| Grade                      | 316 | 316L | 316H |
|----------------------------|-----|------|------|
| Tensile Strength (MPa)     | 515 | 485  | 515  |
| Compression Strength (MPa) | 170 | 170  | 170  |
| Proof Stress 0.2% (MPa)    | 205 | 170  | 205  |
| Elongation A5 (%)          | 40  | 40   | 40   |
| Hardness Rockwell B        | 95  | 95   | 95   |

## Typical Physical Properties

| Property               | Value                             |
|------------------------|-----------------------------------|
| Density                | 8.00 g/cm <sup>3</sup>            |
| Melting Point          | 1375-1400°C                       |
| Modulus of Elasticity  | 193 GPa                           |
| Electrical Resistivity | 0.074x10 <sup>-6</sup> Ω.m        |
| Thermal Conductivity   | 16.3 W/m.K at 100°C               |
| Thermal Expansion      | 15.9x10 <sup>-6</sup> /K at 100°C |



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In particular, the mechanical property requirements vary widely with product form and product dimensions.  
For more complete details please refer to the relevant specification – The BS EN Specifications for Stainless Steel are listed on a separate Datasheet.*

## Alloy Designations

Stainless steel 316 also corresponds to the following standard designations and specifications:

| Euronorm | UNS    | BS     | En  | Grade |
|----------|--------|--------|-----|-------|
| 1.4401   | S31600 | 316S31 | 58H | 316   |
| 1.4404   | S31603 | 316S11 | -   | 316L  |
| -        | S31609 | 316S51 | -   | 316H  |
| 1.4571   | -      | 320S31 | -   | 316Ti |

## Corrosion Resistance

Grade 316 has excellent corrosion resistance when exposed to a range of corrosive environments and media. It is usually regarded as "marine grade" stainless steel but is not resistant to warm sea water. Warm chloride environments can cause pitting and crevice corrosion. Grade 316 is also subject to stress corrosion cracking above around 60°C.

## Heat Resistance

316 has good resistance to oxidation in intermittent service to 870°C and in continuous service to 925°C. However, continuous use at 425-860°C is not recommended if corrosion resistance in water is required. In this instance 316L is recommended due to its resistance to carbide precipitation.

Where high strength is required at temperatures above 500°C, grade 316H is recommended.

## Fabrication

Fabrication of all stainless steels should be done only with tools dedicated to stainless steel materials. Tooling and work surfaces must be thoroughly cleaned before use. These precautions are necessary to avoid cross contamination of stainless steel by easily corroded metals that may discolour the surface of the fabricated product.

## Cold Working

Grade 316 is readily brake or roll formed into a variety of parts. It is also suited to stamping, heading and drawing but post work annealing is recommended to relieve internal stresses.

Cold working will increase both strength and hardness of 316 stainless steel.

## Hot Working

All common hot working processes can be performed on 316 stainless steel. Hot working should be avoided below 927°C. The ideal temperature range for hot working is 1149-1260°C. Post-work annealing is recommended to ensure optimum corrosion resistance.

## Heat Treatment

316 stainless steel cannot be hardened by heat treatment.

Solution treatment or annealing can be done by rapid cooling after heating to 1010-1120°C.

## Machinability

316 stainless steel has good machinability. Machining can be enhanced using the following rules:

- ◆ Cutting edges must be kept sharp. Dull edges cause excess work hardening.
- ◆ Cuts should be light but deep enough to prevent work hardening by riding on the surface of the material.
- ◆ Chip breakers should be employed to assist in ensuring swarf remains clear of the work
- ◆ Low thermal conductivity of austenitic alloys results in heat concentrating at the cutting edges. This means coolants and lubricants are necessary and must be used in large quantities.



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## Welding

Fusion welding performance for 316 stainless steel is excellent both with and without fillers. Recommended filler rods and electrodes for 316 and 316L are the same as the base metal, 316 and 316L respectively. Heavy welded sections may require post-weld annealing. Grade 316Ti may be used as an alternative to 316 in heavy section welds.

Oxyacetylene welding has not been found to be successful for joining of 316 stainless steel.

## 316Ti

Another variation of 316 is available. This variation is 316Ti. Stainless steel grade 316Ti contains a small amount of titanium. Titanium content is typically only around 0.5%. The titanium atoms stabilise the structure of the 316 at temperatures over 800°C. This prevents carbide precipitation at the grain boundaries and protects the metal from corrosion. The main advantage of 316Ti is that it can be held at higher temperatures for a longer period without sensitisation (precipitation) occurring. 316Ti retains physical and mechanical properties similar to standard grades of 316.

## Supplied Forms

316 stainless steel is typically supplied by Aalco in a range of finishes in the following forms:

- ◆ Sheet
- ◆ Plate
- ◆ Welded mesh
- ◆ Quarto plate
- ◆ Round bar
- ◆ Flat bar and rolled edge flat bar
- ◆ Equal angle
- ◆ Square bar
- ◆ Hollow bar
- ◆ Seamless pipe
- ◆ Welded pipe
- ◆ Seamless butt weld fittings
- ◆ Welded butt weld fittings
- ◆ Flanges
- ◆ Seamless tube
- ◆ Hygienic fittings
- ◆ Round, square and rectangular decorative tube

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