outokumpu
high performance stainless steel

Forta LDX 2101

EN 1.4162, ASTM UNS S32101

General characteristics

Forta LDX 2101 is a lean-alloyed duplex product with good resistance to localized and uniform corrosion, as well as stress corrosion cracking, making it a good substitute for coated carbon steel. It also offers high mechanical strength and good machinability.

Austenitic-ferritic stainless steels, also referred to as duplex stainless steels, combine many of the beneficial properties of ferritic and austenitic steels. Due to their high content of chromium and nitrogen, and often also molybdenum, these steels offer good resistance to localized and uniform corrosion. The duplex microstructure contributes to the high strength and high resistance to stress corrosion cracking, and also improves abrasion and erosion resistance. Duplex steels have good weldability. Outokumpu produces a whole range of duplex products, from the lean-alloyed Forta LDX 2101 up to the super duplex products Forta SDX 2507 and Forta SDX 100. All duplex grades have the maximum service temperature restricted to 250 or 325 °C according to EN 10028-7 or ASME II-D 2007 respectively.

The lower nickel content of duplex grades compared to austenitic grades with similar corrosion resistance makes them more price stable. Duplex grades have approximately twice the strength of austentic grades with similar corrosion resistance, thus thinner gauges can be used in many applications.

Typical applications

- Storage tanks
- Household heaters
- Structural components for floodgates and bridges or rebar for concrete structures
- Pulp and paper industry applications
- Flanges and valves

Products & dimensions

Cold rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
2A	2A			2.00-6.35	300-2040

2B	Cold rolled, heat treated, pickled, skin passed	1.50-6.35	30-2040	1.50-6.35	350-2040
2BB	Bright-pickled	0.70-3.50	30-1250	0.70-3.50	600-1250
2C	Cold rolled, heat treated	0.70-5.00	30-1250		
2D	Cold rolled, heat treated, pickled	0.70-5.00	30-1250	0.70-5.00	600-1250
2E	Cold rolled, heat treated, mech. desc. pickled	0.50-5.00	30-2040	0.50-5.00	300-2040
2G	Ground	0.70-3.00	30-1250	0.70-3.00	600-1250
2J	Brushed or dull polished	0.70-3.00	30-1250	0.70-3.00	600-1250

Continous hot rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1C	Hot rolled, heat treated, not descaled	4.00-8.00	750-1350		
1D	Hot rolled, heat treated, pickled	3.00-10.00	50-2040	3.00-10.00	300-2040
1U	Black hot rolled	4.00-8.00	750-1350		

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
1G	Ground			10.00-29.99	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.

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The chemical composition is given as % by mass.

	C	Mn	Cr	Ni	Mo	N	Other
Typical	**0.03**	**5.0**	**21.5**	**1.5**	**0.3**	**0.22**	**Cu:0.3**
AM 611 Ed. 5	≤0.035	4.00-6.00	21.0-22.0	1.35-1.70	0.10-0.80	0.20-0.25	Cu:0.10-0.80
ASME II A SA-240	≤0.040	4.00-6.00	21.0-22.0	1.35-1.70	0.10-0.80	0.20-0.25	Cu:0.10-0.80
ASTM A240	≤0.040	4.0-6.0	21.0-22.0	1.35-1.70	0.10-0.80	0.20-0.25	Cu:0.10-0.80
EN 10028-7	≤0.040	4.0-6.0	21.0-22.0	1.35-1.90	0.10-0.80	0.20-0.25	Cu:0.10-0.80
EN 10088-2	≤0.040	4.0-6.0	21.0-22.0	1.35-1.90	0.10-0.80	0.20-0.25	Cu:0.10-0.80
EN 10088-3	≤0.040	4.0-6.0	21.0-22.0	1.35-1.90	0.10-0.80	0.20-0.25	Cu:0.10-0.80
EN 10088-4	≤0.040	4.0-6.0	21.0-22.0	1.35-1.70	0.10-0.80	0.20-0.25	Cu:0.10-0.80
IS 6911	≤0.040	4.00-6.00	21.0-22.0	1.35-1.70	0.10-0.80	0.20-0.25	Cu:0.10-0.80

Corrosion resistance

Uniform corrosion

Forta LDX 2101 has good resistance to uniform corrosion due to the high chromium content. For guidance on material selection in a large number of environments capable of causing uniform corrosion, consult the tables and isocorrosion diagrams in the Corrosion tables -webpage.

Pitting and crevice corrosion

Chloride ions in a neutral or acidic environment facilitate local breakdown of the passive layer. As a result, pitting and crevice corrosion can propagate at a high rate, causing corrosion failure in a short time. Since the attack is small and may be covered by corrosion products or hidden in a crevice, it often remains undiscovered until perforation or leakage occurs. Resistance to pitting corrosion is determined mainly by the content of chromium, molybdenum, and nitrogen content. Forta LDX 2101 has good resistance to pitting and crevice corrosion due to the chromium and nitrogen content.

Stress corrosion cracking

Forta LDX 2101 has good resistance to chloride-induced stress corrosion cracking. This form of corrosion is a combination of stresses in the material and a corrosive environment, mainly at elevated temperatures. Stresses in the material can be a result of fabrication, like forming or welding.

Pitting corrosion resistance		Crevice corrosion resistance
PRE	CPT	CCT
26	17±3	<0

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

Mechanical properties

Forta LDX 2101 is part of the Outokumpu Forta range of stainless steels with high mechanical strength. If the high strength can be utilized, downgauging 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.

Mechanical properties at room temperature are shown in the table below.

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)	**610**	**660**	**810**	**46**				
AM 611 Ed. 5	≥ 530		700 - 900	≥ 30			≤ 290	
ASME II A SA-240	≥ 450		≥ 650				≤ 290	
ASTM A240	≥ 450		≥ 650			≤ 31HRC	≤ 290	
EN 10028-7	≥ 530		700 - 900	≥ 30				
EN 10088-2	≥ 530		700 - 900	≥ 30				
EN 10088-4	≥ 530		700 - 900	≥ 30				
IS 6911	≥ 450		≥ 650			≤ 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)	**560**	**630**	**755**	**35**			**235**	
AM 611 Ed. 5	≥ 480		680 - 900	≥ 30			≤ 290	
ASME II A SA-240	≥ 450		≥ 650				≤ 290	
ASTM A240	≥ 450		≥ 650				≤ 290	
EN 10028-7	≥ 480		680 - 900	≥ 30				
EN 10088-2	≥ 480		680 - 900	≥ 30				
EN 10088-4	≥ 480		680 - 900	≥ 30				
IS 6911	≥ 450		≥ 650			≤ 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)	**500**		**700**	**38**			**225**	
ASME II A SA-240	≥ 450		≥ 650				≤ 290	
ASTM A240	≥ 450		≥ 650				≤ 290	
EN 10028-7	≥ 450		650 - 850	≥ 30				
EN 10088-2	≥ 450		650 - 850	≥ 30				
EN 10088-4	≥ 450		650 - 850	≥ 30				
IS 6911	≥ 450		≥ 650			≤ 31HRC	≤ 290	

Wire rod	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical	**480**		**700**	**38**				

[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 EN 10088 or EN 10095.

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
7.8	200	13.0	15	500	0.80	Yes

Fabrication

Forta LDX 2101 is suitable for all forming processes applicable to stainless steel. The high yield strength compared to austenitic and ferritic stainless steel can impose some differences in forming behavior depending on the chosen forming technique, such as an increased tendency to springback. This point is particularly relevant to the forming of any high-strength steel. Higher forces may be needed in forming operations, but the possibilities of downgauging offer a viable solution.

Machining

Duplex steels are generally more demanding to machine than conventional austenitic stainless steels, but Forta LDX 2101 is an exception as it has excellent machineability. Machining guidelines are available for Forta LDX 2101 here:
Machining guidelines Forta LDX 2101

Welding

Forta LDX 2101 has good weldability and can be welded using most of the common methods used for 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

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 the as-welded condition, filler material should be used. Forta LDX 2101 can also obtain reasonably good properties without filler.
- 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 being welded.
- Post-weld annealing after welding with filler is not necessary.
- To ensure optimum pitting resistance when using GTAW and PAW methods, the addition of nitrogen to the shielding/purging gas is recommended.
- Removal of weld oxides after welding is important to restore the corrosion properties of the weld and HAZ.

More detailed information concerning welding procedures can be obtained from the Outokumpu Welding Handbook, available from our sales offices.

Standards & approvals

Outokumpu produces and certifies materials to most international and national standards. Work is ongoing to have the different grades approved for relevant standards.

Standard	Designation
ASME SA-240M Code Sect. II. Part A	UNS S32101
ASTM A240/A240M	UNS S32101
EN 10028-7, PED 2014/68/EU	1.4162
EN 10088-2	1.4162
EN 10088-3	1.4162
EN 10088-4	1.4162
IS 6911, AMENDMENT NO. 2	ISS 2101
Material Specification AM 611 Ed.5	1.4162

Note: For pressure purposes Forta LDX 2101 has a Particular Material Appraisal from TÜV and Inspecta. Maximum service temperature is 250 ºC.

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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