

## 904L High Performance Austenitic Welded Stainless Tubular Products

### Characteristics

Grade 904L is a Molybdenum and Copper alloyed Cr-Ni austenitic stainless steel with low Carbon content. The high performance austenitic stainless steels such as 904L have a fully austenitic micro-structure in the quench annealed condition.

#### Characteristic properties:

- Very good resistance to uniform corrosion
- Good to exceptionally good resistance to pitting and crevice corrosion
- Very good resistance to stress corrosion cracking
- Very good formability

### Dimensions

Tubular products in grade 904L are not stock standard, but can be generally manufactured in most common standard sizes within OSTP's product range and to client tailored needs by agreement.

#### Tubes, Pipes and Butt Weld Fittings

- OD: 21.3–1219.0 mm
- WT: 1.5–25.4 mm
- Lengths: up to 12 m

Tubes below 21.3 mm OD and tubes with wall thickness below 1.5 mm or length over 12 m on special request.

### Executions

#### Tubes, Pipes and Butt Weld Fittings

- Welded with- or without filler metal
- Unannealed, pickled
- Solution annealed and pickled
- With – or Without BCW (Bead Cold Work) – Tubes Only
- Bevelled ends according to standards

### Corrosion resistance

Grade 904L has a high corrosion resistance to a wide range of corrosive environments. A PRE of 35 indicates that the steel grade 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 enhances the corrosion resistance in certain 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 Mo and similar "super austenitic" grades. See Outokumpu Corrosion Handbook for more information.

### Product standards

#### Europe

- EN 10217-7: Welded steel tubes for pressure purposes –Technical delivery conditions Part 7: Stainless steel tubes
- EN 10296-2: Welded circular steel tubes for mechanical and general engineering purposes –Technical delivery conditions Part 2: Stainless steel



- EN 10253-3: Butt-welding pipe fittings Part 3: Wrought austenitic and austenitic-ferritic (Duplex) stainless steels without specific inspection requirements.
- EN 10253-4: Butt-welding pipe fittings Part 4: Wrought austenitic and austenitic-ferritic (Duplex) stainless steels with specific inspection requirements.

#### USA

- ASTM A 249: Welded Austenitic steel boiler, superheater, heat-exchanger and condenser tubes.
- ASTM A 269: Seamless and Welded Austenitic Stainless Steel Tubing for General Service
- ASTM A 312: Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- ASTM A 358: Electric-Fusion-Welded Austenitic Cr-Ni Stainless Steel Pipe for High-Temperature Service and General Applications
- ASTM A 774: As-welded wrought austenitic stainless steel fittings for general corrosive service at low and moderate temperatures
- ASTM A 403: Wrought austenitic stainless steel piping fittings

### Pressure vessel requirements

#### Europe

The Pressure Equipment Directive (PED) regulates the use of stainless steel pipe and fittings in most European countries. OSTP fulfils the Directive, and is an approved manufacturer of welded stainless tubular products.

#### Outside Europe

Pressure vessel regulations are authorized to ASME. ASME Section VIII, Division 1, Table UHA-23, shows design values for tube and pipe manufactured and tested according to ASME SA-249 and SA-312 respectively. ASME B31.1 Power Piping and ASME B31.3 Process Piping prescribes design and design stress values for approved pipe materials.

### Fabrication

#### Welding

Common welding methods for tubular products are:

- MMA, SMAW (Shielded Metal Arc Welding)
- TIG, GTAW (Gas Tungsten Arc Welding)
- MIG, MAG, GMAW (Gas Metal Arc Welding)
- FCAW (Flux-Cored Arc Welding)
- PAW (Plasma Arc Welding)
- SAW (Submerged Arc Welding)

The general recommendation for shield and plasma gas is pure Argon (TIG/PAW). Additions of 2–3% hydrogen H<sub>2</sub> and 2–3% nitrogen N<sub>2</sub> will improve the penetration and corrosion resistance. As backing/ purging gas the general recommendation is pure Argon or Formier gas (90% N<sub>2</sub> and 10% H<sub>2</sub>). When material thickness requires more than one run, the interpass temperature has to be below 100°C. General filler recommendation for steel grade 904L can be found in the table below. Welding without filler metal not followed by post heat treatment will reduce the corrosion resistance and is therefore not recommended. See Outokumpu Welding Handbook for more information.

#### Cold forming

Excellent cold forming properties. The same properties as for other standard austenitic stainless steels.

#### Hot forming

Grade 904L is slightly harder at higher temperatures than austenitic standard grades. Hot forming temperature range is 1150 - 850°C. If the hot forming is discontinued at a temperature above 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 has been quenched from temperatures above 1100°C. In the case of partial heating or partial cooling below 1100°C or if the cooling has been too slow, hot working should always be followed by solution annealing and quenching.

#### Heat treatment

The normal solution annealing temperature is 1060–1140°C followed by rapid cooling to at least 700°C. At temperatures between 800–900°C, inter metallic phases that impair the properties will form within a few minutes.

### Applications

- Process equipment in chemical industry
- Bleaching equipment in the pulp and paper industry
- Flue-gas cleaning
- Desalination
- Seawater handling
- Heat exchangers

### Design

The allowable design values are similar to those for standard austenitic steels. Please use our Pressure Calculation Tool on [www.ostp.biz](http://www.ostp.biz) for design purposes.

## General filler recommendation for high performance austenitic stainless steels

Outokumpu	EN	ASTM / UNS	Welding consumables	
			Covered electrodes ISO 3581 / ISO 14172	Wires ISO 14343 / ISO 18274
<b>904L</b>	<b>1.4539</b>	<b>N08904</b>	<b>20 25 5 Cu L</b>	<b>20 25 5 Cu L</b>
254 SMO®	1.4547	S31254	Ni Cr 21 Mo Fe Nb / Ni Cr 25 Mo 16R or P54*	Ni Cr 22 Mo 9 Nb
4565	1.4565	S34565	Ni Cr 21 Mo Fe Nb / Ni Cr 25 Mo 16R or P54*	Ni Cr 22 Mo 9 Nb

\* Avesta Welding designation

## Weld factor

Type of weld process and NDT	EN 13480-3			ASME B31		
	EN 10217-7 / EN 10253-4	EN 10296-2 / EN 10253-3		A 269	A 312 / A 774	A 358 / A 403
EFW, 100% ET	1.0	-		0.8	0.8	0.8
EFW, 100% RT	1.0	-		1.0	1.0	1.0
EFW, spot RT	-	0.85		0.9	0.9	0.9
EFW, double butt	-	0.7		0.85	0.85	0.85
EFW, single butt	-	0.7		0.8	0.8	0.8

EFW = Electric Fusion Welded ET = Eddy Current Test RT = Radiographic Test

The joint coefficient (z used in EN standards) or Joint quality factor (Ej, used in ASME standards) is used for calculation of the wall thickness for welded tubes.

The type of welding process, amount and type of NDT decide the factor.

## Chemical composition, % (Typical values)

Outokumpu	EN	ASTM	Cr	Ni	Mo	N	PRE*
4307	1.4307	304L	18.1	8.3	-	-	18
4404	1.4404	316L	17.2	10.1	2.1	-	24
4432	1.4432	316L	16.9	10.7	2.6	-	25
<b>904L</b>	<b>1.4539</b>	<b>N08904</b>	<b>20</b>	<b>25</b>	<b>4.3</b>	-	<b>34</b>
254 SMO®	1.4547	S31254	20	18	6.1	0.20	43
4565	1.4565	S34565	24	17	4.5	0.45	46

\* PRE = % Cr + 3.3% Mo + 16% N (The formula is used as a ranking tool to estimate pitting corrosion resistance in the material).

## Mechanical properties (At room temperature)

Outokumpu	EN	ASTM	Min values acc. to EN 10028-7:2007									Min values according to ASTM A240-10		
			R <sub>p0.2</sub> , MPa			R <sub>m</sub> , MPa			A <sub>90</sub> , %			R <sub>p0.2</sub> , MPa	R <sub>m</sub> , MPa	A <sub>5</sub> , %
			P	H	C	P	H	C	P	H	C			
4307	1.4307	304L	200	200	220	500	520	520	45	45	45	170	485	40
4404	1.4404	316L	220	220	240	520	530	530	45	40	40	170	485	40
4432	1.4432	316L	220	220	240	520	550	550	45	40	40	170	485	40
<b>904L</b>	<b>1.4539</b>	<b>N08904</b>	<b>220</b>	<b>220</b>	<b>240</b>	<b>520</b>	<b>530</b>	<b>530</b>	<b>35</b>	<b>35</b>	<b>35</b>	<b>220</b>	<b>490</b>	<b>35</b>
254 SMO®	1.4547	S31254	300	300	320	650	650	650	40	35	35	310	655	35
4565	1.4565	S34565	420*	420*	420*	800*	800*	800*	30*	30*	30*	415	795	35

\* Min values according to EN 10088-4:2009

P = Hot rolled plate

H = Hot rolled strip

C = Cold rolled coil and strip

## Physical properties

Outokumpu	EN	ASTM	Density, g/cm <sup>3</sup>	Modulus of elasticity, GPa	Poisson's ratio $\nu = -\epsilon_{trans} / \epsilon_{longitudinal}$	Average linear expansion at RT- 100°C x10 <sup>-6</sup> /°C
4307	1.4307	304L	18.1	200	0.3	16.0
4404	1.4404	316L	17.2	200	0.3	16.0
4432	1.4432	316L	16.9	200	0.3	16.0
<b>904L</b>	<b>1.4539</b>	<b>N08904</b>	<b>20</b>	<b>200</b>	<b>0.3</b>	<b>16.0</b>
254 SMO®	1.4547	S31254	20	200	0.3	16.0
4565	1.4565	S34565	24	200	0.3	16.0

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OSTP is a joint-venture between Tubinoxia and Outokumpu Group. OSTP manufactures the broadest range of stainless steel tubular products:

### PROCESS PIPES

- Jakobstad, Finland
- Riyadh, Saudi Arabia

### HEAVY WALL PIPES

- Storfors, Sweden

### BUTT WELDED FITTINGS

- Örnsköldsvik, Sweden
- Jakobstad, Finland

### PROCESS EQUIPMENT

- ÖMV, Örnsköldsvik, Sweden

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