# Specification Sheet: Alloy 904L
## (UNS N08904) W. Nr. 1.4539

### A Superaustenitic Stainless Steel Designed for Corrosion and Pitting Resistance in a Wide Range of Process Environments

Alloy 904L (UNS N08904) is a superaustenitic stainless steel that is designed for moderate to high corrosion resistance in a wide range of process environments. The combination of high chromium and nickel content, coupled with additions of molybdenum and copper, assure good to excellent corrosion resistance.

With its highly alloyed chemistry — 25% nickel and 4.5% molybdenum — 904L provides good chloride stress corrosion cracking resistance, pitting resistance, and general corrosion resistance superior to 316L and 317L molybdenum enhanced stainless steels.

Alloy 904L was originally developed to withstand environments containing dilute sulfuric acid. It also offers good resistance to other inorganic acids such as hot phosphoric acid as well as most organic acids.

Alloy 904L is easily welded and processed by standard shop fabrication practices.

## Applications

- Air Pollution Control — scrubbers for coal-fired power plants
- Chemical Processing — process equipment for the production of sulfuric, phosphoric, inorganic, and organic acids and the production of phosphate-based fertilizers
- Metallurgical Processing — pickling equipment using sulfuric acid
- Oil and Gas Production — offshore process equipment
- Pharmaceutical Industry — process equipment
- Pulp and Paper — processing equipment
- Seawater and Brackish Water — condensers, heat exchangers, and piping systems

## Standards

**ASTM** ..... A 240, B 625
**ASME** ..... SA 240, SB 625

## Chemical Analysis

**Weight % (all values are maximum unless a range is otherwise indicated)**

| | | | |
|---|---|---|---|
| **Nickel** | 23.0 min.–28.0 max. | **Silicon** | 1.00 |
| **Chromium** | 19.0 min.–23.0 max. | **Phosphorus** | 0.045 |
| **Molybdenum** | 4.0 min.–5.0 max. | **Sulfur** | 0.035 |
| **Copper** | 1.0–2.0 max. | **Iron** | Balance |
| **Manganese** | 2.00 | | |

## Physical Properties

**Density**
0.287 lbs/in$^3$
7.95 g/cm$^3$

**Specific Heat**
0.11 BTU/lb-°F (32–212°F)
450 J/kg-°K (0–100°C)

**Electrical Resistivity**
33.5 Microhm-in at 68°F
95.2 Microhm-cm at 20°C

**Modulus of Elasticity**
28.0 x $10^6$ psi
190 GPa

**Melting Range**
2372–2534°F
1300–1390°C

**Thermal Conductivity 212°F (100°C)**
6.8 BTU/Ft-hr-°F
12.9 W/m-°K

**Mean Coefficient of Thermal Expansion**

| Temperature Range °F | Temperature Range °C | in/in/°F | cm/cm/°C |
|---|---|---|---|
| 68–212 | 20–100 | 8.5 x $10^{-6}$ | 15.3 x $10^{-6}$ |

## Mechanical Properties

**Typical Values at 68°F (20°C) (minimum values, unless specified)**

| Yield Strength 0.2% Offset | | Ultimate Tensile Strength | | Elongation in 2 in. | Hardness |
|---|---|---|---|---|---|
| psi | (MPa) | psi | (MPa) | % | |
| 31,000 | 220 | 71,000 | 490 | 36 | 70–90 Rockwell B |

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## Corrosion Resistance

The high content of alloying elements in 904L gives the alloy exceptionally good resistance to uniform corrosion.

904L was originally developed to withstand environments containing dilute sulfuric acid and is one of the few stainless steels that, at temperatures up to 95°F (35°C), provides full resistance in such environments within the entire concentration range of 0 to 100%. 904L also offers good resistance to a number of other inorganic acids, such as phosphoric acid and most organic acids. However, acids and acid solutions containing halide ions can be very aggressive, and the corrosion resistance of 317L, 317LMN, and 904L may be insufficient.

Fractional distillation of tall oil often needs better material than 316L or even the more frequently used 317LMN. In these hot concentrated caustic solutions, the corrosion resistance is mainly determined by the nickel content of the material. With a nickel content of 25%, 904L has proven to be a good alternative to most conventional stainless steels.

Conventional stainless steels such as 304L and 316L are susceptible to chloride stress corrosion cracking (SCC) under certain conditions. Resistance to SCC increases with the increased content of nickel and molybdenum. Therefore, the higher performance austenitic stainless steels such as 904L have very good resistance to SCC. The table in the upper right corner shows resistance to SCC in a chloride solution under evaporative conditions. High performance austenitic steels and duplex stainless steels clearly outperform 316L.

## Fabrication Data

Alloy 904L can be easily welded and processed by standard shop fabrication practices.

### Hot Forming

Working temperatures of 1562–2102°F (850–1150°C) are recommended for hot working processes. Normally hot working should be followed by a solution anneal and quench, but for 904L, if hot forming is discontinued at a temperature above 2012°F (1100°C) and the material is quenched directly thereafter, the material may be used without subsequent heat treatment. It is important that the entire workpiece be quenched from temperatures above 2012°F (1100°C). In the event of partial heating or cooling below 2012°F (1100°C), or if the cooling has been too slow, hot working should always be followed by a solution anneal and quenching. 904L should be solution annealed at 1940–2084°F (1060–1140°C).

### Cold Forming

904L is quite ductile and forms easily. The addition of molybdenum and nitrogen implies more powerful processing equipment may be necessary when compared with the standard 304/304L grades.

### Welding

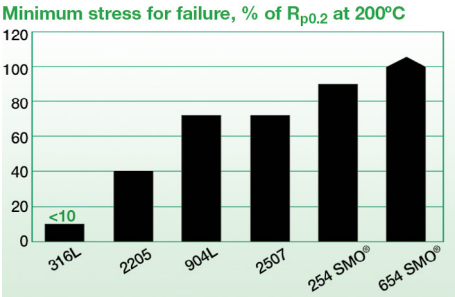
Alloy 904L can be readily welded by most standard processes. Austenitic plate materials have a homogeneous austenitic structure with an even distribution of alloying elements. Solidification after welding causes the redistribution of certain elements such as molybdenum, chromium, and nickel. These segregations remain in the cast structure of the weld and can impair the corrosion resistance in certain environments. Segregation is less evident in 904L, and this material is normally welded using a filler metal of the same composition as the base metal and can even be welded without filler metal.

The welding consumables for 904L are 20 25 CuL covered electrode and 20 25 CuL wire.

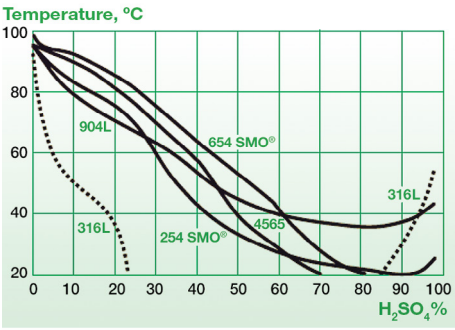
### Machining

The cold work hardening rate of Alloy 904L makes it less machinable than 410 and 304 stainless steels.






Typical threshold stresses determined using the drop evaporation test.




Isocorrosion curves 0.1 mm/year, in pure sulphuric acid.

### Uniform corrosion in pickling acid* at 25°C

| Steel Grade | Corrosion Rate, mm/year |
|---|---|
| 316L | >6 |
| 904L | 0.47 |
| 254 SMO® | 0.27 |
| 654 SMO® | 0.06 |

*Composition: 20% $HNO_3$ + 4% HF.

### Uniform corrosion in wet process phosphoric acid at 60°C

| Steel Grade | Corrosion Rate, mm/year |
|---|---|
| 316L | >5 |
| 904L | 1.2 |
| 254 SMO® | 0.05 |

Composition: 54% $P_2O_5$, 0.06% HCl, 1.1% HF, 4.0% $H_2SO_4$, 0.27% $Fe_2O_3$, 0.17% $Al_2O_3$, 0.10% $SiO_2$, 0.20% CaO and 0.70% MgO.

### Corrosion rates in a fatty acid column for the distillation of tall oil at 253°C

| Steel Grade | Corrosion Rate, mm/year |
|---|---|
| 316L | 0.88 |
| 317LMN | 0.29 |
| 904L | 0.06 |
| 254 SMO® | 0.01 |

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