outokumpu
stainless steel & high performance alloys

Duplex Stainless Steel

Steel grades

Outokumpu	EN	UNS	ISO
LDX 2101®	1.4162	S32101	4162-321-01-E
2304	1.4362	S32304	4362-323-04-I
LDX 2404®	1.4662	S82441	4662-824-41-X
2205	1.4462	S32205/S31803	4462-318-03-I
4501	1.4501	S32760	4501-327-60-I
2507	1.4410	S32750	4410-327-50-E

Characteristic properties

- Good to very good resistance to uniform corrosion
- Good to very good resistance to pitting and crevice corrosion
- High resistance to stress corrosion cracking and corrosion fatigue
- High mechanical strength
- Good abrasion and erosion resistance
- Good fatigue resistance
- High energy absorption
- Low thermal expansion
- Good weldability

Applications

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

General characteristics

Ferritic-austenitic 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 micro-

Chemical composition

Table 1

	Outokumpu Steel name	International steel No				Chemical composition, % by wt. Typical values					
		EN	ASTM	UNS	ISO	C	N	Cr	Ni	Mo	Others
Duplex	LDX 2101®	1.4162	–	S32101	4162-321-01-E	0.03	0.22	21.5	1.5	0.3	5Mn Cu
Duplex	2304[1]	1.4362	–	S32304	4362-323-04-I	0.02	0.10	23.0	4.8	0.3	Cu
Duplex	LDX 2404®	1.4662	–	S82441	4662-824-41-X	0.02	0.27	24.0	3.6	1.6	3Mn Cu
Duplex	2205	1.4462	–	S32205[2]	4462-318-03-I	0.02	0.17	22.0	5.7	3.1	
Duplex	4501	1.4501	–	S32760	4501-327-60-I	0.02	0.27	25.4	6.9	3.8	W Cu
Duplex	2507	1.4410	–	S32750	4410-327-50-E	0.02	0.27	25.0	7.0	4.0	
Austenitic	4307	1.4307	304L	S30403	4307-304-03-I	0.02		18.1	8.1		
Austenitic	4404	1.4404	316L	S31603	4404-316-03-I	0.02		17.2	10.1	2.1	
Austenitic	904L	1.4539	904L	N08904	4539-089-04-I	0.01		20.0	25.0	4.3	1.5Cu
Austenitic	254 SMO®	1.4547	–	S31254	4547-312-54-I	0.01	0.20	20.0	18.0	6.1	Cu

[1]also available as EDX 2304™ with modified composition for enhanced properties. [2]also available as S31803.

structure contributes to the high strength and high resistance to stress corrosion cracking. Duplex steels have good weldability.

Outokumpu produces a whole range of duplex grades from the lean alloyed LDX 2101® up to the super duplex grades 2507 and 4501. This publication presents the properties of LDX 2101®, 2304, LDX 2404®, 2205 and 2507. The properties of 4501 is in general terms very similar to those of 2507. Grade 4501 is delivered if specified. In this data sheet only data for 2507 is given.

Chemical composition

The typical chemical compositions of Outokumpu grades are shown in Table 1. The chemical composition of grade EDX 2304™ is balanced to achieve optimal corrosion resistance and mechanical strength, but it still corresponds to EN 1.4362/UNS S32304 standards. The chemical composition of a specific steel grade may vary slightly between different national standards. The required standard will be fully met as specified on the order.

Microstructure

The chemical composition of duplex steels is balanced to give approximately equal amounts of ferrite and austenite in solution-annealed condition. The higher the annealing temperature the higher the ferrite content.

Duplex steels are more prone to precipitation of sigma phase, nitrides and carbides than corresponding austenitic steels, causing embrittlement and reduced corrosion resistance. The formation of intermetallic phases such as sigma phase occurs in the temperature range 600-1000°C and decomposition of ferrite occurs in the range 350-500°C (475°C embrittlement).

Exposures at these temperatures should therefore be avoided. In proper welding and heat-treatment operations the risk of embrittlement is low. However, certain risks exist, for example at heat treatment of thick sections, especially if the cooling is slow.

Figure 1 illustrates the relation between time and temperature that leads to a reduction of the impact toughness with 50%. Due to the risk of embrittlement, the duplex steels should not be used at temperatures above 250-325°C.

The maximum temperature and strength value depends on grade and the design rules being used.

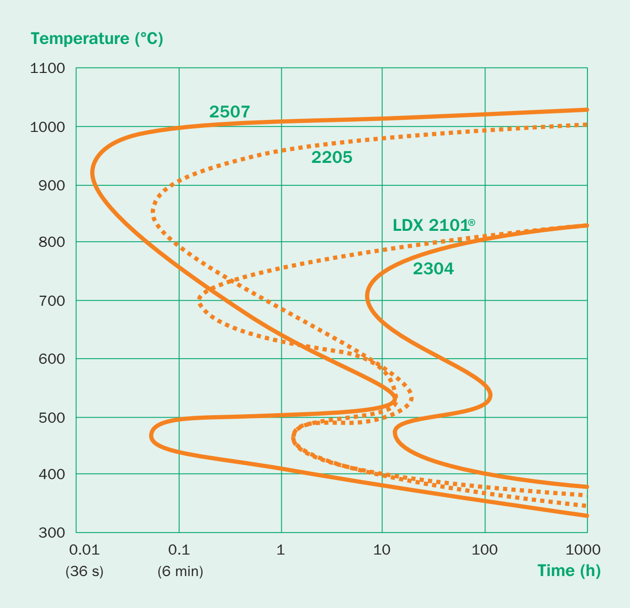

Fig. 1. Curves for reduction of impact toughness to 50% compared to solution annealed condition.

Mechanical properties at 20 °C

Table 2

				Minimum values, according to EN 10088			Typical values		
				P	H	C	P (15 mm)	H (4 mm)	C (1 mm)
LDX 2101®	Proof strength	$R_{p0.2}$	MPa	450	480	530	500	560	610
	Tensile strength	R_m	MPa	650	680	700	700	755	810
	Elongation	A_5	%	30	30	30/20[1]	38	35	29[3]
	Hardness	HB					225	235	99[2]
2304	Proof strength	$R_{p0.2}$	MPa	400	400	450	450	600	620
	Tensile strength	R_m	MPa	630	650	650	670	765	790
	Elongation	A_5	%	25	20	20/20[1]	40	30	26[3]
	Hardness	HB					210	235	99[2]
LDX 2404®*	Proof strength	$R_{p0.2}$	MPa	480	550	550	520	645	640
	Tensile strength	R_m	MPa	680	750	750	750	825	850
	Elongation	A_5	%	25	25	25/20[1]	33	30	24[3]
	Hardness	HB, max		290	290	290	230	250	
2205	Proof strength	$R_{p0.2}$	MPa	460	460	500	510	630	690
	Tensile strength	R_m	MPa	640	700	700	750	840	880
	Elongation	A_5	%	25	25	20/20[1]	35	30	26[3]
	Hardness	HB					230	250	101[2]
2507	Proof strength	$R_{p0.2}$	MPa	530	530	550	580	700	730
	Tensile strength	R_m	MPa	730	750	750	830	905	940
	Elongation	A_5	%	20	20	20/20[1]	35	30	24[3]
	Hardness	HB					250	270	103[2]

P=hot rolled plate. H=hot rolled strip. C=cold rolled coil and strip. *Mechanical properties according to AM 641. [1]Refers to A_{80} for gauges less than 3 mm. [2]HRB. [3]A_{80}

Mechanical properties

Tables 2-4 show the mechanical properties for flat rolled products. Data according to EN 10088 and EN 10028 when applicable. LDX 2404® is not yet listed in EN 10088. Data for LDX 2404® corresponds to the internal standard AM 641. The allowable design values may vary between product forms. The appropriate values are given in the relevant specifications.

Impact toughness.
Minimum values according to EN 10028, transverse direction, J

Table 3

	LDX 2101®*	2304	LDX 2404®**	2205	2507
20°C	60 (80[1])	60	60	60	60
-40°C	27 (50[1])	40	40	40	40

*Values from internal standard, AM 611. **Values from internal standard, AM 641. [1]For cold rolled 0.5-6.4 mm and hot rolled 3.0-10.0 mm, according to EAM-0045-01/2012/01.

Tensile properties at elevated temperatures.
Minimum values according to EN 10028, MPa

Table 4

	LDX 2101®*		2304		LDX 2404®**		2205		2507	
	$R_{p0.2}$	R_m	$R_{p0.2}$	R_m	$R_{p0.2}$	R_m	$R_{p0.2}$	R_m	$R_{p0.2}$	R_m
100°C	380	590	330	540	385	615	360	590	450	680
150°C	350	560	300	520	345	590	335	570	420	660
200°C	330	540	280	500	325	575	315	550	400	640
250°C	320	540	265	490	310	560	300	540	380	630

*Values for hot rolled and cold rolled strip according to EAM-0045-01:2012/01. **Values from internal standard, AM 641.

Fatigue

The high tensile strength of duplex steels also implies high fatigue strength. Table 5 shows the result of pulsating tensile fatigue tests ($R = \sigma_{min}/\sigma_{max} = 0.1$) in air at room temperature. The fatigue strength has been evaluated at 2 million cycles and a 50% probability of rupture. The test was made using round polished bars. As shown by the table the fatigue strength of the duplex steels corresponds approximately to the proof strength of the material.

Fatigue, pulsating tensile test, MPa. Hot rolled plate, 20 mm. Failure propability 50% at 2 million cycles

Table 5

	LDX 2101®	2304	2205	2507	4404
$R_{p0.2}$	478	446	497	565	280
R_m	696	689	767	802	578
Fatigue strength	500	450	510	550	274

Physical properties

Physical data according to EN 10088 apply for all our duplex steels, see Table 6.

Typical values*

Table 6

		20°C	100°C	200°C	300°C
Density	g/cm³	7.8			
Modulus of elasticity	GPa	200	194	186	180
Poissons ratio		0.3			
Linear expansion at (RT → T)°C	x 10^{-6}/°C	–	13.0	13.5	14.0
Thermal conductivity	W/m°C	15	16	17	18
Thermal capacity	J/kg°C	500	530	560	590
Electric resistivity	µΩm	0.80	0.85	0.90	1.00

*Values may differ slightly between the different duplex grades. RT=Room temperature.

Corrosion resistance

The duplex steels provide a wide range of corrosion resistance in various environments. For a more detailed description of their resistance, see the Outokumpu Corrosion Handbook. A brief description follows below regarding their resistance in different types of environments.

Uniform corrosion

Uniform corrosion is characterised by a uniform attack on the steel surface that has come into contact with a corrosive medium. The corrosion resistance is generally considered good if the corrosion rate is less than 0.1 mm/year.

Due to their high chromium content, duplex steels offer excellent corrosion resistance in many media.

LDX 2101® has, in most cases, a better resistance than 4307 and in some cases as good as 4404. 2304 is in most cases equivalent to 4404, while the other more highly-alloyed duplex steels show even better resistance.

Sulphuric acid

The isocorrosion diagram in sulphuric acid is shown in Figure 2. In sulphuric acid contaminated by chloride ions, 2205 shows much better resistance than 4404 and a similar resistance to that of 904L, Figure 3.

Hydrochloric acid

Stainless steel grades such as 4307 and 4404 have very limited use in hydrochloric acid because of the risk of uniform and localised corrosion. High-alloyed steels such as 2507 and to some extent also 2205 can be used in dilute hydrochloric acid, Figure 4. Pitting is normally not a problem in the area below the boundary line in the isocorrosion diagram but crevices should be avoided.

Nitric acid

In strongly oxidising acids, e.g. nitric acid, non-molybdenum alloyed steels are often more resistant than the molybdenum alloyed steels. LDX 2101® and 2304 are good alternatives because of their high chromium content in combination with a low molybdenum content.

Pitting and crevice corrosion

The resistance to pitting and crevice corrosion increases with the content of chromium, molybdenum and nitrogen in the steel. This is often illustrated by the pitting resistance equivalent (PRE) for the material, which can be calculated by using the formula: PRE = %Cr + 3.3 x %Mo + 16 x %N. PRE values given for different grades are presented in Table 7.

The PRE value can be used for a rough comparison between different materials. A much more reliable way of ranking steels is according to the critical pitting temperature (CPT). There are several methods available to measure CPT.

The electrochemical method, used by Outokumpu makes it possible to measure the resistance to pitting without interference from crevice corrosion (ASTM G 150). The results are given as the critical pitting temperature, CPT, at which pitting is initiated. The pitting corrosion resistance of the steels in a ground (P320 mesh) condition is shown in Figure 5.

The actual value of the as delivered surface may differ between product forms.

When ranking the resistance to crevice corrosion, it is common to measure a critical temperature at which corrosion is initiated in a well defined solution. The typical critical crevice corrosion temperatures (CCT) measured in 6% $FeCl_3$ + 1% HCl according to

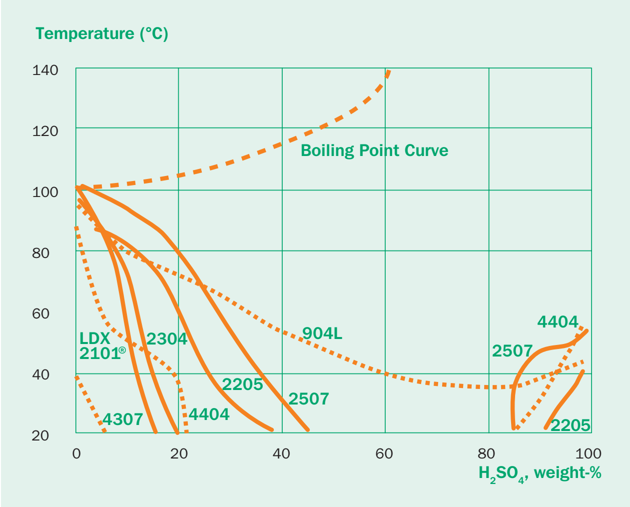

Fig. 2. Isocorrosion curves, 0.1 mm/year, in sulphuric acid.

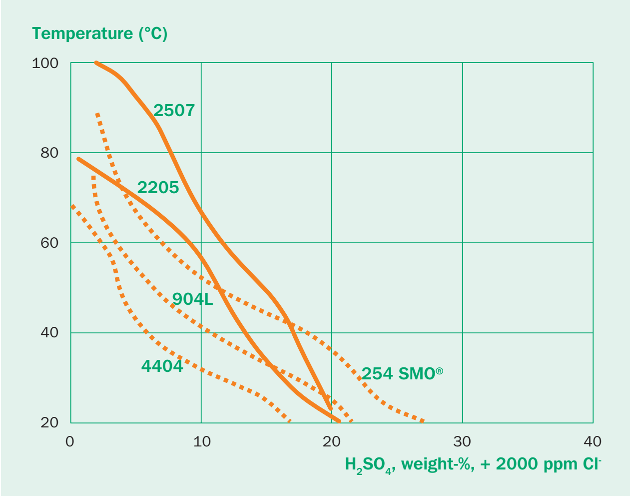

Fig. 3. Isocorrosion curves, 0.1 mm/year, in sulphuric acid containing 2000 ppm chloride ions.

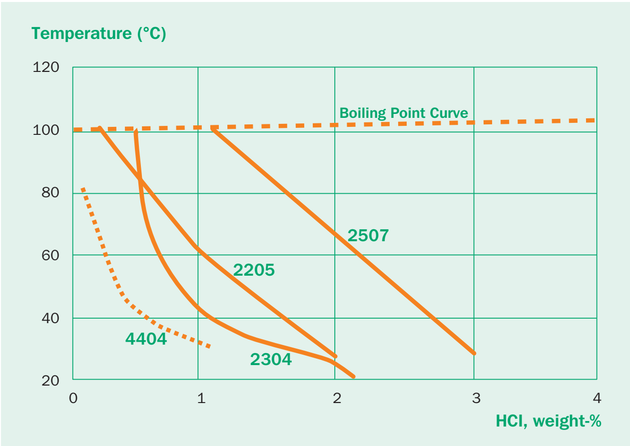

Fig. 4. Isocorrosion curves 0.1 mm/year, in hydrochloric acid.

ASTM G 48 Method F, is presented in Figure 6. Different products and different surface finishes, e.g. mill finish surfaces, may show CCT values that differ from the values given in the figure.

Due to their different alloying levels, the uplex steels show considerable differences in the resistance to pitting and crevice corrosion. LDX 2101® has a resistance in-between 4307 and 4404, 2304 is on a level with conventional molybdenum-alloyed steels of the 4404 type, while LDX 2404® and 2205 is on a level

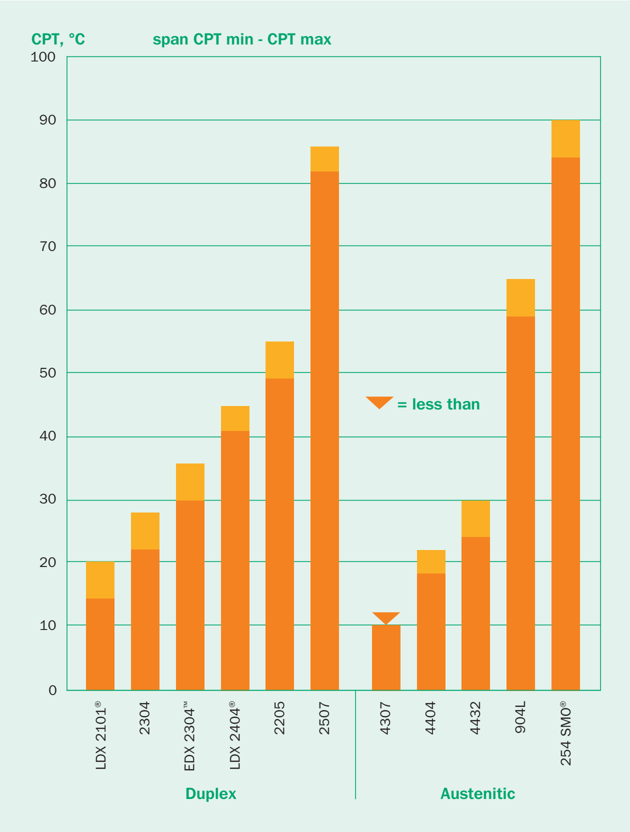

Fig. 5. Typical critical pitting corrosion temperatures (CPT) in 1M NaCl measured according to ASTM G 150 using the Avesta Cell. Test surfaces wet ground to P320 mesh. CPT varies with product form and surface finish.

Fig. 6. Typical critical crevice corrosion temperature (CCT) according to ASTM G 48 Method F. Test surfaces dry ground to 120 mesh. CCT varies with product form and surface finish.

Stress corrosion cracking

Stainless steel can be affected by stress corrosion cracking (SCC) in chloride containing environment at elevated temperatures. Conventional austenitic stainless steel is particularly vulnerable to stress corrosion cracking while stainless steels of the duplex type are less susceptible to this type of corrosion.

Different methods are used to rank stainless steel grades with regard to their resistance to stress corrosion cracking and results may vary depending on the test method as well as test environment. In Table 8 a comparison is given of the stress corrosion cracking resistance of conventional austenitic stainless steels and duplex stainless steels for a number of accelerated laboratory tests. These methods include immersion tests in several chloride solutions as well as the Wick test (ASTM C 692) which is performed under evaporative conditions.

The results show that while duplex stainless steels are not immune under very harsh conditions, such as boiling concentrated magnesium chloride, they withstand stress corrosion cracking under many conditions where conventional austenitic grades are expected to fail.

PRE values for some austenitic and duplex grades

Table 7

Steel grade	PRE
4307	18
4404	24
LDX 2101®	26
2304	26
EDX 2304™	28
LDX 2404®	33
904L	34
2205	35
254 SMO®	43
2507	43

Comparative stress corrosion cracking resistance in accelerated laboratory tests

Table 8

Test solution Temperature Load	ASTM G 36 45% MgCl 155°C (b.p.) U-bend	40% $CaCl_2$ (100°C) U-bend	40% $CaCl_2$ (100°C) 0.9 x $R_{p0.2}$ (4-PB)	ASTM G 123 25% NaCl, pH 1.5 106°C (b.p.) U-bend	25% NaCl 106°C (b.p.) U-bend	ASTM C 692 1500 ppm Cl^- 100°C $R_{p0.2}$
4307	Expected	Expected	Expected	Expected	Expected	Expected
4404	Expected	Expected	Possible	Expected	Possible	Expected
LDX 2101®	Expected	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated
2304	Expected	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated
LDX 2404®	Expected	Possible	Not anticipated	Not anticipated	Not anticipated	Not anticipated
2205	Expected	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Possible
2507	Expected	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated
254 SMO®	Expected	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated

b.p. = boiling point. Expected = SCC is expected to occur. Not anticipated = SCC is not expected to occur. Possible = SCC may occur.

Sulphide induced stress corrosion cracking

In the presence of hydrogen sulphide and chlorides the risk of stress corrosion cracking, at low temperatures, increases. Such environments can exist, for example, in boreholes for oil and gas wells. Duplex grades, such as 2205 and 2507 have demonstrated good resistance, while 13% chromium steels have shown a tendency towards stress corrosion cracking. However, caution should be observed regarding conditions with high partial pressure of hydrogen sulphide and where the steel is subjected to high internal stress.

2205 and 2507 are both approved materials according to *NACE MR0175/ISO 1515 Petroleum and natural gas industries - Materials for use in* H_2S*-containing environments in oil and gas production*.

Corrosion fatigue

The combination of high mechanical strength and very good resistance to corrosion gives duplex steels a high corrosion fatigue strength. S-N curves for 2205 and 4404 in synthetic seawater are shown in Figure 7. The corrosion fatigue strength of 2205 is considerably higher than that of 4404.

Intergranular corrosion

Due to the duplex microstructure and low carbon content, the duplex steels have very good resistance to intergranular corrosion. The composition of the steel ensures that austenite is reformed in the heat-affected zone after welding. The risk of undesirable precipitation of carbides and nitrides in the grain boundaries is thus minimised.

Erosion corrosion

Stainless steel in general offers good resistance to erosion corrosion. Duplex grades are especially good thanks to their combination of high surface hardness and good corrosion resistance. Examples of applications where this is beneficial are systems subjected to particles causing hard wear e.g. pipe systems containing water with sand or salt crystals.

Fig. 7. Corrosion fatigue of stainless steel in synthetic seawater. Rotating bending test, 1500 r/min, with smooth specimens from 15 mm plate.

Galvanic corrosion

Galvanic corrosion can occur when two dissimilar metals are connected. The noblest material is protected while the less noble material is more severely attacked. As long as the duplex stainless steels are passive they are, in most environments, nobler than other metallic construction materials, meaning that the stainless steel is protected while the corrosion rate of e.g. carbon steel is increased.

Galvanic corrosion does not occur between different grades of stainless steels as long as both grades are passive.

Fabrication

Duplex stainless steel is suitable for all forming processes available for stainless steel. The high proof strength compared to austenitic and ferritic 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.

Outokumpu, Avesta Research Centre, can support customers in detailed computer analyses of the impact on the forming process when stainless steel grades are to be selected.

Cold forming

The high strength of the duplex grades is clearly demonstrated when the stress-strain curves of Outokumpu duplex grades are compared with the corresponding austenitic grades, see Figures 8-9. The $R_{p0.2}/R_m$ ratio also demonstrates a lower deformation hardening rate for duplex grades at higher values of the plastic strain.

A sheet material's ability to withstand thinning during forming is demonstrated by the r-value, anisotropic value, in different tensile directions, and the higher the r-value the better, see Figures 10-11.

The formability of duplex stainless steel can be characterized in several ways. Figure 13 shows a relative ranking of Outokumpu duplex grades in comparison to a selection of austenitic grades. The ranking resembles the most critical failure mode in sheet forming.

In pure drawing, the duplex grades are comparable to austenitic grades in that about the same limiting drawing ratio can be drawn.

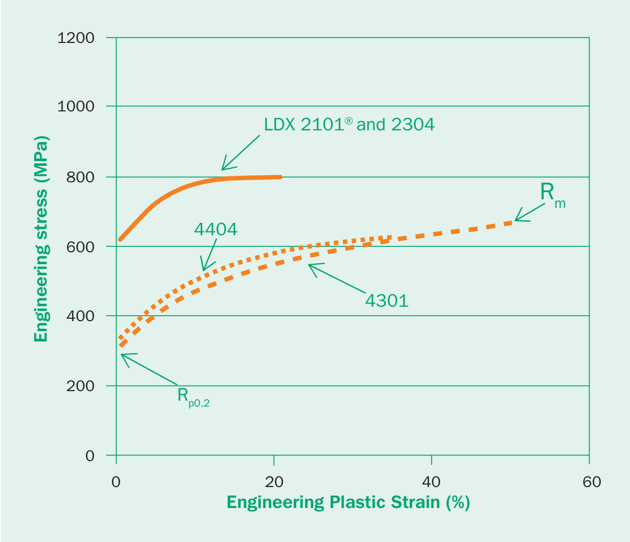

Fig. 8. Stress-strain curves for duplex and austenitic grades with corresponding corrosion resistance.

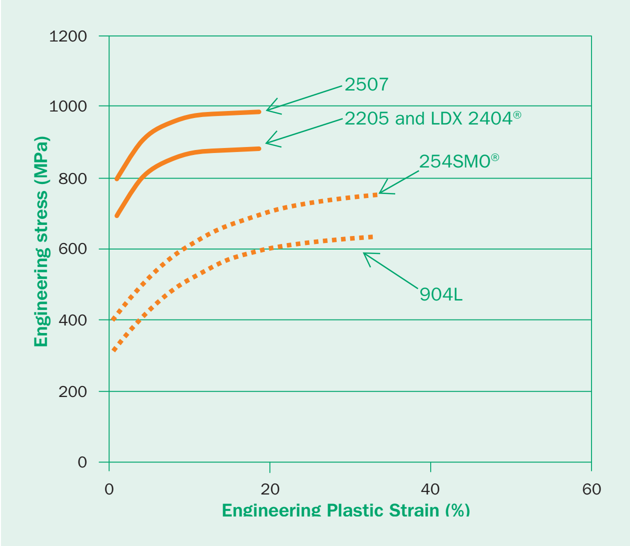

Fig. 9. Stress-strain curves for duplex and austenitic grades with corresponding corrosion resistance.

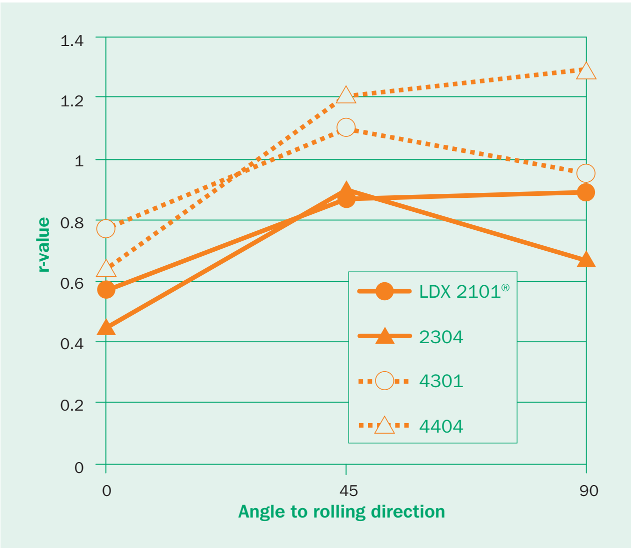

Fig. 10. r-values for duplex and austenitic grades with corresponding corrosion resistance.

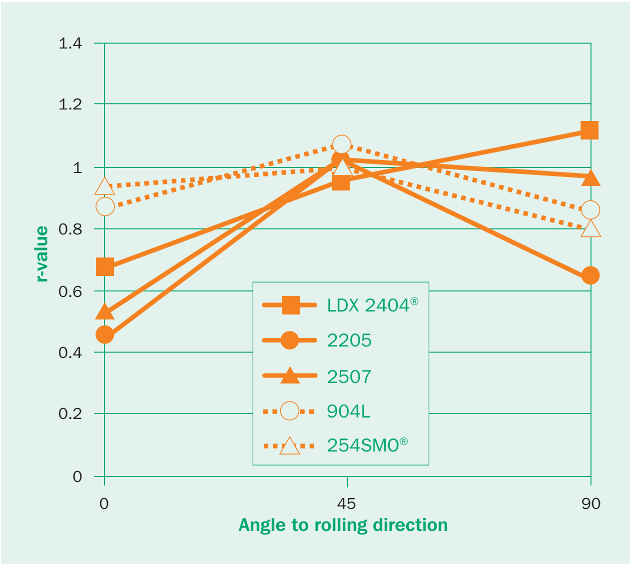

Fig. 11. r-values for duplex and austenitic grades with corresponding corrosion resistance.

Hot forming

Hot forming is performed at the temperatures illustrated in Table 9. It should, however, be observed that the strength of the duplex materials is low at high temperatures and components require support during fabrication. Hot forming should normally be followed by quench annealing.

Heat treatment

Temperatures suitable for heat treatment are presented in Table 9. The heat treatment should be followed by subsequent rapid cooling in water or air. This treatment applies for both solution annealing and stress relieving. The latter can in special cases be done at 500-550°C. Further information concerning these operations is available from Outokumpu.

Machining

Duplex steels are generally more demanding to machine than conventional austenitic stainless steel such as 4404, due to the higher hardness. However LDX 2101® has shown excellent machining properties.

The machinability can be illustrated by a machinability index, as illustrated in Figure 12. 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. For further information see our Machining Guidelines available for all duplex grades, or contact Outokumpu.

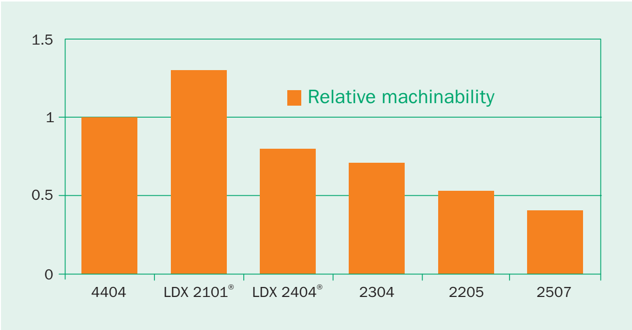

Fig. 12. Machinability index for duplex and some other stainless steels.

Characteristic temperatures, °C

Table 9

	LDX 2101®	2304	LDX 2404®	2205	2507
Hot forming	1100-900	1100-900	1120-900	1150-950	1200-1025
Quench annealing	1020-1080	950-1050	1000-1120	1020-1100	1040-1120
Stress relief annealing	1020-1080	950-1050	1000-1120	1020-1100	1040-1120

See also "Welding"

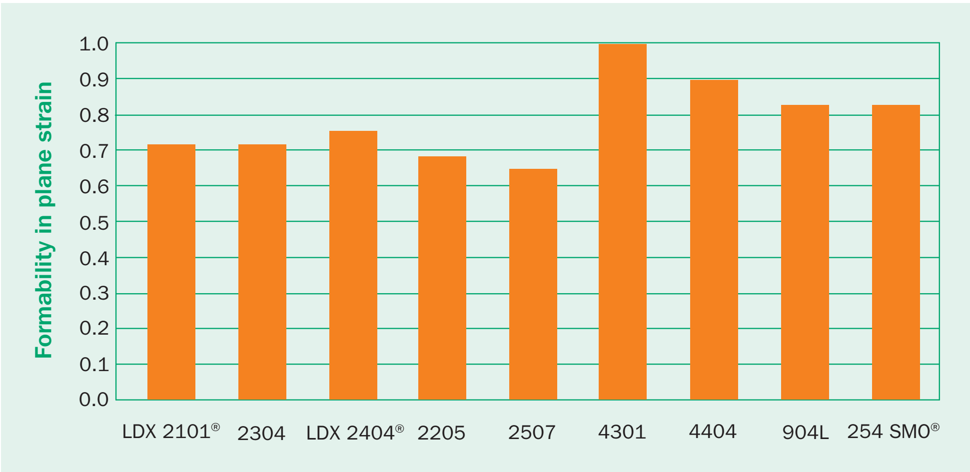

Fig 13. Formability ranking of some duplex and austenitic grades in relation to grade 4301.

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. For LDX 2101® reasonably good properties can be obtained also 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 to be welded.
- Post-weld annealing after welding with filler is not necessary. In cases where heat treatment is considered, e.g., for stress relieving, it should be carried out in accordance with the temperatures stated in Table 9, but with the minimum temperature increased with 30-50°C to secure full dissolution of intermetallic phase in the the weld metal.
- To ensure optimum pitting resistance when using GTAW and PAW methods, an addition of nitrogen in the shielding/purging gas is recommended.

Post fabrication treatment

In order to restore the stainless steel surface and achieve good corrosion resistance after fabrication, it is often necessary to perform a post fabrication treatment.

There are different methods available, both mechanical methods such as brushing, blasting and grinding and chemical methods, e.g. pickling. Which method to apply depend on what consequences the fabrication caused, i.e. what type of imperfections to be removed, but also on requirements with regard to corrosion resistance, hygienic demands and aesthetic appearance. For more information, see the Outokumpu Welding Handbook.

Welding consumables

Table 10

Steel grade	Consumable ISO Designation	Typical composition, % by wt.				
		C	Cr	Ni	Mo	N
LDX 2101®	23 7 NL	0.02	23.5	8.0	0.3	0.14
	22 9 3 NL	0.02	22.5	8.5	3.0	0.15
2304	23 7 NL[1]	0.02	23.5	8.0	0.3	0.14
	22 9 3 NL[1]	0.02	22.5	8.5	3.0	0.15
LDX 2404®	22 9 3 NL	0.02	22.5	8.5	3.0	0.15
2205	22 9 3 NL	0.02	22.5	8.5	3.0	0.15
2507	25 9 4 NL	0.02	25	9.5	3.5	0.25

[1]also valid for EDX 2304™, however filler 22 9 3 NL is recommended to match the higher tensile strength and corrosion resistance of EDX 2304™

Products

Outokumpu products

Table 11

Product	LDX 2101®	2304	LDX 2404®	2205	4501	2507
Hot rolled plate Quarto	✓	✓	✓	✓	✓	✓
Hot rolled coil and sheet	✓	✓	✓	✓		✓
Cold rolled coil and sheet	✓	✓	✓	✓		✓
Rod coil	✓	✓	✓	✓	✓	✓
Bars	✓	✓	✓	✓	✓	✓
Semifinished (bloom, billet, ingot, slab)	✓	✓	✓	✓	✓	✓
Pipe	✓	✓	✓	✓	✓	✓
DUPROF™, high strength profiles	✓	✓		✓		

See also outokumpu.com

Material Standards

Table 12

ISO 15510	Stainless steels – Chemical composition
EN 10028-7	Flat products for pressure purposes – Stainless steels
EAM-0045-01:2012/01	Pressure equipment Directive 97/23/EC. European approval for materials. EN 1.4162.
EN 10088-2	Stainless steels – Corrosion resisting sheet/plate/strip for general and construction purposes
EN 10088-3	Stainless steels – Corrosion resisting semi-finished products/bars/rods/wire/sections for general and construction purposes
EN 10088-4	Stainless steel flat products, technical delivery conditions, steels for construction
EN 10088-5	Stainless steel long products, technical delivery conditions, steels for construction
EN 10272	Stainless steel bars for pressure purposes
ASTM A 240 / ASME SA-240	Heat-resisting Cr and Cr-Ni stainless steel plate/sheet/strip for pressure purposes
ASTM A 276	Stainless and heat-resisting steel bars/shapes
ASTM A 479 / ASME SA-479	Stainless steel bars for boilers and other pressure vessels
ASTM A 790 / ASME SA-790	Seamless and welded duplex stainless steel pipe
ASTM A 928	Duplex stainless steel pipe welded with addition of filler metal
VdTÜV WB 418	Ferritisch-austenitischer Walz- und Schmiedestahl, 1.4462
VdTÜV WB 496	Ferritisch-austenitischer Walz- und Schmiedestahl, 1.4362
VdTÜV WB 556	Austenitic-ferritic steel X2CrMnNi21-5-1, Material No. 1.4162, Manufacturer designation: LDX 2101®
NACE MR0175 / ISO 1515	Petroleum and natural gas industries - Materials for use in H_2S-containing environments in oil and gas production.
Norsok M-CR 630, MDS D45, MDS D55	
ASME Boiler and Pressure	21Cr-5Mn-1.5Ni-Cu-N (UNS S32101), Austenitic-Ferritic Duplex Stainless Steel
Vessel Code Case 2418	Section VIII, Division 1

Outokumpu 2205 corresponds in American Standards to two different steel designations; UNS S31803 and UNS S32205. The latter has closer tolerance limits for some alloying elements to further optimise properties such as corrosion resistance and strength, the properties described in this datasheet corresponds to UNS S32205.

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.

1008EN-GB:8. Centrumtryck AB Avesta, May, 2013.

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research.stainless@outokumpu.com
outokumpu.com