outokumpu
high performance stainless steel

Forta LDX 2404

EN 1.4662, ASTM UNS S82441

General characteristics

Austenitic-ferritic stainless steel also referred to as duplex stainless steels, combine many of the beneficial properties of ferritic and austenitic steels. Due to the high content of chromium and nitrogen, and often also molybdenum, these steels offer good resistance to localised and uniform corrosion. The duplex microstructure contributes to the high strength and high resistance to stress corrosion cracking. Duplex steels have good weldability. All duplex grades have the maximum service temperature restricted to 250 or 325°C according to EN10028-7 or ASME II-D 2007 respectively. Outokumpu produces a range of duplex grades, LDX 2101®; 2304; LDX 2404®; 2205; 4501 and 2507.

LDX 2404®is a molybdenum-containing duplex stainless steel with high contents of chromium and nitrogen. The grade combines a higher mechanical strength than for other common duplex grades with a generally high corrosion resistance.These characteristics make

LDX 2404® well suited for optimal designs with respect to strength, reduced maintenance, durability and long-term cost efficiency.

Typical applications

- Pulp and paper industry
- Desalination plants
- Cargo tanks and pipe systems in chemical tankers
- Firewalls and blast walls on offshore platforms
- Components for structural design
- Boilers and water heaters
- Storage tanks
- Pressure vessels
- Water heaters
- Heat exchangers
- Rotors, impellers and shafts
- Bridges
- Flue-gas cleaning

Products & dimensions

Cold rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
2E	Cold rolled, heat treated, mech. desc. pickled	0.50-6.00	36-2040	0.50-4.00	300-2040

Continous hot rolled products, available dimensions (mm)

Surface finish	Coil / Strip		Plate / Sheet	
	Thickness	Width	Thickness	Width

1D	Hot rolled, heat treated, pickled	4.00-9.13	96-2040	4.00-9.13	300-2040

Quarto plate products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1D	Hot rolled, heat treated, pickled			5.00-75.00	400-3200

Chemical composition

The typical chemical composition for this grade is given in the table below, together with composition limits given for this grade according to different standards. The required standard will be fully met as specified on the order.The relatively low Ni and Mo content of Outokumpu LDX 2404® make this grade more price stable compared to common standard stainless steel grades.

	C	Mn	Cr	Ni	Mo	N	Other
Typical	**0.02**	**3.0**	**24.0**	**3.6**	**1.6**	**0.27**	**Cu:0.40**
AM 641	≤0.030	2.5-4.0	23.0-25.0	3.0-4.5	1.00-2.00	0.20-0.30	Cu:0.10-0.80
ASME II A SA-240	≤0.030	2.5-4.0	23.0-25.0	3.0-4.5	1.00-2.00	0.20-0.30	Cu:0.10-0.80
ASTM A240	≤0.030	2.5-4.0	23.0-25.0	3.0-4.5	1.00-2.00	0.20-0.30	Cu:0.10-0.80
EN 10028-7	≤0.030	2.50-4.00	23.0-25.0	3.0-4.5	1.00-2.00	0.20-0.30	Cu:0.10-0.80
EN 10088-2	≤0.030	2.50-4.00	23.0-25.0	3.0-4.5	1.00-2.00	0.20-0.30	Cu:0.10-0.80
EN 10088-3	≤0.030	2.50-4.00	23.0-25.0	3.0-4.5	1.00-2.00	0.20-0.30	Cu:0.10-0.80
IS 6911	≤0.030	2.50-4.00	23.0-25.0	3.0-4.5	1.00-2.00	0.20-0.30	Cu:0.10-0.80

Corrosion resistance

The corrosion resistance of LDX 2404® is better than for Cr-Ni-Mo grades such as 4404 and duplex grades suchas 2304. The grade is suitable for use in a wide range of applications and environments.

The resistance to pitting and crevice corrosion is particularly important in chloride-containing environments. The resistance of LDX 2404® to these types of corrosion is good, due to the high chromium and nitrogen content of this gradeand further improved by the addition of molybdenum.

Pitting corrosion resistance		Crevice corrosion resistance
PRE	CPT	CCT
34	43±2	15

PRE Pitting Resistant Equivalent calculated using the formula: PRE = %Cr + 3.3 x %Mo + 16 x %N
CPT Corrosion Pitting Temperature as measured in the Avesta Cell (ASTM G 150), in a 1M NaCl solution (35,000 ppm or mg/l chloride ions).
CCT Critical Crevice Corrosion Temperature is the critical crevice corrosion temperature which is obtained by laboratory tests according to ASTM G 48 Method F

Mechanical properties

The duplex stainless steels have much higher mechanical strength compared to standard stainless steels. If the high strength of the duplex grades can be utilised, down gauging can be done in many applications leading to cost efficient solutions. The allowable design values may vary between product forms. The appropriate values are given in the relevant specifications.Outokumpu LDX 2404® is not yet listed in EN 10088. The data given for LDX 2404® corresponds to the internal standard AM 641.

The product types P= hot rolled plate, H=hot rolled strip and C=cold rolled coil and strip.

Cold rolled coil and sheet	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 1 mm)	**640**		**850**	**30**				
AM 641	≥ 550		750 - 900	≥ 25			≤ 290	
ASME II A SA-240	≥ 540		≥ 740				≤ 290	
ASTM A240	≥ 480		≥ 680			≤ 31HRC	≤ 290	
EN 10028-7	≥ 550		750 - 900	≥ 25				
EN 10088-2	≥ 550		750 - 900	≥ 25				
IS 6911	≥ 540		≥ 740			≤ 31HRC	≤ 290	

Hot rolled coil and sheet	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 4 mm)	**645**	**720**	**825**	**30**			**250**	
AM 641	≥ 550		750 - 900	≥ 25			≤ 290	
ASTM A240	≥ 540		≥ 740				≤ 290	
EN 10028-7	≥ 550		750 - 900	≥ 25				
EN 10088-2	≥ 550		750 - 900	≥ 25				
IS 6911	≥ 480		≥ 680			≤ 31HRC	≤ 290	

Hot rolled quarto plate	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 15 mm)	**520**		**750**	**33**			**230**	
AM 641	≥ 480		680 - 900	≥ 25				
ASME II A SA-240	≥ 480		≥ 680				≤ 290	
ASTM A240	≥ 480		≥ 680				≤ 290	
EN 10028-7	≥ 480		680 - 900	≥ 25				
EN 10088-2	≥ 480		680 - 900	≥ 25				
IS 6911	≥ 480		≥ 680			≤ 31HRC	≤ 290	

[1)]Elongation according to EN standard:
A_{80} for thickness below 3 mm.
A for thickness = 3 mm.
Elongation according to ASTM standard $A_{2"}$ or A_{50}.

Physical properties

The physical properties at room temperature are shown in the table below. Data according to EN10088 or EN10095. LDX 2404® is not yet included in the standards, values according to internal specification.

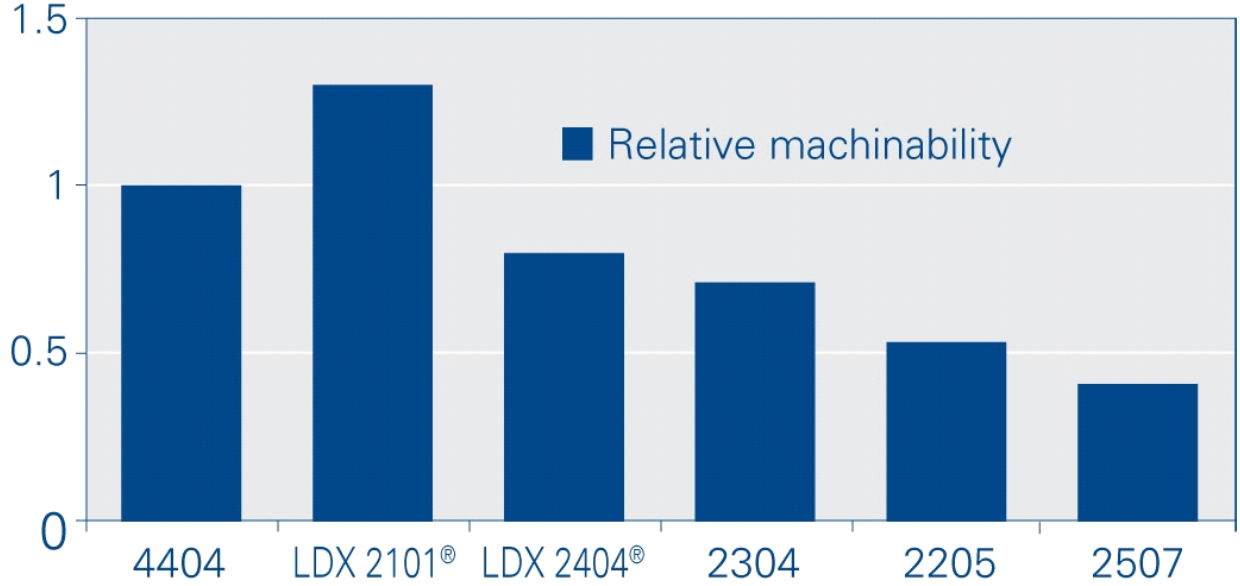
Density kg/dm^3	Modulus of elasticity GPa	Thermal exp. at 100 °C 10^{-6}/°C	Thermal conductivity W/m°C	Thermal capacity J/kg°C	Electrical resistance µΩm	Magnetizable
7.7	205	13.0	14.5	500	0.80	Yes

Fabrication

Duplex stainless steel is suitable for all forming processes available for stainless steel. The high proof strength compared to austenitic and ferritics stainless steel can impose some differences in forming behaviour depending on chosen forming technique, such as an increased tendency to springback. This point is particularly relevant to forming of any high strength steel. If the forming process is not already decided, it is certainly possible to choose the most suitable one for duplex grades. Moreover, an excellent interplay between high proof strength, work hardening rate and elongation promote the duplex grades for light weight and cost-efficient applications with complex shapes. The impact of the high strength varies for different forming techniques. Common for all is that the estimated forming forces will be higher than for the corresponding austenitic and ferritic stainless steel grades. This effect will usually be lower than expected from just the increase in strength since the choice of duplex stainless steel is often associated with down gauging. It is important to consider that duplex stainless steel may also be more demanding for the tool materials and the lubricant. Also in this case attention should be given to the down gauging.

Machining

Duplex steels are generally more demanding to machine than conventional austenitic stainless steel such as 4404, due to the higher hardness. The machinability can be illustrated by a machinability index, as illustrated in below figure. This index, which increases with improved machinability, is based on a combination of test data from several different machining operations. It provides a good description of machinability in relation to 4404. More information can be found in the machining guidelines which are available for each duplex grade.



Welding

Duplex steels generally have good weldability and can be welded using most of the welding methods used for austenitic stainless steel:

- Shielded metal arc welding (SMAW)
- Gas tungsten arc welding TIG(GTAW)
- Gas metal arc welding MIG (GMAW)
- Flux-cored arc welding (FCW)
- Plasma arc welding (PAW)
- Submerged arc welding (SAW)
- Laser welding
- Resistance welding
- High frequence welding

Due to the balanced composition, the heat-affected zone obtains a sufficiently high content of austenite to maintain a good resistance to localised corrosion. The individual duplex steels have slightly different welding characteristics. For more detailed information regarding the welding of individual grades, see the Outokumpu Welding Handbook or contact Outokumpu. The following general instructions should be followed:

- The material should be welded without preheating.
- The material should be allowed to cool between passes, preferably to below 150°C.
- To obtain good weld metal properties in as welded condition, filler material shall be used.
- The recommended arc energy should be kept within certain limits to achieve a good balance between ferrite and austenite in the weld. The heat input should be adapted to the steel grade and be adjusted in proportion to the thickness of the material to be welded.
- Post-weld annealing after welding with filler is not necessary
- To ensure optimum pitting resistance when using GTAW and PAW methods, an addition of nitrogen in the shielding/purging gas is

recommended

More information

A number of publications regarding this steel grade are available for downloading from our publications system. The downloads can be found under Products/Useful Tools Online/Publications. Below are a few publications that might be of interest.

Duplex Stainless Steel - LDX 2101®,2304, LDX 2404®, 2205, 2507
Basic material data sheet giving a general overview over the properties of the duplex grades

Duplex Stainless Steel LDX 2404 ®
Describes our new steel LDX 2404® and its properties.

LDX 2404® Machining Guideline
Machining guidelines for duplex LDX 2404®

Standards & approvals

Outokumpu produce and certify materials to most international and national standards. Work is continuously on-going to get the different grades approved for relevant standards.

Standard	Designation
ASME SA-240M Code Sect. II. Part A	UNS S82441
ASTM A240/A240M	UNS S82441
EN 10028-7, PED 2014/68/EU	1.4662
EN 10088-2	1.4662
EN 10088-3	1.4662
IS 6911, AMENDMENT NO. 2	ISS 2441
Outokumpu Material Specification AM 641E	LDX 2404

Contacts & Enquiries

Contact your nearest sales office

www.outokumpu.com/contacts

Working towards forever.

We work with our customers and partners to create long lasting solutions for the tools of modern life and the world's most critical problems: Clean energy, clean water and efficient infrastructure. Because we believe in a world that lasts forever.

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