

**Grade 904L** is a non-stabilised low carbon high alloy austenitic stainless steel. The addition of copper to this grade gives it greatly improved resistance to strong reducing acids, particularly sulphuric acid. It is also highly resistant to chloride attack - both pitting / crevice corrosion and stress corrosion cracking.

This grade is non-magnetic in all conditions and has excellent weldability and formability. The austenitic structure also gives this grade excellent toughness, even down to cryogenic temperatures.

904L does have very substantial contents of the high cost ingredients nickel and molybdenum. Many of the applications in which this grade has previously performed well can now be fulfilled at lower cost by duplex stainless steel 2205 (S31803 or S32205), so 904L is used less commonly than in the past.

### Corrosion Resistance

Although originally developed for its resistance to sulphuric acid it also has a very high resistance to a wide range of environments. A PRE of 35 indicates that the material has good resistance to warm sea water and other high chloride environments. High nickel content results in a much better resistance to stress corrosion cracking than the standard austenitic grades. Copper adds resistance to sulphuric and other reducing acids, particularly in the very aggressive "mid concentration" range.

In most environments 904L has a corrosion performance intermediate between the standard austenitic grade 316L and the very highly alloyed 6% molybdenum and similar "super austenitic" grades.

In aggressive nitric acid 904L has less resistance than molybdenum-free grades such as 304L and 310L.

For maximum stress corrosion cracking resistance in critical environments the steel should be solution treated after cold work.

Consult Atlas Technical Assistance for specific environmental recommendations.

### Heat Resistance

Good resistance to oxidation, but like other highly alloyed grades suffers from structural instability (precipitation of brittle phases such as sigma) at elevated temperatures. It should not be used above about 550°C. 904L has design stress values in the ASME Boiler and Pressure Vessel Code to 371°C.

### Heat Treatment

#### Solution Treatment (Annealing)

Heat to 1090-1175°C and cool rapidly. This grade cannot be hardened by thermal treatment.

### Welding

904L can be successfully welded by all standard methods. Care needs to be taken as this grade solidifies fully austenitic, so is susceptible to hot cracking, particularly in constrained weldments. No pre-heat should be used and in most cases post weld heat treatment is also not required. AS 1554.6 pre-qualifies Grade 904L rods and electrodes for welding of 904L.

### Fabrication

904L is a high purity, low sulphur grade, and as such will not machine as well as other grades optimised for machinability. Grade 904L can however be machined using standard techniques.

Bending to a small radius is readily carried out. In most cases this is performed cold. Subsequent annealing is generally not required, although it should be considered if the fabrication is to be used in an environment where severe stress corrosion cracking conditions are anticipated.

### Typical Applications

Processing plant for sulphuric, phosphoric and acetic acids. Pulp and paper processing. Components in gas scrubbing plants. Seawater cooling equipment. Oil refinery components. Wires in electrostatic precipitators.

### Specified Properties

These properties are specified for flat rolled product (plate, sheet and coil) in ASTM A240M. Similar but not necessarily identical properties are specified for other products such as pipe, tube and bar in their respective specifications.

#### Composition Specification (%)

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	Cu	N
904L	min.	-	-	-	-	-	19.0	4.0	23.0	1.0	-
	max.	0.020	2.00	1.00	0.045	0.035	23.0	5.0	28.0	2.0	0.10

#### Mechanical Property Specification

Grade	Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
				Rockwell B (HR B) max	Brinell (HB)
904L	490	220	35	90	-

### Physical Properties

(typical values in the annealed condition)

Grade	Density (kg/m <sup>3</sup> )	Elastic Modulus (GPa)	Mean Coefficient of Thermal Expansion			Thermal Conductivity		Specific Heat (J/kg.K)	Electrical Resistivity (nΩ.m)
			0-100°C (µm/m/°C)	0-315°C (µm/m/°C)	0-538°C (µm/m/°C)	at 20°C (W/m.K)	at 500°C (W/m.K)		
904L	8000	200	15.0	-	-	13.0	-	500	850

### Grade Specification Comparison

Grade	UNS No	Euronorm		Swedish SS	Japanese JIS
		No	Name		
904L	N08904	1.4539	X1NiCrMoCu25-20-5	2562	-

These comparisons are approximate only. The list is intended as a comparison of functionally similar materials **not** as a schedule of contractual equivalents. If exact equivalents are needed original specifications must be consulted.

### Possible Alternative Grades

Grade	Why it might be chosen instead of 904L
316L	A lower cost alternative, but with much lower corrosion resistance.
6Mo	A higher resistance to pitting and crevice corrosion resistance is needed. A large range of super austenitic grades is available, with selection based on intended environment.
2205	A very similar corrosion resistance to 904L, with the 2205 having higher mechanical strength, and at a lower cost to 904L. (2205 not suitable for temperatures above 300°C, and not appropriate for difficult forming.)
Super duplex	Higher corrosion resistance is needed, together with a higher strength than 904L.

### Limitation of Liability

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