



## General characteristics

LDX 2101® is a lean Duplex stainless steel with low Ni-content. Its high mechanical strength is similar to other Duplex grades and its good corrosion resistance is better than the 4307 (304L) grade. 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

LDX 2101® is manufactured in most common standard sizes within our product range.

### Tubes and Pipes

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

## 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	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
<b>LDX 2101®</b>	<b>1.4162</b>	<b>S32101</b>	<b>0.03</b>	<b>21.5</b>	<b>1.5</b>	<b>0.3</b>	<b>0.22</b>	<b>5Mn</b>	<b>26</b>
2304	1.4362	S32304	0.02	23	4.8	0.3	0.10	-	26
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	-	43

\* 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.

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### Heat exchanger tubes

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

### Stock dimensions

- ISO dimension range DN 15-600
- WT: 1.5-4.0 (8.0) mm

## Executions

### Tubes, Pipes and Butt Weld Fittings

- Welded with- or without filler metal
- Unannealed, pickled
- Solution annealed, pickled
- Bevelled ends according to standards
- With- or without BCW (Bead Cold Worked)

### Heat exchanger tubes

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

## Corrosion resistance

The corrosion resistance of LDX 2101® is good, and the grade is suitable for use in a wide range of applications and environments. LDX 2101® has a better corrosion resistance than 4307 (304L), approaching 4404 (316L) in some cases. Like other Duplex stainless steels, LDX 2101® shows much better resistance to SCC than standard austenitic grades. For more details see e.g. Outokumpu data sheet for Duplex Stainless Steel and Outokumpu Corrosion Handbook at our web site [www.outokumpu.com](http://www.outokumpu.com)

## Microstructure / Ferrite content

The balanced chemical composition of LDX 2101® 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 2101® 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

- EN 10296-2 Welded Stainless Steel for general purposes.
- EN 10217-7: Welded steel tubes for pressure purposes. Technical Delivery Conditions – Part 7: Stainless Steel Tubes.
- 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. Wrought austenitic and austenitic-ferritic (Duplex) stainless steels with specific inspection requirements.

**Note:** LDX 2101® (EN 1.4162) is not included in EN standards yet. For pressure purposes a PMA (Particular Material Appraisal) is used today. This will be replaced by EAM (European Approval for pressurised equipment Materials), which is equal to having the material in a harmonized standard.

### USA

- ASTM A 789 Welded and seamless Ferritic/Austenitic SS heat exchanger tubes
- ASTM A 790 Welded and seamless Ferritic/Austenitic SS pipe
- ASTM A 928 Ferritic/Austenitic pipe fusion welded with filler metal
- ASTM A 815 Wrought Ferritic, Ferritic/Austenitic and Martensitic SS Piping Fittings

## Pressure vessel approvals

### 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)

For TIG and PAW methods the general recommendation for shield and plasma gas is pure Ar. An addition of 1-2 % N<sub>2</sub> in the shield gas will improve the corrosion resistance in the weld. As backing/purging gas the general recommendation is pure Argon or Formier gas (90 % N<sub>2</sub> and 10 % H<sub>2</sub>).

General filler recommendation for Duplex steel grade LDX 2101® can be found in the table below. Welding without filler metal not followed by post heat treatment might reduce the corrosion resistance. Welding against other steel grades is also possible when suitable filler metal is used. See Outokumpu Welding Handbook for more information (will be launched beginning of 2010).

### 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 2101® 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.

### Heat treatment

LDX 2101® is solution annealed at 1020-1080°C. Rapid cooling is recommended after annealing.

## Applications

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

"LDX 2101® has passed all test procedures required to permit approval for use in the UK water supply."

## Design

Please use our Press Calculation Tool on [www.outokumpu.com](http://www.outokumpu.com), to discover the weight saving possibilities and other benefits of Duplex stainless steel.

### European Harmonized Standards:

EN 13480 Part 1 – 6 Metallic industrial piping and EN 13455 Part 1 Unfired pressure vessels. LDX 2101® can be used in pressure vessel equipment by applying EN 13480 or EN 13445 together with PMA or EAM approval.

For pressure design of tubular products in LDX 2101®, the requirements of EN 13480-3 part 5.2.1.1 is used to define the design stress.

### American Standard – ASME section VIII

LDX 2101® can be used in pressure vessel equipment by applying ASME and Code Case 2418.

## General filler recommendation for Duplex stainless steels

Outokumpu	EN	ASTM / UNS	Welding consumables	
			Covered electrodes	Wires
			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
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)

Outokumpu	Min values acc. to EN 10028-7:2007									Min values according to ASTM A240-07		
	R <sub>p0.2</sub> , MPa			R <sub>m</sub> , MPa			A <sub>80</sub> , %			R <sub>p0.2</sub> , MPa	R <sub>m</sub> , MPa	A <sub>5</sub> , %
	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*	480*	530*	650*	680*	700*	30*	30*	20*	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
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 EN 10088-4:2009

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

For hot rolled plate (P) with T = 4.76 – 75 mm the impact toughness in transverse direction for LDX 2101® = 60 Joule at 20°C and 27 Joule at -40°C (values from internal standard AM 611E). For hot rolled strip (H) and cold rolled coil and strip (C) with T ≤ 10 mm the impact toughness in transverse direction for LDX 2101® = 80 Joule at 20°C and 50 Joule at -40°C (values from internal standard AM 611E).

## Physical properties

Outokumpu	Density, g/cm <sup>3</sup>	Modulus of elasticity, GPa	Poisson's ratio $\nu = -\epsilon_{\text{trans}} / \epsilon_{\text{longitudinal}}$	Average linear expansion at RT -
				100°C x 10 <sup>-6</sup> / °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
2205	7.8	200	0.3	13.0
2507	7.8	200	0.3	13.0

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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