MACSTEEL VRN

STAINLESS STEEL PLATE, SHEET & COIL

316/316L Technical Data

Summary

316 is an improved version of 304, with the addition of molybdenum and a slightly higher nickel content. The resultant composition of 316 gives the steel much increased corrosion resistance in many aggressive environments. The molybdenum makes the steel more resistant to pitting and crevice corrosion in chloride-contaminated media, sea water and acetic acid vapour's. The lower rate of general corrosion in mildly corrosive environments gives the steel good atmospheric corrosion resistance in polluted marine atmospheres.

316 offers higher strength and better creep resistance at higher temperatures than 304. 316 also possesses excellent mechanical and corrosion properties at sub-zero temperatures. When there is a danger of corrosion in the heat-affected zones of weldments, the low-carbon variety 316L should be used. 316 Ti, the titanium-stabilised version, is used for its resistance to sensitization during prolonged exposure in the 550^{o}C-800^{o}C temperature range.

Typical Applications

Because of its superior corrosion and oxidation resistance, good mechanical properties and fabricability, 316 has applications in may sectors of industry. Some of these include:
Tanks and storage vessels for corrosive liquids.

Specialised process equipment in the chemical, food, paper, mining, pharmaceutical and petroleum industries.

Architectural applications in highly corrosive environments.

Chemical Composition (ASTM A 240)

	C	Mn	P	S	Si	Cr	Ni	Mo	Ti
316 316L 316Ti	0.08 max 0.03 max 0.08 max	2.0 max	0.045 max	0.030 max	1.0 max	16.0 to 18.0	10.0 to 14.0	2.00 to 3.00	- - 0.5 max 5X%C

Typical properties in the annealed condition

The properties quoted in this publication are typical of mill products and unless indicated must not be regarded as guaranteed minimum values for specification purposes.

1. Mechanical properties at room temperature

	316		316L		316Ti	
	Typical	Minimum	Typical	Minimum	Typical	Minimum
Tensile Strength, MPa	580	515	570	485	600	515
Proof Stress (0.2 % offset), MPa	310	205	300	170	320	205
Elongation (Percent in L = 5.65 S_o)	55	40	60	40	50	40
Hardness (Brinell)	165	-	165	-	165	-
Erichsen Cup Test Value mm	8 - 10	-	10 - 11	-	-	-
Endurance (fatigue) limit, MPa	260	-	260	-	260	-

2. Properties at elevated temperatures

The values given refer to 316 and 316 Ti only as strength values for 316L fall rapidly above 425^{o}C.

Short Time Elevated Temperature Tensile Strength

Temperature, C	600	700	800	900	1000
Strength, MPa	460	320	190	120	70

Creep data

Stress for a creep rate of 1% in 10 000 h

Temperature, ^{o}C	550	600	650	700	800
Stress, MPa	160	120	90	60	20

Recommended Maximum Service Temperature

(Oxidising conditions)

Continuous Service 925^{o}C

Intermittent Service 870^{o}C

3. Properties at Sub-Zero Temperatures

(316)

Temperature	^{o}C	-78	-161	-196
Proof Strength (0.2% Offset)	MPa	400	460	580
Tensile Strength	MPa	820	1150	1300
Impact Strength (Charpy V-Notch)	J	180	165	155

4. Corrosion Resistance

4.1 Aqueous

For specific conditions, consult Macsteel VRN technical staff. As a rough guide, the following examples are given for pure acid-water mixtures.

Temperature°C	20				80			
Concentration, (-% by mass)	10 80	20 100	40	60	10 80	20 100	40	60
Sulphuric Acid	0 1	1 0	2	2	2 2	2 2	2	2
Nitric Acid	0 0	0 1	0	0	0 1	0 2	0	0
Phosphoric Acid	0 1	0 2	0	0	0 1	0 2	0	0
Formic Acid	0 1	0 0	0	1	0 1	0 0	1	1

Key: 0 = resistant - corrosion rate less than 100 mm/year
1 = partly resistant - corrosion rate 100 m to 1000 mm/year
2 = non resistant - corrosion rate more than 1000 mm/year

4.2 Atmospheric

The performance of 316 compared with other metals in various environments is shown in the following table. Corrosion rate is based on a 5 year exposure.

Environment	Corrosion Rate (mm/year)		
	316	Aluminium-3S	Mild Steel
Rural	0.0025	0.025	5.8
Marine	0.0076	0.432	34.0
Marine-Industrial	0.0051	0.686	46.2

Note: For corrosion resistance of 316 relative to other types, see the section in Comparative Data.

4.3 Thermal Processing

4.3.1 Annealing. Heat from 1 010°C to 1 120°C and cool rapidly in air or water. The best corrosion resistance is obtained when the final annealing temperature is above 1 070°C.

4.3.2 Stress relieving. Heat from 200 - 400°C and air cool.

4.3.3 Hot working

Initial forging and pressing:	1150 - 1200°C
Finishing temperature:	above 900°C
For upsetting operations, forgings should be finished between:	930 and 980°C

All hot working operations should be followed by annealing.

Note: Soaking times to ensure uniformity of temperature are up to 12 times that required for the same thickness of mild steel.

Cold Working

316/316L, being extremely tough and ductile, can be readily fabricated by cold working. Typical operations include bending, forming, deep drawing and upsetting.