

High Strength Duplex Welded Stainless Tubular Products

LDX 2304 – 1.4362 – S32304

Characteristics

Grade 2304 is a lean Duplex stainless steel with general corrosion resistance similar or better than 316L (PRE), but with a yield strength nearly double that of austenitic stainless steels.

Characteristic properties:

- High mechanical strength
- Good weldability
- Good corrosion resistance
- High resistance to Stress Corrosion Cracking (SCC)
- Good machinability
- Very good wear and abrasive resistance
- Low thermal expansion
- Good fatigue properties
- Temperature range -40°C to 250°C

Dimensions

Tubular products in grade 2304 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.



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

With 2304's Duplex microstructure, a low nickel and high chromium content, the alloy has improved stress corrosion resistance properties compared to the 304L and 316L standard austenitic grades

Microstructure / Ferrite content

The balanced chemical composition of 2304 results in a microstructure containing approximately equal amount of ferrite and austenite in the microstructure after annealing in a temperature about 950–1050°C. By determining the ferrite content in the weld, it is ensured that the welding and/or annealing has been done properly. The general opinion is that a too high ferrite content, i.e. > 70% decreases the toughness and pitting resistance, and a too low ferrite content, i.e. < 25% decreases the SCC-resistance.

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.

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

PROCESS PIPES
Jakobstad, Finland

BUTT WELDED FITTINGS
Örnsköldsvik, Sweden
Jakobstad, Finland
PCM Technology, Finland

PROCESS EQUIPMENT
ÖMV, Örnsköldsvik, Sweden

USA

- ASTM A 789: Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
- ASTM A 790: Seamless and Welded Ferritic/Austenitic Stainless Steel Pipes
- ASTM A 928: Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe electric fusion welded with addition of filler metal
- ASTM A 815: Wrought Ferritic, Ferritic/Austenitic, and Martensitic 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 Duplex stainless tubular products.

Outside Europe

Pressure vessel regulations are authorized to ASME. ASME Section II, Part D Table 2A, shows design values for tube and pipe. ASME B31.1 Power Piping and ASME B31.3 Process Piping state design for approved pipe material.

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 shielding and plasma gas is pure Argon (TIG/PAW). An addition of 1–2% nitrogen in the shielding gas for TIG and PAW methods will improve the corrosion resistance in the weld. As backing/purging gas the general recommendation is Formier gas (90% N₂ and 10% H₂), pure Argon could also be used but the addition of nitrogen enhances the corrosion resistance of the weld.

When material thickness requires more than one run, the interpass temperature has to be below 150°C. General filler recommendation for steel grade 2304 can be found in the table below. Welding without filler metal not followed by post-weld heat treatment will reduce the corrosion resistance and is therefore not recommended. Welding against other steel grades is also possible when suitable filler metal and shielding/ backing gas is used.

Cold forming

Since the yield strength is about twice that of standard austenitic grades, a higher initial force is necessary in operations such as bending or expanding tubes into tube sheets. The spring back effect is also more pronounced. For example, during tube bending operations the minimum recommended bending radius is $\geq 2.5 \times OD$. However, this requires good quality bending machine, tooling and qualified operator.

Heat treatment

Normal annealing temperature is 950–1050°C followed by rapid cooling. The microstructure of 2304 Duplex is very stable compared to molybdenum-containing Duplex stainless steels. Intermetallic phases will only form after several hours at around 700°C.

Applications

- Chloride containing environments
- Welded pipe systems within Pulp and Paper-, Chemical and Petrochemical-, Water Treatment Industries
- Transportation
- Architecture, Building and Construction
- Heat exchanger tubes

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Design

The allowable design values are about twice those for standard austenitic steels. This means that the possibility of designing thinner walls can save costs. Lower cost for material, transport, welding and maintenance. Please use our Pressure Calculation Tool on www.ostp.biz, to discover the weight saving possibilities and other benefits of Duplex Stainless Steel.

Mechanical Properties (at room temperature)														
Grade	EN Grade	ASME/UNS	acc. To EN 10028-7:16									Acc to ASTM A240:20		
			Cold Rolled Strip (C)			Hot Rolled Strip (H)			Hot rolled Plate (P)			Rp 0.2 Mpa	Rm Mpa	A50 %
			Rp 0.2 Mpa	Rm Mpa	A %	Rp 0.2 Mpa	Rm Mpa	A %	Rp 0.2 Mpa	Rm Mpa	A %			
304L/4307	1.4307	304L	> 220	520 - 700	> 45	> 200	520 - 700	> 45	> 200	500 - 700	> 45	> 170	> 485	> 40
316L/4404	1.4404	316	> 240	530 - 680	> 40	> 220	530 - 680	> 40	> 220	520 - 670	> 45	> 170	> 485	> 40
DX 2205	1.4462	S32205	> 485 / 500	700 - 950	> 20	> 445 / 460	700 - 950	> 25	> 445 / 460	640 - 840	> 25	> 450	> 655	> 25
LDX 2304	1.4362	S32304	> 405 / 420	630 - 850	> 20	> 385 / 400	630 - 850	> 20	> 385 / 400	600 - 800	> 25	> 400	> 600	> 25
SDX 2507	1.4410	S32750	> 535 / 550	750 - 1000	> 20	> 515 / 530	750 - 1000	> 20	> 515 / 530	730 - 930	> 20	> 550	> 795	> 15
LDX 2101	1.4162	S32101	> 515 / 530	700 - 900	> 25 / 30	> 465 / 480	680 - 900	> 30	> 435 / 450	650 - 850	> 30	>530 (t ≤ 5,0mm) >450 (t > 5,0mm)	>700 (t ≤ 5,0mm) >650 (t > 5,0mm)	> 30
LDX 2404	1.4662	S82441	> 550	750 - 900	> 20 / 25	> 550	750 - 900	> 25	> 480	680 - 900	> 25	>540 (t ≤ 10,0mm) >480 (t > 10,0mm)	>740 (t ≤ 10,0mm) >680 (t > 10,0mm)	> 25

1) Elongation according to EN standard: A80 for thickness below 3 mm, A for thickness ≥ 3 mm. Elongation according to ASTM standard A2* or A50

Physical Properties						
Grade	EN Grade	ASME/UNS	Density kg/dm ³	Modulus of elasticity Gpa	Poissons' ratio $\mu = -\epsilon/\epsilon_l$	Coefficient of thermal expansion 20 -100°C 10 ⁻⁶ /K
304L/4307	1.4307	304L	7,9	200	0,3	16,0
316L/4404	1.4404	316	8,0	200	0,3	16,0
DX 2205	1.4462	S32205	7,8	200	0,3	13,0
LDX 2304	1.4362	S32304	7,8	200	0,3	13,0
SDX 2507	1.4410	S32750	7,8	200	0,3	13,0
LDX 2101	1.4162	S32101	7,8	200	0,3	13,0
LDX 2404	1.4662	S82441	7,7	205	0,3*	13,0

* 0.3 is the typical Duplex value. Grade specific value are in the process of being established for LDX 2404™

Chemical Composition, % (Typical values)										
Grade	EN Grade	ASME/UNS	C	Cr	Ni	Mo	N	Others	PRE*	
304L/4307	1.4307	304L	0,02	18,1	8,1	–	–	–	18	
316L/4404	1.4404	316	0,02	17,2	10,1	2,1	–	–	24	
DX 2205	1.4462	S32205**	0,02	22,4	5,7	3,1	0,17	–	35	
LDX 2304	1.4362	S32304	0,02	23	4,8	0,3	0,1	Cu	28	
SDX 2507	1.4410	S32750	0,02	25	7	4	0,27	–	43	
LDX 2101	1.4162	S32101	0,03	21,5	1,5	0,3	0,22	Mn Cu	26	
LDX 2404	1.4662	S82441	0,02	24	3,6	1,6	0,27	Mn Cu	34	

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

** Also available as S31803

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