

Supra 316L/4435

EN 1.4435, ASTM TYPE 316L

General characteristics

Supra 316L/4435 is a Supra 316L/4432 alternative with higher chromium and nickel content for enhanced corrosion resistance and formability. Supra 316L/4435 is an austenitic stainless steel that belongs to the standard CrNiMo stainless steel family. Supra 316L/4435 has low carbon content for improved resistance against intergranular corrosion after welding, increased nickel content for improved formability, and increased molybdenum content for slightly improved corrosion resistance.

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

Supra 316L/4435 is available in many product forms and dimensions. It can be supplied with a wide range of functional and aesthetic surface finishes.

Typical applications

- Urea plants
- Pulp and synthetic fiber plants
- 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	0.40-3.20	36-1540	0.40-3.20	400-1500
2BB	Bright-pickled	0.50-3.50	30-1300	0.50-3.50	600-1300
2D	Cold rolled, heat treated, pickled	0.40-6.00	30-1540	0.40-6.00	400-1500
2E	Cold rolled, heat treated, mech. desc. pickled	0.50-6.00	30-1300	0.50-6.00	600-1300
2G	Ground	0.50-3.00	30-1300	0.50-3.00	600-1300
2H	Work hardened	0.05-6.00	3-1500	0.50-6.00	600-1300
2J	Brushed or dull polished	0.50-3.00	30-1300	0.50-3.00	600-1300
2R	Cold rolled, bright annealed	0.05-3.00	3-1250	0.50-3.00	350-1250

Continuous hot rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1C	Hot rolled, heat treated, not descaled	3.50-8.00	750-1530		
1D	Hot rolled, heat treated, pickled	3.00-6.00	50-1250	3.00-6.00	350-1250
1U	Black hot rolled	3.50-8.00	750-1530		

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	0.02		17.3	12.6	2.6		
ASME II A SA-240	≤0.030	≤2.00	16.00-18.00	10.00-14.00	2.00-3.00	≤0.10	
EN 10028-7	≤0.030	≤2.00	17.0-19.0	12.5-15.0	2.50-3.00	≤0.10	
EN 10088-2	≤0.030	≤2.0	17.0-19.0	12.5-15.0	2.5-3.0	≤0.10	
EN 10088-4	≤0.030	≤2.0	17.0-19.0	12.5-15.0	2.5-3.0	≤0.10	

Corrosion resistance

Supra 316L/4435 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 316L/4435 may suffer from uniform corrosion in strong mineral acids and hot strong alkaline solutions. Due to its increased molybdenum and nickel content, its performance is, however, the best among the austenitic CrNiMo

standard grades. More detailed information on the corrosion properties of Supra 316L/4435 can be found in Outokumpu's Corrosion Tables published in the [Outokumpu Corrosion Handbook](#) and on www.outokumpu.com.

Due to its low carbon content, the risk of sensitisation for intergranular corrosion after welding sheets up to 6 mm thick is strongly reduced when compared to basic austenitic CrNiMo grade 4401 with normal carbon content.

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. Due to its increased molybdenum content, the resistance of Supra 316L/4435 against pitting and crevice corrosion is slightly increased compared to the basic austenitic CrNiMo grades 4401 and 4404. The presence of corrosion-inhibiting or accelerating compounds like e.g. transition metal ions or organic compounds may influence the corrosion behavior of Supra 316L/4435.

Supra 316L/4435 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 316L/4435 can be used for indoor and outdoor applications in rural, urban, and moderately corrosive industrial environments. When chloride contamination may be high for instance in coastal areas, pitting and staining is possible. The best material performance is usually reached with the help of adequate design, correct post-weld treatment, and regular cleaning during use (if applicable).

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

Pitting corrosion resistance		Crevice corrosion resistance
PRE	CPT	CCT
26	21±2	<0

Pitting Resistance Equivalent (PRE) is calculated using the following formula: $PRE = \%Cr + 3.3 \times \%Mo + 16 \times \%N$

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

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)	290	320	610					
EN 10028-7	≥ 240	≥ 270	550 - 700	≥ 40				
EN 10088-2	≥ 240	≥ 270	550 - 700	≥ 40				

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)								
EN 10088-2	≥ 220	≥ 260	550 - 700	≥ 40				

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				
EN 10028-7	≥ 220	≥ 260	520 - 670	≥ 45				
EN 10088-2	≥ 220	≥ 260	520 - 670	≥ 45				
EN 10088-4	≥ 220	≥ 260	520 - 670	≥ 45				

Wire rod	R _{p0.2} MPa	R _{p1.0} MPa	R _m MPa	Elongation ¹⁾ %	Impact strength J	Rockwell	HB	HV
Typical	270	310	570	55				

¹⁾Elongation according to EN standard:

A₈₀ for thickness below 3 mm.

A for thickness = 3 mm.

Elongation according to ASTM standard A₂ or A₅₀.

Physical properties

Physical properties according to EN 10088 are shown below.

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

Fabrication

Cold forming

Supra 316L/4435 can be readily formed and fabricated using a 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.

Hot forming

Hot forming can be carried out in the 850 °C–1150 °C range. For maximum corrosion resistance, forgings should be annealed at 1070 °C and rapidly cooled in air or water after hot forming operations.

Machining

Better machinability performance is achieved using Prodec versions, which have been modified for improved machinability. Prodec is available as hot rolled plate and bar in 4401, 4404, 4436 and 4432.

Welding

Supra 316L/4435 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 316L/4435 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. 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 3 L.

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
EN 10028-7, PED 2014/68/EU	1.4435
EN 10088-2	1.4435
EN 10088-4	1.4435

Contacts & Enquiries

Contact your nearest sales office

www.outokumpu.com/contacts

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