

Supra 316L/4404

EN 1.4404, ASTM TYPE 316L / UNS S31603

General characteristics

Supra 316L/4404 is our most widely used molybdenum-alloyed austenitic stainless steel. Supra 316L/4404 is a low-carbon stainless steel and is used in various process industries and other aggressive environments with higher than average corrosion resistance requirements. Due to its low carbon content, this product is also weldable in thicknesses of more than 5–6 mm/ 0.19–0.23 in without sensitivity to intergranular corrosion.

Supra 316L/4404 is an austenitic stainless steel that belongs to the standard CrNiMo stainless steels. Grade Supra 316L/4404 has low carbon content for improved resistance against intergranular corrosion after welding.

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/4404 is commonly available from many stainless steel stockists in many product forms and dimensions. It can be supplied with a wide range of functional and aesthetic surface finishes.

Typical applications

- Equipment in the chemical and petrochemical industry
- Pulp and paper industry equipment
- Textile industry equipment
- Food and beverage industry equipment
- Pharmaceutical industry equipment
- Medical applications
- 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 | 12-2070 | 0.25-8.00 | 18-2070 |
| 2BB | Bright-pickled | 0.25-3.50 | 30-1500 | 0.20-3.50 | 600-1500 |
| 2C | Cold rolled, heat treated | 0.80-6.00 | 30-1500 | | |
| 2D | Cold rolled, heat treated, pickled | 0.20-6.35 | 30-1610 | 0.25-6.35 | 35-1610 |
| 2E | Cold rolled, heat treated, mech. desc. pickled | 0.33-6.35 | 12-2070 | 0.33-6.35 | 18-2070 |
| 2F | Cold rolled, heat treated, skin passed | 0.33-3.58 | 12-1524 | 0.33-3.58 | 18-1524 |
| 2G | Ground | 0.20-4.00 | 12-1600 | 0.20-4.00 | 18-1530 |
| 2H | Work hardened | 0.05-6.00 | 3-1530 | 0.25-6.00 | 18-1530 |
| 2J | Brushed or dull polished | 0.20-3.00 | 30-1530 | 0.20-3.00 | 400-1530 |
| 2K | Satin finish | 0.50-4.00 | 12-1600 | 0.50-4.00 | 18-1524 |
| 2M | Patterned | 0.30-3.50 | 30-1530 | 0.25-3.50 | 400-1524 |
| 2R | Cold rolled, bright annealed | 0.05-3.00 | 3-1500 | 0.25-3.00 | 18-1500 |
| 2S | Surface coated | 0.40-3.00 | 30-1500 | | |
| 2W | Profile rolled | 0.40-1.50 | 36-1275 | 0.40-1.50 | 400-1250 |

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 | 2.70-12.70 | 50-2070 | 2.70-12.70 | 50-2070 |
| 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 |
| 1G | Ground | | | 12.00-19.99 | 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 | | 17.2 | 10.1 | 2.1 | | |
| ASME II A SA-240 | ≤0.030 | ≤2.00 | 16.0-18.0 | 10.0-14.0 | 2.00-3.00 | ≤0.10 | |
| ASTM A240 | ≤0.030 | ≤2.00 | 16.0-18.0 | 10.0-14.0 | 2.00-3.00 | ≤0.10 | |
| ASTM A666 | ≤0.030 | ≤2.00 | 16.0-18.0 | 10.0-14.0 | 2.00-3.00 | ≤0.10 | |
| EN 10028-7 | ≤0.030 | ≤2.00 | 16.5-18.5 | 10.0-13.0 | 2.00-2.50 | ≤0.10 | |
| EN 10088-2 | ≤0.030 | ≤2.0 | 16.5-18.5 | 10.0-13.0 | 2.0-2.5 | ≤0.11 | |
| EN 10088-3 | ≤0.030 | ≤2.00 | 16.5-18.5 | 10.0-13.0 | 2.0-2.5 | ≤0.11 | |
| EN 10088-4 | ≤0.030 | ≤2.0 | 16.5-18.5 | 10.0-13.0 | 2.0-2.5 | ≤0.11 | |
| TECHNETICS M118 Rev A (Z2 CND) | ≤0.030 | ≤2.0 | 16-19 | 10.0-14.0 | 2.0-2.5 | ≤0.11 | |

Corrosion resistance

Outokumpu Supra 316L/4404 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/4404 may suffer from uniform corrosion in strong mineral acids and hot strong alkaline solutions. More detailed information on the corrosion properties of Supra 316L/4404 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 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. The presence of corrosion-inhibiting or accelerating compounds like transition metal ions or organic compounds may influence the corrosion behavior of Supra 316L/4404.

Supra 316L/4404 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/4404 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 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: $PRE = \%Cr + 3.3 \times \%Mo + 16 \times \%N$

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) | 300 | 325 | 625 | 70 | | | | |

| | | | | | | | | |
|--------------------------------|------------|------------|------------|-----------|--|---------------------|------------|--|
| ASME II A SA-240 | ≥ 170 | | ≥ 485 | | | | ≤ 217 | |
| ASTM A240 | ≥ 170 | | ≥ 485 | | | $\leq 95\text{HRB}$ | ≤ 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 | | | | |
| TECHNETICS M118 Rev A (Z2 CND) | ≥ 240 | ≥ 270 | 530 - 680 | ≥ 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) | 300 | 350 | 600 | 55 | | | 170 | |
| ASME II A SA-240 | ≥ 170 | | ≥ 485 | | | | ≤ 217 | |
| ASTM A240 | ≥ 170 | | ≥ 485 | | | | ≤ 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 | | | | |
| TECHNETICS M118 Rev A (Z2 CND) | ≥ 240 | ≥ 270 | 530 - 680 | ≥ 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 | | | | |
| ASME II A SA-240 | ≥ 170 | | ≥ 485 | | | $\leq 95\text{HRB}$ | ≤ 217 | |
| ASTM A240 | ≥ 170 | | ≥ 485 | | | $\leq 95\text{HRB}$ | ≤ 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 | | | | |
| TECHNETICS M118 Rev A (Z2 CND) | ≥ 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 | 220 | 260 | 530 | 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 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 316L/4404 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.

Hardening

Supra 316L/4404 cannot be hardened by heat treatment. However, it can be hardened by cold forming.

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.

Annealing

Quench annealing should be performed at 1030–1110 °C and followed by rapid cooling in water or air. In applications where high residual stresses cannot be accepted, stress relief treatment may be necessary. This can be performed by annealing as outlined above, but may also be performed at lower temperatures. Please contact us for further information.

Machining

Supra 316L/4404 is more difficult to machine than ordinary carbon steels but are still comparatively easier than more highly alloyed stainless grades. Unless modified for improved machinability, it requires higher cutting forces than carbon steels, shows resistance to chip breaking, and a high tendency to built-up edge formation. The best machining results are obtained by using high-power equipment, sharp tooling, and a rigid set-up. Better machinability performance is given 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

Austenitic Supra 316L/4404 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/4404 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 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 |
|--|------------------------|
| ASME SA-240M Code Sect. II. Part A | TYPE 316L / UNS S31603 |
| ASTM A240/A240M | TYPE 316L / UNS S31603 |
| ASTM A666 | TYPE 316L / UNS S31603 |
| EN 10028-7, PED 2014/68/EU | 1.4404 |
| EN 10088-2 | 1.4404 |
| EN 10088-3 | 1.4404 |
| EN 10088-4 | 1.4404 |
| TECHNETICS M118 Rev A (Z2 CND 17-12 acc RCCM M3307) + JN 14-2016 | 1.4404 |

Contacts & Enquiries

[Contact your nearest sales office](#)

www.outokumpu.com/contacts

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