

## High Strength Duplex Welded Stainless Tubular Products

### LDX 2404/ 1.4662/ S82441

#### Characteristics

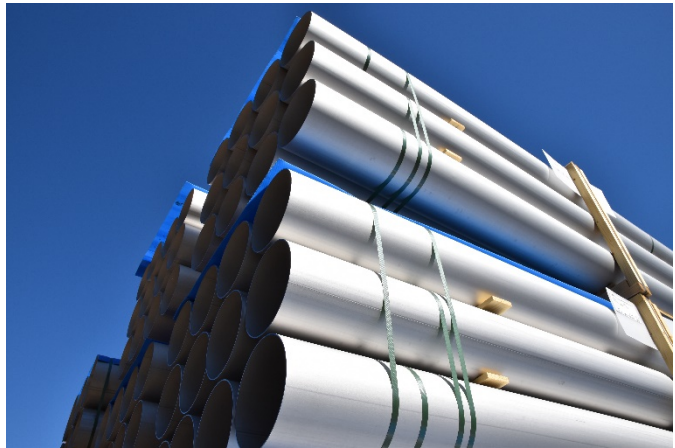
LDX 2404™ is a lean Duplex stainless steel with low Ni-content. Its high mechanical strength is similar to other Duplex grades and has very good corrosion resistance. Combined, these properties can be utilized to get an optimized design with respect to strength, maintenance, durability and long-term cost efficiency.

#### Characteristic properties:

- High mechanical strength
- Good weldability
- Good corrosion resistance
- High Stress Corrosion Cracking (SCC) resistance
- Very 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 LDX 2404™ 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

The corrosion resistance of LDX 2404™ is good, and the grade is suitable for use in a wide range of applications and environments. Like other Duplex stainless steels, LDX 2404™ shows much better resistance to SCC than standard austenitic grades.

#### Microstructure / Ferrite content

The balanced chemical composition of LDX 2404™ results in a microstructure containing approximately equal amounts of ferrite and austenite after annealing at a temperature of about 1050°C. Due to its relatively low alloying content, LDX 2404™ is less prone to precipitation of intermetallic phases than other Duplex steels. The high nitrogen content results in rapid reformation of austenite when welding. 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

LDX 2404(EN 1.4662) is not included in EN standards yet, but LDX 2404 is an established material to use in pressure applications if a PMA is created with a reference to AM641E.a

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

## 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. Information

### 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)

For TIG and PAW methods the general recommendation for shielding and plasma gas is pure Ar. An addition of 1–2% N<sub>2</sub> in the shielding gas will improve the corrosion resistance in the weld. As backing/purging gas the general recommendation is Formier gas (90% N<sub>2</sub> and 10% H<sub>2</sub>), 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 Duplex steel grade LDX 2404™ can be found in the table below. Welding without filler metal not followed by post-weld heat treatment might reduce the corrosion resistance. Welding against other steel grades is also possible when suitable filler metal and shielding/backing gas is used.

### Cold forming

Due to the high proof strength of Duplex material, greater working forces than those required for austenitic steel are usually needed for cold forming. LDX 2404™ is suitable for most forming operations used in stainless steel fabrication. However, due to the grade's higher mechanical strength and lower toughness, operations such as expanding, bending, hydro forming or other forming methods are more demanding to perform than with austenitic steel.

The grade's high mechanical strength, may give rise to a relatively high spring back. 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

LDX 2404™ is solution annealed at 1000–1080°C.

Rapid cooling is recommended after annealing.

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PROCESS PIPES  
Jakobstad, Finland

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

PROCESS EQUIPMENT  
ÖMV, Örnsköldsvik, Sweden

## Applications

- Welded pipe systems within: – Pulp and Paper – Chemical and Petrochemical – Water Treatment
- Transportation
- Architecture, Building and Construction
- Heat exchanger tubes

## Design

Please use our Pressure Calculation Tool on [www.ostp.biz](http://www.ostp.biz), to discover the weight saving possibilities and other benefits of Outokumpu 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/dm³	Modulus of elasticity Gpa	Poisson's ratio $\mu = -\epsilon/\epsilon_l$	Coefficient of thermal expansion 20 -100°C 10 <sup>-6</sup> /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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