X1NiCrMoCu25-20-5 / 1.4539 (904L)

Specification /Data sheet

Standard Name	EN Designation: X1NiCrMoCu25-20-5
Werkstoff Number	1.4539
UNS Number	N08904
ASTM Equivalent	ASTM A240 / A312 / B625 / B649 / B677
EN Standard	EN 10088-1, EN 10216-5 (for tubes), EN 10088-2 (plates)
Material Type	Austenitic Stainless Steel
Delivery Conditions	Solution Annealed, Pickled, Bright Annealed (if tubes)

Chemical Composition (% max.)

Element	Content (%)
C	≤ 0.02
Si	≤ 1.00
Mn	≤ 2.00
P	≤ 0.035
S	≤ 0.015
Cr	19.0 – 23.0
Ni	23.0 – 28.0
Mo	4.0 – 5.0
Cu	1.0 – 2.0
N	≤ 0.10

Mechanical Properties

904L (UNS N08904 / 1.4539) super austenitic stainless steel offers an excellent combination of strength, ductility, and toughness. Its mechanical properties make it suitable for demanding applications where both structural integrity and corrosion resistance are required.

Tensile Properties

Property	Temperature	Value (MPa)	Value (ksi)
0.2% Yield Strength (Rp0.2)	20°C (68°F)	313	45
	100°C (212°F)	205	30
	300°C (572°F)	145	21
	500°C (932°F)	125	18
Tensile Strength (Rm)	20°C (68°F)	520	75
	100°C (212°F)	520	75
	300°C (572°F)	490	71
	500°C (932°F)	410	59
Elongation (minimum)	All temperatures	40%	
Hardness	–	180-220 HV10	

Impact Properties

904L exhibits excellent toughness even at cryogenic temperatures:

- Charpy V-notch: > 100 J/cm² (70 ft-lbs) at -196°C (-320°F)

Physical Properties

Property	Value
Density	8.05 kg/dm³ (0.29 lb/in³)
Modulus of Elasticity at 20°C (68°F)	190 GPa (27.5 × 10^6 psi)
Thermal Expansion Coefficient (20-100°C)	15 × 10^{-6} K^{-1}
Thermal Conductivity at 20°C (68°F)	17 $W \cdot m^{-1} \cdot K^{-1}$
Specific Heat at 20°C (68°F)	500 $J \cdot kg^{-1} \cdot K^{-1}$

Property	Value
Electrical Resistivity at 20°C (68°F)	80 μΩ·cm
Magnetisable	No (except when cold worked)

Heat Treatment

904L stainless steel should be solution annealed (solution treated) between 1095°C and 1150°C (2000°F and 2100°F) followed by rapid cooling, typically water quenching. This treatment ensures optimal corrosion resistance by dissolving any carbides or intermetallic phases that might have formed during processing, and retaining the elements in solid solution.

Fabrication Information

Corrosion Resistance

904L (UNS N08904 / 1.4539) offers exceptional resistance to various types of corrosion:

- **Sulfuric Acid Resistance:** 904L performs exceptionally well in sulfuric acid environments across a wide range of concentrations and temperatures, outperforming most other high corrosion-resistant grades. This is attributed to its high content of nickel, chromium, molybdenum, and copper additions.
- **Phosphoric Acid Resistance:** 904L exhibits excellent corrosion resistance in industrial phosphoric acid solutions, significantly better than austenitic grades 316L and 317L. It’s commonly used in phosphoric acid applications, though its performance can be influenced by the presence of impurities like chlorides and fluorides.
- **Localized Corrosion:** The high chromium and molybdenum contents provide superior resistance to pitting and crevice corrosion compared to 316L and 317L grades, as demonstrated by laboratory tests and field experience.
- **Stress Corrosion Cracking:** Due to its high nickel and molybdenum content, 904L offers enhanced resistance to stress corrosion cracking compared to standard austenitic materials, performing significantly better than 304L and 316L grades, particularly in high-temperature chloride-containing solutions.

- **Intergranular Corrosion:** The very low carbon content makes 904L resistant to intergranular corrosion, even in the welded condition.

Welding

904L can be welded using standard processes including TIG/GTAW, MIG/GMAW, SMAW, PAW, and SAW, with the following considerations:

- The grade should be welded with matching filler metal or nickel-based alloys
- Basic electrodes and fluxes are preferable to rutile ones
- Due to its fully austenitic microstructure, certain precautions should be taken:
    - Minimize heat input (string bead, limitation of electrode diameter) – preferably limit to 1.5 kJ/mm
    - Control interpass temperature to less than 140°C (284°F)
    - No preheating or post-heating is required
    - Carefully clean and degrease weld areas; descale and clean finished welds
    - Use run-on and run-off plates and anti-spatter protection
    - Dry electrodes according to manufacturer’s instructions

Machining

Machining 904L requires consideration of the following factors:

- The alloy has a high work hardening rate combined with low sulfur content, making it more difficult to machine than standard grades
- Best results are achieved with slow speeds, sharp tools, positive feeds, powerful machine tools, and ample lubrication
- Cutting tools should be kept engaged with the workpiece and interrupted cuts should be avoided

General machining parameters include:

- Parting off: 10-15 m/min (33-49 ft/min) for high-speed steel tools
- Drilling: 7-11 m/min (23-36 ft/min) for high-speed steel drills
- Milling/profiling: 10-20 m/min (33-66 ft/min) for high-speed steel tools

1.4539 / X1NiCrMoCu25-20-5 Product Types & Standards

Product Type	Standard / Specification
Plates / Sheets / Coils	EN 10088-2, ASTM A240, ASTM B625
Seamless Pipes / Tubes	EN 10216-5, ASTM A312, ASTM B677
Welded Pipes / Tubes	EN 10217-7, ASTM A358
Bars / Rods	EN 10088-3, ASTM B649, ASTM A276
Forgings (Flanges, Rings)	EN 10222-5, ASTM A182
Pipe Fittings (Elbow, Tee)	ASTM A403 (for wrought fittings), ASTM B366
Wire / Welding Wire	ASTM A580, AWS A5.9 ER385
Tube Sheets / Custom Parts	Manufacturer Standard (based on ASTM B625 or A240 + Machining)
Fasteners / Bolts	ASTM F594 (for 904L), ISO 3506 (Austenitic Grades)