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Complete in Duplex

TECHNICAL INFORMATION • PROGRAMME • LOGISTICS

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We are pleased to present our Duplex programme - with detailed technical information, our product range and logistics to suit your requirements!

By choosing a balanced composition, it is possible to produce stainless steel qualities with a structure that comprises both ferrite and austenite. This group of stainless steel grades is known by the name Duplex stainless steel. The ratio of ferrite to austenite in Duplex stainless steel is approx. 50/50%. With regard to austenitic grades of stainless steel, Duplex is particularly noted for its good mechanical properties in combination with high corrosion resistance (up to a temperature of approx. 315°C). Duplex metals are simple to weld and machine. For this reason they are often used in:

- The oil & gas industry
- The chemical & petrochemical industry
- The bio-industry
- The food industry
- Maritime applications
- Water cleaning and desalination plants
- The paper processing industry

This brochure compares stainless steel grades such as AISI 304 / 316L / 316Ti / 904L and 254SMO on the one hand and the Duplex grades Lean Duplex, Duplex and Super Duplex on the other. The comparison is made on the basis of:

1. Composition
2. Corrosion resistance
3. Mechanical properties
4. Weldability, machinability and other machining properties

The brochure also contains information about the product range and possibilities of the various Duplex grades.

Composition

The Duplex stainless steel grades Lean Duplex, Duplex and Super Duplex have different compositions. Each type therefore has its own specific characteristics. It is important to have the right balance between ferrite formers and austenite formers. Table 1 clearly shows the composition of the various stainless steel grades, including the Duplex metals. Various elements each fulfil their own role in Duplex metals.

Chromium (Cr)

Chromium is the most important alloying element in stainless steel. When exposed to an oxidizing environment it forms a layer of chromium oxide, which is resistant to corrosion. Corrosion resistance increases as the value of chromium rises. However, chromium is a typical ferrite former. An increasing percentage of chromium in Duplex must be compensated by other elements in order to maintain the right balance between ferrite and austenite.

Nickel (Ni)

Nickel is an austenite former and therefore essential for obtaining the right balance in Duplex metals in combination with ferrite formers such as chromium. The percentage of nickel in Duplex stainless steel is about half of the percentage of nickel in stainless steel grades from the 300 series.

Nitrogen (N)

Nitrogen takes on various roles in the Duplex metals. The main reason for adding nitrogen is to improve resistance to pitting and crevice corrosion, a typical characteristic of Duplex metals. For more details, see ‘Corrosion resistance’. Nitrogen is also many times smaller than iron (by a factor of 1500) and is therefore much easier to soluble in metals. It also provides barriers to deformations. Finally, nitrogen is also an excellent austenite former. The percentage of nitrogen used in Duplex is therefore as

high as possible in order to maintain the final balance between ferrite and austenite.

Molybdenum (Mo)

Molybdenum enhances the function of chromium, especially in a chloride-containing environment, which causes frequent crevice corrosion and pitting. The enhancement occurs at a minimum chromium content of 18%. However, molybdenum is a ferrite former, so the percentage is limited to a maximum of 4%.

Copper (Cu)

The addition of copper to the Duplex metals increases corrosion resistance, especially to sulphuric acid.

Manganese (Mn)

Manganese is an austenite former and a cheap alternative to nickel (about 10 times cheaper).

Table 1: Chemical composition - in %

AISI	EN	ASTM-UNS	^{C} % min	^{Cr} % min	^{Ni}min	^{Mo}min	^{Mn}gem	^{N}min	^{Ti}min	^{Cu}gem
AISI 304(L)	1.4301(4307)	S30400(403)	0.03(0,07)	17.5	8.0	-	1.1	-	-	-
AISI 316L	1.4404	S31603	0.03	16.5	10.5	2.5	1.5	-	-	-
AISI 316Ti	1.4571	S31635	0.08	16.5	10.5	2.0	1.5	-	0.35	-
904L	1.4539	N08904	0.02	19.0	24.0	4.0	2.0	-	-	1.2
254SMO	1.4547	S31254	0.02	19.5	17.5	6.0	1.0	0.2	-	0.5
Lean Duplex	1.4362	S32304	0.03	22.0	3.5	0.1	2.0	0.05	-	0.1-0.6
Duplex	1.4462	S32205/S31803	0.03	21.0	4.5	2.5	2.0	0.10	-	-
Super Duplex	1.4410	S32750	0.03	24.0	6.0	3.0	0.8	0.24	-	0.5
Super Duplex (F55)	1.4501	S32760	0.03	24.0	6.0	3.0	1.0	0.20	-	0.7

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Corrosion resistance

There are many forms of corrosion, including:

- Pitting
- Crevice corrosion
- Stress corrosion cracking

Accelerated corrosion tests are carried out for each of the above types under laboratory conditions. The results shown in this brochure come from tests whose execution and measuring methods are described according to the international ASTM standards. The results are intended to facilitate comparison of the various stainless steel grades with each other during the selected conditions.

Pitting

Under unfavourable conditions the chromium oxide layer can be broken which can cause damage to the material. Pitting occurs in an environment with aggressive substances and in the presence of a pit, damage, scratch or inclusion. The level of sensitivity for pitting is obtained by the determination of the Critical Pitting Temperature, or CPT. Because this type of corrosion also depends on the percentage of the elements chromium, molybdenum and nitrogen, a mathematical formula has been determined. This formula is called 'Pitting Resistance Equivalent Number'
(PREN): PREN = %Cr + 3,3 x %Mo + 16 x %N.

This formula also works well in combination with the method that uses CPT temperatures. It is important to note that the degree of the surface condition has a significant effect on the values obtained. Graphic 1 shows the results of the austenitic stainless steels and Duplex grades. Little is known about the values of AISI 316Ti; however, the presence of titanium carbides suggests that AISI 316Ti has a lower resistance to pitting than AISI 316L. The data in the graphic show that Lean Duplex is comparable with AISI 316L and 316Ti with respect to pitting. This also applies to the comparison of Duplex with 904L and Super Duplex with 254SMO.

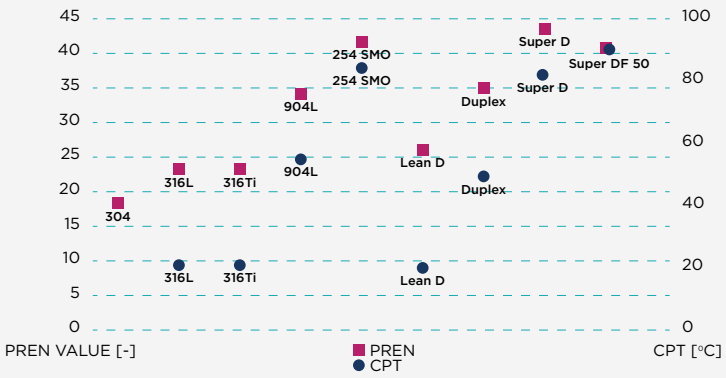
Crevice corrosion

Crevice corrosion is a localised form of corrosion that occurs in a stationary corrosive medium. In practice, it appears that metals are less protected against crevice corrosion than pitting, because crevice corrosion is more aggressive than pitting. This is the reason why the temperatures for crevice corrosion shown in graphic 2 are also lower than those for pitting. The temperatures are determined in the same way as those for pitting, except that this method is standardized under the ASTM G48B test. The conclusion is that Lean Duplex has better resistance to crevice corrosion than AISI 316L/316Ti, thus also for Duplex versus 904L and Super Duplex versus 254SMO.

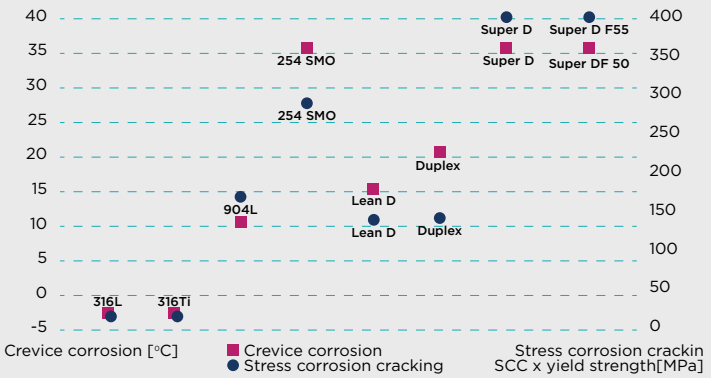
Stress corrosion cracking

The term stress corrosion cracking refers to the formation of cracks due to the simultaneous inward or outward tensile stress in a corrosive environment. Austenitic stainless steel is particularly sensitive to stress corrosion cracking at elevated temperatures in a chloride-containing environment. Tests are carried out using a drop evaporation system and a salt solution at 120°C. The values shown in graphic 2 are the result of the reduction in strength multiplied by the minimum strength per grade according to the EN standard. The results show that AISI 316 in a chloride-containing environment at 120°C is highly sensitive to stress corrosion cracking, while Lean Duplex offers significantly better resistance. Duplex and 904L have a similar level of resistance. Super Duplex scores highest and is comparable to 254SMO.

Graphic 1: Pitting



Graphic 2: Crevice & Stress Corrosion



Mechanical properties

The chemical composition and resulting ferritic and austenitic structure gives the Duplex grades relatively high mechanical properties. Table 2 shows the minimum values for the yield strength, tensile strength and elongation of both the austenitic and Duplex grades according to the EN standard. In particular, the various Duplex grades have a considerably higher yield strength than the austenitic grades. This means that in principle lighter constructions can be achieved with Duplex grades, considerably reducing the total investment.

Weldability

Within certain limits, Duplex can be welded using all common welding methods. By choosing the correct type of welding additive (with a Ni content approx. 3% higher than the basic material) and having good control of the thermal cooling cycle, it is possible to create a weld that is similar with the basic material in terms of both mechanical properties and corrosion resistance. The cooling rate over the range 1200°C - 800°C is particularly important. A cooling rate that is too high produces too much ferrite, which has a negative effect on hardness and resistance to pitting and intercrystalline corrosion. In general, the ferrite component in the weld is limited to approx. 60%. A cooling rate that is too low can result in the undesirable formation of chromium carbides, which can negatively influence hardness and corrosion resistance. Pre-heating is recommended for thick sheets (as from 15 mm). A protective atmosphere must be used for Duplex grades.

Other processing properties

Machining

Duplex grades are more difficult to machine than AISI 316L. The cutting speed will be approx. 20% lower for the same cutting depth and feed. The lower cutting speeds for Duplex grades are caused by higher mechanical properties and the absence of sulphur.

Sawing

Duplex metals are harder to saw than steel. A good rule of thumb is that the saw speed and the feed must be set as for AISI 316L.

Trimming

Duplex can be trimmed in the same way as austenitic stainless steel grades, with the difference that the forces are significantly higher. A good indication is that 85% of the thickness of stainless steel AISI 316 can be used as the maximum thickness for Lean Duplex and Duplex. For Super Duplex, the maximum thickness for trimming is about 65% of the thickness of austenitic metals.

Perforating/punching

The combination of high strength and rapid punch movement makes it difficult to perforate Duplex metals. As an indication, the thickness of Duplex behaves like 2x the thickness of austenitic stainless steel metals.

Plasma & laser cutting

The Duplex metals are fully comparable with the austenitic metals at this point.

Table 2: Mechanical properties

AISI	EN	ASTM-UNS	min. 0,2% yield strenght* MPa	min. tensile strenght * MPa	elongation%
AISI 304(L)	1.4301(4307)	S30400 (S30403)	210	520	45
AISI 316L	1.4404	S31603	220	520	45
AISI 316Ti	1.4571	S31635	220	520	40
904L	1.4539	N08904	220	520	35
254SMO	1.4547	S31254	300	650	40
Lean Duplex	1.4362	S32304	400	630	25
Duplex	1.4462	S32205/S31803	460	640	25
Super Duplex	1.4410	S32750	530	730	20
Super Duplex (F55)	1.4501	S32760	530	730	25

** min. mechanical values according to the EN standard, at room temperature*

More options in Lean Duplex, Duplex and Super Duplex

In addition to the stock programme shown below, we also offer excellent supply options with short delivery times for non-standard items, such as flanges, butweld and threaded wire fittings, perforated sheet and sheet to size. We can deliver to any desired standard and/or certification (NACE, NorSok, ASME, etc.).

Lean Duplex - 1.4362 / plate material	CR, finish 2E	HR, finish 1D
2000 x 1000	2 mm	-
3000 x 1500	3 mm	4/5 mm
6000 x 2000	2/3/4 mm	5/6/8/10/15/20 mm
Other products and/or dimensions on request		

Duplex - 1.4462 / plate material	CR, finish 2E	HR, finish 1D
2000 x 1000	1/1.5/2/3/4 mm	5/6/8/10/12/15/20/25/30/40 mm
2500 x 1250	1.5/2/3 mm	4/5/6/8/10 mm
3000 x 1500	1,5/2/3 mm	4/5/6/8/10/12/15/20/25/30 mm
4000 x 2000	-	6/8/10 mm
6000 x 1500	-	6/8/10 mm
6000 x 2000	2/3/4 mm	5/6/8/10/12/15/20/25/30/35/40/50 mm

Duplex - 1.4462 / flat bars HR(4-6 mtr)	5	6	8	10	12	15	20	thickness
Width 30		x	x	x		x		
Width 40		x	x	x	x	x		
Width 50	x	x	x	x	x	x	x	
Width 60		x	x	x		x	x	
Width 70			x					
Width 75						x		
Width 80			x	x	x	x	x	
Width 100				x			x	

Duplex - 1.4462 / angle profile HR(6 mtr)						
30x30x3 mm	40x40x4mm	50x50x5mm	60x60x6mm	70x70x7mm	80x80x8mm	100x100x10 mm

Duplex - 1.4462 / round bars	CR (3 mtr)	HR (5-6 mtr)
Round	6/8/10/12/15/16/35 mm	-
Round	20/25/30/40/50 mm	20/25/30/40/50 mm
Round	-	60/70/75/80/90/100/110/120/ 130/150/160/180/200 mm

Duplex - 1.4462 / round seamless tubes(6 mtr lang)			
20.0 x 2.0	33.4 x 2.77 (1” 10S)	60.3 x 2.0	114.3 x 3.05 (4” 10S)
21.3 x 2.0	33.4 x 3.38 (1” 40S)	60.33 x 2.77 (2” 10S)	114.3 x 3.6
21.34 x 2.11 (1/2” 10S)	33.7 x 2.0	60.33 x 3.91 (2” 40S)	114.3 x 6.02 (4” 40S)
21.34 x 2.77 (1/2” 40S)	42.16 x 2.77 (1 1/4” 10S)	60.33 x 5.54 (2” 80S)	139.7 x 4.0
21.34 x 3.73 (1/2” 80S)	42.16 x 3.56 (1 1/4” 40S)	76.1 x 3.05	168.3 x 3.4 (6” 10S)
25.0 x 2.0	42.4 x 2.0	88.9 x 2.6	168.3 x 7.11 (6” 40S)
26.67 x 2.11 (3/4” 10S)	48.26 x 2.77 (1 1/2” 10S)	88.9 x 3.05 (3” 10S)	219.1 x 8.18 (8” 40S)
26.67 x 2.77 (3/4” 40S)	48.26 x 3.68 (1 1/2” 40S)	88.9 x 5.49 (3” 40S)	
26.67 x 3.73 (3/4” 80S)	48.26 x 5.08 (1 1/2” 80S)	88.9 x 2.6	
Associated welding fittings and flanges are available			

Super Duplex

MCB Specials offers very good possibilities for sheet metal, bars, tubes and fittings.

Our specialists are here to advice you on the materials and operations. In addition, we provide metallurgical support and application advice.

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