2507 High Strength Duplex Welded Stainless Tubular Products

Characteristics

Grade 2507 is a Molybdenum and Nitrogen alloyed Super-Duplex stainless steel with corrosion resistance in-line with the 6 Mo grades (e.g. 254 SMO®), and with a yield strength more than double that of austenitic stainless steels. It is also the strongest Duplex in welded tubular products.

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

2507 is considered a stock standard material for OSTP in selected production standards and dimension ranges.

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.

Standard Stock Dimension Range

- ANSI NPS 6–12" Sch 10S, ASTM A928 Class 3
- Fittings according to ASTM A815

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 2507 possesses excellent resistance to general corrosion, SCC, pitting corrosion and high resistance to crevice corrosion. It has similar resistance to sea water as the 6 Mo grades, and has hence been widely used in sea water RO desalination. See Outokumpu Corrosion Handbook for more information.

Microstructure / Ferrite content

The balanced chemical composition of 2507 results in a microstructure containing approximately equal amount of ferrite and austenite in the microstructure after annealing in a temperature about 1050–1125°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

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 welded SS pipe in most European countries. OSTP fulfils the Directive, and is an approved manufacturer of welded Duplex stainless steel tubes and fittings.

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.

Norway

NORSOK is a Norwegian standard that regulates the use of materials in some offshore applications. OSTP is an approved manufacturer of Duplex UNS S32750 pipe and butt weld fittings based on NORSOK requirements.

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 928
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
EFW, double butt	-	0.7	0.85	0.85	0.85
EFW, single butt	-	0.7	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	ASME/UNS	C	Cr	Ni	Mo	N	Others	PRE*
4307	1.4307	304L	0.02	18.1	8.1	-	-	-	18
4404	1.4404	316L	0.02	17.2	10.1	2.1	-	-	24
LDX 2101®	1.4162	S32101	0.03	21.5	1.5	0.3	0.22	5Mn	26
2304	1.4362	S32304	0.02	23	4.8	0.3	0.10	-	26
LDX 2404™	1.4662	S82441	0.02	24	3.6	1.6	0.27	3Mn	33
2205	1.4462	S32205**	0.02	22	5.7	3.1	0.17	-	35
2507	**1.4410**	**S32750**	**0.02**	**25**	**7**	**4**	**0.27**	**-**	**41**

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

** Also available as S31803.

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% N_2 and 10% H_2), 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 100°C. General filler recommendation for steel grade 2507 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. See Outokumpu Welding Handbook for more information.

Cold forming

Since the yield strength is more than 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 ≥ 4.5 x OD. However, this requires good quality bending machine, tooling and qualified operator.

Heat treatment

Normal annealing temperature is 1050–1125°C followed by rapid cooling to at least 700°C. At temperatures between 800–950°C, intermetallic phases that impair the properties will form within 1–2 minutes.

Applications

- Chloride containing environments
- Heat exchanger tubes
- Pipe systems within:
  - Hydrometallurgy
  - Chemical and Petrochemical
  - Desalination
  - Oil & Gas

Design

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

General filler recommendation for Duplex stainless steels

			Welding consumables	
			Covered electrodes	Wires
Outokumpu	EN	ASTM / UNS	ISO 3581 / ISO 14172	ISO 14343 / ISO 18274
LDX 2101®	1.4162	S32101	23 7 NL or 22 9 3 NL	23 7 NL or 22 9 3 NL
2304	1.4362	S32304	23 7 NL or 22 9 3 NL	23 7 NL or 22 9 3 NL
LDX 2404™	1.4662	S82441	22 9 3 NL	22 9 3 NL
2205	1.4462	S2205 / S31803	22 9 3 NL	22 9 3 NL
2507	**1.4410**	**S32750**	**25 9 4 NL**	**25 9 4 NL**

Mechanical properties (At room temperature)

	Min values acc. to EN 10028-7:2007									Min values according to ASTM A240-10		
	$R_{p0.2}$, MPa			R_m, MPa			A_{80}, %			$R_{p0.2}$, MPa	R_m, MPa	A_5, %
Outokumpu	P	H	C	P	H	C	P	H	C			
4307	200	200	220	500	520	520	45	45	45	170	485	40
4404	220	220	240	520	530	530	45	40	40	170	485	40
LDX 2101®	450*	465*	515*	650*	680*	700*	30*	30*	25/30*	530 (t ≤ 5.0 mm) / 450 (t > 5.0 mm)	700 (t ≤ 5.0 mm) / 650 (t > 5.0 mm)	30
2304	385/400	385/400	405/420	630	600	600	25	20	20	400	600	25
LDX 2404™	480**	550**	550**	680**	750**	750**	25**	25**	25/20**	540 (t < 10 mm) / 480 (t ≥ 10 mm)	740 (t < 10 mm) / 680 (t ≥ 10 mm)	25
2205	445/460	445/460	485/500	640	700	700	25	25	20	450	655	25
2507	**515/530**	**515/530**	**535/550**	**730**	**750**	**750**	**20**	**20**	**20**	**550**	**795**	**15**

* Min values according to EAM 0045-01-2012/01 ** Min values according to AM 641 Ed.2

P = Hot rolled plate H = Hot rolled strip C = Cold rolled coil and strip

Physical properties

Outokumpu	Density, g/cm³	Modulus of elasticity, GPa	Poisson´s ratio $\nu = -\varepsilon_{trans}/\varepsilon_{longitudinal}$	Average linear expansion at RT - 100°C x10⁻⁶/ °C
4307	7.9	200	0.3	16.0
4404	8.0	200	0.3	16.0
LDX 2101®	7.8	200	0.3	13.0
2304	7.8	200	0.3	13.0
LDX 2404™	7.7	205	0.3*	13.0
2205	7.8	200	0.3	13.0
2507	**7.8**	**200**	**0.3**	**13.0**

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