



Characteristics

Grade 904L is a Molybdenum and Copper alloyed Cr-Ni austenitic stainless steel with low Carbon content.

Its specific characteristics are:

- Austenitic micro structure
- High resistance to:
 - pitting and crevice corrosion
 - stress corrosion and corrosion fatigue
 - uniform corrosion
- Good ductility and weldability

Dimensions

Tubular products in grade 904L are not stock standard, but can be manufactured in most common standard sizes within Outokumpu Stainless Tubular Products product range.

Tubes & Pipes

- OD: 17.2-1219.0 mm
- WT: 1.5-25.4 mm
- Lengths: up to 12 m

Heat exchanger tubes

- OD: 12.0-114.3 mm
- WT: 0.6-4.0 mm
- Lengths: up to 15 m

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 Worked)
- Bevelled ends according to standards

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
904L	1.4539	N08904	20 25 5 CuL	20 25 5 CuL
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

Heat exchanger tubes

- No BCW for laser welded tubes, h max = 0.15 mm
- Tig welded tubes are BCW
- Solution annealed and pickled

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 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 Mo and similar "super austenitic" grades. See Outokumpu Corrosion Handbook for more information.

Product standards

Europe

- EN 10296-2 Welded SS tubes for general purposes.
- EN 10217-7 Welded SS tubes for pressure purposes.
- EN 10253-3: Butt-welding pipe fittings. Wrought austenitic and austenitic-ferritic (Duplex) stainless steels without specific inspection requirements.
- EN 10253-4: Butt-welding pipe fittings. Wrought austenitic and austenitic-ferritic (Duplex) stainless steels with specific inspection requirements.

USA

- ASTM A 249 Welded Austenitic SS Heat Exchanger Tubes
- ASTM A 269 Welded and seamless Austenitic SS Tubing
- ASTM A 312 Welded and seamless Austenitic SS Pipes
- ASTM A 358 EF Welded Austenitic Pipe with filler metal
- ASTM B 673 Welded Pipe
- ASTM B 674 Welded Tube

Pressure vessel approvals

Europe

The Pressure Equipment Directive PED regulates the use of welded SS pipe in most European countries. Outokumpu Stainless Tubular Products fulfils the Directive, and is an approved manufacturer of welded SS tubes.

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 H2 and 2-3 % nitrogen N2 will improve the penetration and corrosion resistance. As backing/purging gas the general recommendation is pure Argon or Formier gas (90 % N2 and 10 % H2). 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 (will be launched during 2010).

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. Forming at temperatures in the range 1000-1200°C does not require any post heat treatment, if the operation is followed by a reasonable fast cooling, (>600°C/min).

Heat treatment

The normal annealing temperature is 1120-1180°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 Press Calculation Tool on www.outokumpu.com for design purposes.

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 789	A 790	A 798	A 928
EFW, 100 % ET	1.0	-		0.8	0.8	0.8	0.8
EFW, 100 % RT	1.0	-		1.0	1.0	1.0	1.0
EFW, spot RT	-	0.85		-	-	-	0.9
EFW, double butt	-	0.7		0.85	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
904L	1.4539	N08904	20	25	4.3	-	34
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 A240-07		
			R _{p0.2r} MPa			R _{m,r} MPa			A _{80r} %			R _{p0.2r} MPa	R _{m,r} MPa	A _{5r} %
			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
904L	1.4539	N08904	220	220	240	520	530	530	35	35	35	220	490	35
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 ³	Modulus of elasticity, GPa	Poisson's ratio $\nu = -\epsilon_{trans} / \epsilon_{longitudinal}$	Average linear expansion at RT - 100°C x10 ⁻⁶ / °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
904L	1.4539	N08904	20	200	0.3	16.0
254 SMO®	1.4547	S31254	20	200	0.3	16.0
4565	1.4565	S34565	24	200	0.3	16.0

Outokumpu is a global leader in stainless steel with the vision to be the undisputed number one. Customers in a wide range of industries use our stainless steel and services worldwide. Being fully recyclable, maintenance-free, as well as very strong and durable material, stainless steel is one of the key building blocks for sustainable future.

What makes Outokumpu special is total customer focus – all the way, from R&D to delivery. You have the idea. We offer world-class stainless steel, technical know-how and support. We activate your ideas.

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