



Welded Stainless Tubes for Heat Exchangers
Outokumpu Stainless Tubular Products

www.outokumpu.com/ostp

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Outokumpu is an international stainless steel and technology company. Our vision is to be the undisputed number one in stainless, with success based on operational excellence. Customers in a wide range of industries use our products, technologies and services worldwide. We are dedicated to helping our customers gain competitive advantage. We call this promise the Outokumpu factor.

Outokumpu Stainless Tubular Products offers a wide range of stainless tubes, pipes, fittings and flanges for extreme conditions. Our large resources and decades of experience ensure products to the highest quality at short lead-times and reliable deliveries. Our product range includes process pipes, heat exchanger tubes, hygienic tubes, spiral welded tubes, box sections, butt weld fittings, threaded fittings and flanges.

Welded stainless tubes from Outokumpu Stainless Tubular Products

Welded tubular products are normally classified according to method of manufacture or intended use. Outokumpu Stainless Tubular Products's manufacturing programme includes three main product groups.

Heat exchanger tubes

Heat exchanger tubes are used in all kinds of industries. Used primarily in tubular heat exchangers, they are made from strip and welded without filler metal. The tubes have smooth inner surface with a low weld bead and are heat-treated.

They are most commonly delivered in fixed lengths. Further details are contained in this brochure.

Hygienic tubes

Hygienic tubes have to satisfy stringent demands as regards surface finish. The main application is pipe systems handling food and beverages.

For further details, see separate brochure "Welded stainless tubes for hygienic applications".

Pipes

Pipes and fittings are predominantly used in pipe systems and pipelines for the process industry. More information can be found in our product catalogue and our website.



Welded stainless heat exchanger tubes

Size range

	Straight tubes	Coiled tubes
Outside diameter	6 – 114.3 mm	10 – 28 mm
Wall thickness	0.5 – 6.0 mm	0.5 – 1.5 mm
Length	up to 18 m	50 – 800 m

Manufacturing

The manufacture of stainless steel welded tubes requires sophisticated equipment, special methods and, most importantly, considerable expertise in the areas of metallurgy and materials.

The Heat Exchanger tubes are available as:

- solution annealed and pickled
- inline bright annealed
- inline annealed, externally pickled
- electro polished
- externally ground
- internally polished (mechanically)

Principal chemical composition of Outokumpu Stainless Tubular Products's steel grades

OSTP Name	EN	ASTM	SS*	Typical chemical composition %					
				C	Cr	Ni	Mo	N	Others
Standard grades									
4301	1.4301	(304)	2333	0.04	17.0	8.5			
4307	1.4307	304L	(2352)	0.02	18.0	8.0			
4306	1.4306	304L	2352	0.02	18.0	10.0			
4541	1.4541	321	2337	0.04	17.0	9.0			Ti
4401	1.4401	316	(2347)	0.04	16.5	10.0	2.0		
4571	1.4571	316Ti	2350	0.04	16.5	10.5	2.0		Ti
4404	1.4404	316L	2348	0.02	16.5	10.0	2.0		
4436	1.4436	316	2343	0.04	16.5	10.5	2.5		
4432	1.4432	316L	2343	0.02	16.5	10.5	2.5		
4435	1.4435	316L	2353	0.02	17.0	12.5	2.5		
4438	1.4438	317L	2367	0.02	18.0	13.0	3.0		
Wet corrosion resistant duplex grades									
LDX 2101®	1.4162	S32101	-	0.03	21.5	1.5	0.3	0.22	5 Mn
SAF 2304®	1.4362	S32304	2327	0.02	23.0	4.8	0.3	0.10	
2205	1.4462	S32205	2377	0.02	22.0	5.7	3.1	0.17	
SAF 2507®	1.4410	S32750	2328	0.02	25.0	7.0	4.0	0.27	
Wet corrosion resistant austenitic grades									
904L	1.4539	NO8904	2562	0.01	20.0	25.0	4.3	0.06	
254 SMO®	1.4547	S31254	2378	0.01	20.0	18.0	6.1	0.20	
High temperature grades									
153 MA™	1.4818	S30415	2372	0.05	18.5	9.5		0.15	1.3 Si, Ce
253 MA®	1.4835	S30815	2368	0.09	21.0	11.0		0.17	1.6 Si, Ce
4828	1.4828	—	—	0.04	20.0	12.0		0.04	2.0 Si
4833	1.4833	309S	—	0.06	22.3	12.6		0.08	
4845	1.4845	310S	2361	0.05	25.0	22.0		0.04	

The LDX 2101®, SMO and MA names are trademarked and owned by Outokumpu.

The SAF names are trademarked and owned by Sandvik AB.

* SS-designations are shown for comparison and are now replaced with EN-designations.

Steel grades

Stainless steels are mostly known as Type 304(L) and 316(L). Thanks to their excellent corrosion resistance, strength and weldability they have become the dominant steels for tubes in the process industry.

Higher alloyed stainless steels, which have more chromium, molybdenum and nitrogen in order to improve the corrosion resistance and the strength, have found increased use as an alternative to e.g. more expensive nickel alloys and titanium.

Outokumpu Stainless Tubular Products is manufacturing heat exchanger tubes using a wide range of austenitic and duplex (austenitic-ferritic) grades. Other grades and variants can be offered on request.

Our steel grades for heat exchanger tubes can be divided into the following groups:

- **Corrosion resistant standard**
- **Wet corrosion resistant**
 - **Duplex grades**
 - **High alloy austenitic grades**
- **High temperature**

Corrosion resistant standard grades

Outokumpu Stainless Tubular Products's austenitic standard grades of Cr-Ni and Cr-Ni-Mo type are the most common stainless steels used to resist corrosive environments. All our grades have a low carbon content in order to avoid intergranular corrosion. Ti-stabilised grades can also be supplied.

Wet corrosion resistant duplex grades

In environments containing chlorides, standard grades may fail due to stress corrosion and/or pitting corrosion. Duplex stainless steels often are the answer, especially when stress corrosion is the main concern. Besides high corrosion resistance, they also have high strength, good resistance to erosion and linear expansion similar to carbon steels.

LDX 2101[®] combines a resistance to pitting and crevice corrosion in-between grades 4307 and 4404 with the general features of duplex steels, i.e. high mechanical strength, good resistance to stress corrosion cracking and low linear expansion.

SAF 2304[®] is a good alternative in most cases when carbon steel or 304 fails. It can often replace 316, especially when stress corrosion is a major concern.

2205 has higher strength and corrosion resistance than steels of type 316L. It has similar corrosion resistance as 904L in many environments.

SAF 2507[®] has higher strength and corrosion resistance than 2205 and 904L. Its pitting resistance is equal to that of 254 SMO[®].

Wet corrosion resistant high alloy austenitic grades

These grades are characterised by very high resistance to stress corrosion, pitting and crevice corrosion in chloride containing media. They also offer good resistance to uniform corrosion in acids.

904L has a pitting corrosion resistance equal to that of ASTM 2205 in chloride containing environments. It also has high resistance to stress corrosion cracking and high corrosion resistance in acids.

254 SMO[®] is more highly alloyed than 904L and, for this reason, have higher corrosion resistance – especially suitable in seawater cooled applications.

High temperature grades

EN 1.4833 (ASTM 309), EN 1.4845 (ASTM 310S) and EN 1.4828 are since long well established high temperature steels.

The maximum service temperature in dry air is about 1000°C for 1.4833 and 1.4828 and about 1100°C for 1.4845.

With respect to corrosion properties 1.4833 is similar to 153 MA, but the creep strength is lower. The same holds for 1.4845 compared to 253 MA.

153 MA[™] is a steel for medium-high temperatures, i.e. 600-950°C. It has very good creep strength and good scaling resistance. It is especially resistant to embrittlement. The scaling temperature in air is 1050°C.

253 MA[®] is an excellent steel for temperatures between 850 and 1100°C. Very good creep strength and good scaling resistance are important here and 253 MA is especially resistant to deformation. The scaling temperature in air is 1150°C.

Welded stainless tubes from Outokumpu Stainless Tubular Products in

CASE STUDIES

SULHPURIC ACID COOLER

Grade: 904L and 254 SMO®
 Size: 19.05 x 1.25 mm
 Shell side: 96% H₂SO₄ up to 100°C
 Tube side: Chlorinated seawater up to 30°C.

VINYL CHLORIDE PRODUCTION

Evaporation of dichlorethane
 Grade: 904L
 ID surface: Electropolished
 Size: 25.4 x 2.11 mm
 Shell side: Steam; 30 bar
 Tube side: Dichlorethane.
 Temperature 230°C.
 (Scaling on the ID of C-steel tubes)

CARBON BLACK PRODUCTION

Combustion air preheater
 Grade: 253 MA®
 Size: 88.9 x 3.0 mm, 88.9 x 4.0 mm
 88.9 x 5.5 mm
 Shell side: Hot air.
 Temperature 800°C.
 Tube side: Process gas.
 Comment: Continuous use for more than 10 years.

ALUMINA PRODUCTION

Heating caustic liquor containing Al₂O₃
 Grade: SAF 2304®
 Size: 38.1 x 1.65 mm
 Shell side: Steam 200°C
 Tube side: Caustic liquor with Al₂O₃.
 Temperature 120–155°C
 Comment: Descaling with 5% H₂SO₄ and Rodine 85 for 20 minutes every 9th day.
 Thanks to the smooth surface (small grain size) of SAF 2304®, the build-up of scale is far less pronounced than on carbon steel. This gives improved thermal efficiency and reduces the need for acid cleaning. The very high resistance to stress corrosion cracking of SAF 2304® is also decisive in the choice of material.

Some case studies are presented on these two pages. A selection of references is also given below. For the full range of current applications, please contact Outokumpu Stainless Tubular Products.

Our customers demand the utmost reliability and quality of heat exchanger tubes. In processes where corrosion resistance and leak tightness are essential, welded tubes from OSTP have brought many benefits to users worldwide.



Environmental: Equipment for heat recovery and waste incineration.

High temperature: Recuperators in the steel industry

Water treatment: Heating coils

Chemical industry: Heat exchangers and evaporators in the production of soda, ethylene oxide, fertilisers, etc.

Energy: Heat recovery and gas cleaning

Food: Milk pasteurisation, production of sugar, fruit juices, etc.

Pulp & paper: Liquor heaters and evaporators

Oil & gas refineries: Oil coolers, sour water strippers, etc.

Heat exchangers, Evaporators, Condensers..



CASE STUDIES

STRAND ANNEALING FURNACES

Solution annealing of stainless steel wire
Grade: Outokumpu 4845 (310S)
Size: 33.7x2.0 mm
Conditions: 1100°C, 60% H₂ +40 N₄
Comments: Cost effective compared to other thick walled furnace tubes.
Preoxidised tubes up to 18.9 m.

ENVIRONMENT PROTECTION

Heat recovery and gas cleaning
Grade: 254 SMO® and 2205
Size: 34 x 1 mm
Shell side: Water for district heating.
Tube side: Condensates of Cl⁻, F and SO₄²⁻, with pH -1 to 3.
Temperature: 50°C.

REFINERIES

Overhead condenser and sour water stripper
Grade: 904L
Size: 19.05 x 2.11 mm and 25.0 x 2.5 mm
Grade: 2205
Size: 19.05 x 1.25 mm and 25.4 x 1.65 mm
Typical conditions
Shell side: Petrol and sour water.
Temperature up to 95°C.
pH 4.5–8.
Cl⁻ up to 100 ppm.
Tube side: Cooling water.
Temperature 20–40°C.
pH 6.5–7.5.
Cl⁻ up to 1000 ppm.

PULP & PAPER INDUSTRY

Liquor heater
Grade: 2205 and SAF 2304®
Size: 31.75 x 1.65 mm and 38.1 x 2.11 mm
Shell side: Steam.
Temperature 170–185°C.
Tube side: Craft liquor.

FOOD INDUSTRY

Evaporation – food products
Grade: 254 SMO®
Size: 42.4 x 1.0 mm
Shell side: Steam
Tube side: Water solution with max. 2.9% Cl⁻, pH 5–8,
O₂ = 5 ppm, some % of Na, Ca, NH₄⁺, organic and mineral material.
Temperature up to 104°C.

Technical information about welded stainless heat exchanger tubes from Outokumpu Stainless Tubular Products

Characteristics of welded tubes

The Heat exchanger tubes from Outokumpu Stainless Tubular Products are welded from cold rolled strip. This allows the manufacturing of a concentric tube with very narrow tolerances on diameter as well as wall thickness. A low internal weld bead is characteristic of all Outokumpu Stainless Tubular Products' heat exchanger tubes. This facilitates roller expansion at the fabricator. The low bead is obtained by either bead working after welding, or careful selection of welding parameters. Welding and bead working is followed by heat treatment, which restores mechanical properties and corrosion resistance.

Extensive testing ensures the integrity of the finished tube. European pressure vessel rules treat welded and seamless tubes equally, i.e. a Weld Joint Efficiency Factor of 1.0 is used for both kinds of tubes.

ASTM specifications still only allow a Weld Joint Efficiency Factor of 0.85 for welded tubes, unless extensive x-ray testing is carried out.

Heat treatment

Our Heat exchanger tubes are always heat treated. Separate as well as in-line annealing can be offered. The main reason for heat treating welded Cr-Ni-Mo austenitic stainless steel tubes is to reduce chromium and molybdenum segregation. Segregation occurs during the solidification of the weld metal and has a negative effect on resistance to pitting corrosion.

For grades with a high Mo content, in-line induction annealing is not always sufficient to fully counteract the negative effect of segregation. Separate furnace annealing with a long soaking time is then necessary.

In order to optimise the corrosion resistance of duplex grades, the quantities of chromium, molybdenum and nitrogen in the ferrite and the austenite must be carefully controlled.

Proper in-line annealing is sufficient, but only in combination with air or water quenching.

Optimisation of the welding and heat treatment procedures ensures that the required corrosion resistance and strength are obtained.

Heat treatment also has the following benefits:

- reduction of the stresses and hardness naturally arising during strip manufacture.
- carbides and other precipitates are dissolved.

Calculation of wall thickness

Outokumpu Stainless Tubular Products welded tubes have a Weld Joint Efficiency Factor of 1.0. This means that the weld has the same strength as the base metal and that the tube can thus be regarded as equal to a seamless tube.

The high strength of the new corrosion resistant stainless steels makes it possible to use tubes with a wall thickness less than that necessary when using austenitic standard grades. In many cases, the thickness can be reduced by 50%, e.g. where Outokumpu Stainless Tubular Products 2205 is used to replace Outokumpu Stainless Tubular Products 4404 or 4571.

Use our tool for on-line calculation of wall thickness at www.outokumpu.com/ostp

Design example

Wall thicknesses (mm) necessary for a design pressure of 200 bar at 200°C, calculated according to DIN 2413.

Grade	Outside diameter, mm		
	18.00	19.05	25.4
Wall thickness, mm			
4404	1.65	2.00	2.50
254 SMO®	1.24	1.50	2.00
2205	0.90	1.00	1.25

Certificates and approvals

Outokumpu Stainless Tubular Products is proud of our reputation to be known for our reliability and high product quality and also wishes to be known and respected for our contribution to environmental protection.

Besides satisfied customers, the proof of this is our several quality certifications like;

- Quality Management System in accordance with EN ISO 9001:2000
- Environmental Management System in accordance with EN ISO 14001:2004
- Approved material manufacturer in accordance with AD2000-Merkblatt W0
- Approved Quality System in accordance with the Pressure Equipment Directive (PED 97/23/EC) as well as procedures and personnel approved by notified bodies

We also hold a number of other certificates as approved manufacturer of welded stainless steel tubes in accordance with different rules for 3rd party organizations such as AQUAP, Lloyd's Register, Det Norske Veritas, DVGW, SITAC, ISCIR as well as several well-known customer requirements.

Technical conditions of delivery for heat exchanger tubes

EUROPE: **EN 10217-7** Welded steel tubes for pressure purposes – Technical Delivery Conditions Part 7: Stainless Steel Tubes.

GERMANY *): **DIN 17457** Geschweisste kreisförmige Rohre aus austenitischen nichtrostenden Stählen für besondere Anforderungen. Prüfklasse 1 und 2.

SWEDEN *): **SS 21 97 11** Stainless steel Pressure vessel tubes. Inspection class I. SS 21 97 13 Stainless steel Pressure vessel tubes. Inspection class II.

UNITED KINGDOM *): **BS 3606** Specification for Steel tubes for heat exchangers.

USA: **ASTM A 249/A 249M** Welded austenitic steel boiler, super heater, heat exchanger and condenser tubes.

ASTM A 269 Seamless and welded austenitic stainless steel tubing for general service.

ASTM A 789/A 789 M Seamless and welded ferritic/austenitic stainless steel tubing for general service.

ASTM B 674 Standard specification for **UNS N08904** and **UNS N08925** welded tube.

ASTM A 312/A312M Seamless and welded austenitic stainless steel pipe.

FRANCE *): **NF A 49-247** Tubes soudés longitudinalement pour échangeurs de chaleur – Aciers inoxydables austénitiques.

*) Is now replaced with **EN 10217-7**.



Dimensions, quantities and coil stock

Our heat exchanger tubes are manufactured to order in standardised metric, imperial, ANSI and ISO sizes with outside diameters ranging from 6-114.3 mm and wall thicknesses from 0.5-6.0 mm. The table below illustrates our program of Imperial dimensions.

Imperial dimensions – standardised inch sizes

BWG									
Outside diameter		22	20	18	16	14	12	10	
		Wall thickness, mm							
		0.71	0.89	1.24	1.65	2.11	2.77	3.40	
mm	inch	Weight, kg/m							
12.70*	1/2	0.214	0.263	0.356	–	–	–	–	
15.88	5/8	0.271	0.334	0.455	0.588*	–	–	–	
19.05	3/4	0.327	0.405	0.553	0.729	0.895	–	–	
25.4	1	0.440	0.546	0.750	0.981	1.23	1.57	–	
31.75	1 1/4	0.554	0.688	0.947	1.24	1.57	2.01	–	
38.1	1 1/2	0.667	0.832	1.14	1.51	1.90	2.45	–	
44.5	1 3/4	–	–	1.34	1.77	2.24	2.89	3.50	
50.8	2	–	–	1.54	2.03	2.57	3.33	4.03	
63.5	2 1/2	–	–	1.94	2.55	3.24	4.21	5.13	
76.2	3	–	–	2.34	3.08	3.91	5.09	6.19	
88.9	3 1/2	–	–	2.72	3.60	4.58	5.97	7.27	
101.6	4	–	–	–	4.13	5.25	6.85	8.35	
114.3	4 1/2	–	–	–	4.65	5.92	7.73	9.43	

* Not bead worked

Quantities

As steel grade, outside diameter, wall thickness, length and specification requirements vary from case to case, our heat exchanger tubes are not held in stock.

However, cold-rolled coils are stocked in the most common standard and special grades. This ensures not only fast manufacture and delivery, but also ready availability of reasonable quantities.

For the grades and thicknesses that are stocked as coil, the minimum order quantity, depending on wall thickness and grade, is 300–1 300 m per dimension.

For other combinations, the quantity of a full coil can be offered, i.e. 5 to 7 tons for special grades and 9 to 10 tons for standard grades.

Coil stock

Selected standard thicknesses for each grade.

Standard grades

Outokumpu	EN	ASTM	DIN
4307	1.4307	304L	–
4541	1.4541	321	1.4541
4571	1.4571	316Ti	1.4571
4404	1.4404	316L	–
4432	1.4432	316L	–

Special grades

Outokumpu	EN	ASTM	DIN
2205	1.4462	S32205	1.4462
904L	1.4539	N08904	1.4539
254 SMO®	1.4547	S31254	–
253 MA®	1.4835	S30815	1.4893

Packaging

Standard package

E41

Wooden crate with tube bundle wrapped in plastic.
End caps on request.

Package for overseas and on special request

E51

Fully streathed wooden box with tube bundle wrapped in plastic.
End caps on request.

Package for coiled tubing

Wooden pallet with plastic cover.



E41

E51

Information given in this brochure may be subject to alteration without notice.

Care has been taken to ensure that the contents of this publication are accurate but Outokumpu Stainless Tubular Products and its subsidiary companies do not accept responsibility for errors or for information which is found to be misleading. Suggestions for or descriptions of the end use or application of products or methods of working are for information only and the company and its subsidiaries accept no liability in respect thereof. Before using products supplied or manufactured by the company the customer should satisfy himself of their suitability. If further assistance is required, the company, which has extensive research facilities, will often be able to help.

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Heat exchanger tubes

Hygienic tubes

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Outokumpu is an international stainless steel and technology company. Our vision is to be the undisputed number one in stainless, with success based on operational excellence. Customers in a wide range of industries use our products, technologies and services worldwide. We are dedicated to helping our customers gain competitive advantage. We call this promise the Outokumpu factor.



www.outokumpu.com/ostp