outokumpu
high performance stainless steel

Supra 316/4401

EN 1.4401, ASTM TYPE 316H / UNS S31609

General characteristics

Supra 316/4401 is a normal-carbon alternative to Supra 316/4404 that is widely used for various applications. Supra 316/4401 is an austenitic stainless steel that belongs to the standard CrNiMo stainless steel family and has normal carbon, nickel, and molybdenum content.

Due to their molybdenum content, the austenitic CrNiMo standard grades can be used in applications that demand increased corrosion resistance. Their well-balanced material properties make them suitable for the fabrication of many products.

Supra 316/4401 is available in many product forms and dimensions, often also from many stainless steel stockholders. It can be supplied with a wide range of functional and aesthetic surface finishes.

Typical applications

- Heat exchangers
- Flanges and valves

Products & dimensions

Cold rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
2B	Cold rolled, heat treated, pickled, skin passed	0.25-6.35	30-2070	0.25-6.35	300-2070
2BB	Bright-pickled	0.25-3.50	30-1500	0.25-3.50	600-1500
2C	Cold rolled, heat treated	0.80-6.00	30-1500		
2D	Cold rolled, heat treated, pickled	0.25-6.35	30-1610	0.25-6.35	35-1610
2E	Cold rolled, heat treated, mech. desc. pickled	0.40-6.35	30-1650	0.50-6.35	300-2070
2G	Ground	0.25-4.00	30-1530	0.25-4.00	35-1530
2H	Work hardened	0.05-6.00	3-1530	0.25-6.00	100-1530
2J	Brushed or dull polished	0.25-3.00	30-1530	0.25-3.00	50-1530
2K	Satin finish	0.60-4.00	50-1530	0.60-4.00	50-1530
2M	Patterned	0.30-3.50	30-1530	0.30-3.50	600-1524
2R	Cold rolled, bright annealed	0.05-3.00	3-1500	0.25-3.00	350-1500

Continous hot rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1C	Hot rolled, heat treated, not descaled	2.40-10.00	50-1550		
1D	Hot rolled, heat treated, pickled	2.40-12.70	50-2070	2.40-12.70	50-2070
1E	Hot rolled, heat treated, mech. desc.	1.41-4.50	50-1610	1.41-4.50	50-1610
1G	Ground	2.40-3.00	750-1200	2.40-3.00	750-1200
1M	Patterned	2.40-3.00	750-1200	2.40-3.00	750-1200
1U	Black hot rolled	2.40-10.00	50-1550		

Quarto plate products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1D	Hot rolled, heat treated, pickled			5.00-130.00	400-3200

Chemical composition

The typical chemical composition for this grade is given in the table below, together with composition limits given for the product according to different standards. The required standard will be fully met as specified on the order.

The chemical composition is given as % by mass.

	C	Mn	Cr	Ni	Mo	N	Other
Typical	**0.04**		**17.2**	**10.1**	**2.1**		
ASTM A240	≤0.08	≤2.00	16.0-18.0	10.0-14.0	2.00-3.00	≤0.10	
ASTM A240	0.04-0.10	≤2.00	16.0-18.0	10.0-14.0	2.00-3.00		
ASTM A666	≤0.08	≤2.00	16.0-18.0	10.0-14.0	2.00-3.00	≤0.10	

EN 10028-7	≤0.07	≤2.00	16.5-18.5	10.0-13.0	2.00-2.50	≤0.10	
EN 10088-2	≤0.07	≤2.0	16.5-18.5	10.0-13.0	2.0-2.5	≤0.10	
EN 10088-3	≤0.07	≤2.00	16.5-18.5	10.0-13.0	2.0-2.5	≤0.10	
EN 10088-4	≤0.07	≤2.0	16.5-18.5	10.0-13.0	2.0-2.5	≤0.10	
IS 6911	≤0.08	≤2.00	16.0-18.0	10.0-14.0	2.00-3.00	≤0.10	
IS 6911	0.04-0.10	≤2.00	16.0-18.0	10.0-14.0	2.00-3.00		

Corrosion resistance

Supra 316/4401 has excellent corrosion resistance in solutions of many halogen-free organic and inorganic compounds over a wide temperature and concentration range. It can withstand many organic and diluted mineral acids depending on the temperature and concentration of the solution. Supra 316/4401 may suffer from uniform corrosion in strong mineral acids and hot strong alkaline solutions. More detailed information on the corrosion properties of Supra 316/4401 can be found in Outokumpu's Corrosion Tables published in the Outokumpu Corrosion Handbook and on www.outokumpu.com.

In aqueous solutions containing halogenides, e.g. chlorides or bromides, pitting and crevice corrosion may occur depending on halogenide concentration, temperature, pH-value, concentration of oxidizing compounds, or crevice geometry, if applicable. The presence of corrosion-inhibiting or accelerating compounds like transition metal ions or organic compounds may influence the corrosion behavior of Supra 316/4401.

Supra 316/4401 is prone to chloride-induced stress corrosion cracking at temperatures over about 50 °C depending on the applied stress and the chloride concentration in the environment. Prior cold deformation of the structure under load increases the risk of stress corrosion cracking.

Supra 316/4401 can be used for indoor and outdoor applications in urban and moderately corrosive industrial environments. In environments where chloride contamination may be high, for instance in coastal areas, pitting and staining is possible. The best material performance is reached usually with the help of adequate design, correct post-weld treatment, and regular cleaning during use (if applicable).

For more information on corrosion resistance refer to the Outokumpu Corrosion Handbook or contact our corrosion experts.

Pitting corrosion resistance		Crevice corrosion resistance
PRE	CPT	CCT
24	20±2	<0

Pitting Resistance Equivalent (PRE) is calculated using the following formula: PRE = %Cr + 3.3 x %Mo + 16 x %N
Corrosion Pitting Temperature (CPT) as measured in the Avesta Cell (ASTM G 150), in a 1M NaCl solution (35,000 ppm or mg/l chloride ions).
Critical Crevice Corrosion Temperature (CCT) is obtained by laboratory tests according to ASTM G 48 Method F

For a more detailed description of their corrosion resistance properties in different environments see Outokumpu Corrosion Handbook.

Mechanical properties

The mechanical properties of the available products in the soft annealed condition at room temperature are given in the table below. Moderate strengths can be reached at elevated temperatures (~550 °C/1022 °F). Temperatures for excessive scaling are close to 850 °C/1562 °F. This grade, along with other austenitic corrosion-resistant steels, exhibits very high ductility and high elongation to fracture. It is not susceptible to brittle fracture in the solution annealed condition.

Cold rolled coil and sheet	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 1 mm)	**300**	**325**	**630**	**70**				
ASTM A240	≥ 205		≥ 515				≤ 217	
ASTM A240	≥ 205		≥ 515			≤ 95HRB	≤ 217	
EN 10028-7	≥ 240	≥ 270	530 - 680	≥ 40				
EN 10088-2	≥ 240	≥ 270	530 - 680	≥ 40				
EN 10088-4	≥ 240	≥ 270	530 - 680	≥ 40				
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	

Hot rolled coil and sheet	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 4 mm)	**300**	**350**	**600**	**55**			**170**	
ASTM A240	≥ 205		≥ 515				≤ 217	
ASTM A240	≥ 205		≥ 515				≤ 217	
EN 10028-7	≥ 240	≥ 270	530 - 680	≥ 40				
EN 10088-2	≥ 240	≥ 270	530 - 680	≥ 40				
EN 10088-4	≥ 240	≥ 270	530 - 680	≥ 40				
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	

Hot rolled quarto plate	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 15 mm)	**260**	**300**	**570**	**55**				
ASTM A240	≥ 205		≥ 515			≤ 95HRB	≤ 217	

ASTM A240	≥ 205		≥ 515			≤ 95HRB	≤ 217	
EN 10028-7	≥ 220	≥ 260	520 - 670	≥ 45				
EN 10088-2	≥ 220	≥ 260	520 - 670	≥ 45				
EN 10088-4	≥ 220	≥ 260	520 - 670	≥ 45				
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	

Wire rod	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical	**190**	**220**	**500**	**55**				

[1)]Elongation according to EN standard:
A_{80} for thickness below 3 mm.
A for thickness = 3 mm.
Elongation according to ASTM standard $A_{2"}$ or A_{50}.

Physical properties

Physical properties according to EN 10088 are shown below.

Density kg/dm^3	Modulus of elasticity GPa	Thermal exp. at 100 °C 10^{-6}/°C	Thermal conductivity W/m°C	Thermal capacity J/kg°C	Electrical resistance µΩm	Magnetizable
8.0	200	16.0	15	500	0.75	No

Fabrication

Cold forming

Supra 316/4401 can be readily formed and fabricated by the full range of cold forming operations. It can be used in heading, drawing, and bending. Any cold forming operations will increase the strength and hardness of the material.

Hardening

Supra 316/4401 cannot be hardened by heat treatment. However, it can be hardened by cold forming.

Machining

This austenitic product is more difficult to machine than ordinary carbon steels but is still comparatively easy to machine compared to more highly alloyed stainless grades. Unless modified for improved machinability, they require higher cutting forces than carbon steels, show resistance to chip breaking, and a high tendency to built-up edge formation. The best machining results are obtained by using high-powered equipment, sharp tooling, and a rigid setup. Better machinability performance is given by Outokumpu Prodec products, which have been modified for improved machinability. Prodec is available as hot rolled plate and bar in 4401, 4404, 4436, and 4432 grades.

Welding

Supra 316/4401 has excellent weldability and is suitable for the full range of conventional welding methods (like MMA, MIG, MAG, TIG, SAW, LBW, or RSW), except gas welding.

Supra 316/4401 has about 50% higher thermal expansion and lower heat conductivity compared to carbon steels. This means that larger deformation and higher shrinkage stresses may result from welding.

In thin sections, autogenous welding may be used. In thicker sections, the low-carbon content Supra 316L/4404 is preferred. To ensure that the weld metal properties (e.g. strength, corrosion resistance) are equivalent to those of the parent metal, matching or slightly over-alloyed fillers should preferably be used. The recommended filler metal is 19 12 3L.

Post-weld heat treatment is generally not required. In special cases where there is high risk of stress corrosion cracking or fatigue, stress relief treatment may be considered.
In order to fully restore the corrosion resistance of the weld seam, the weld discoloration should be removed by pickling and passivation.

More detailed information concerning welding procedures can be obtained from the Outokumpu Welding Handbook, available from our sales offices.

Standards & approvals

The most commonly used international product standards are given in the table below.

Standard	Designation
ASTM A240/A240M	TYPE 316H / UNS S31609; TYPE 316H / UNS S31609
ASTM A666	TYPE 316H / UNS S31609
EN 10028-7, PED 2014/68/EU	1.4401
EN 10088-2	1.4401
EN 10088-3	1.4401
EN 10088-4	1.4401
IS 6911, AMENDMENT NO. 2	ISS 316; ISS 316H

Contacts & Enquiries

Contact your nearest sales office

www.outokumpu.com/contacts

Working towards forever.

We work with our customers and partners to create long lasting solutions for the tools of modern life and the world's most critical problems: Clean energy, clean water and efficient infrastructure. Because we believe in a world that lasts forever.

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