GNS NEDERLAND

FLEXIBLE METAL SERVICE & DISTRIBUTION

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1 Technical information Stainless steel

1.1 General information

In many circumstances, a galvanic protection provided by coating the surface of mild steel is impractical. Here is the special oxide film formed on chrome alloyed steel very useful.

Stainless steels are chromium containing steel alloys. The minimum chromium content of the standardized stainless steel is 10.5%. Chromium makes the steel 'stainless' - this means with improved corrosion resistance. The better corrosion resistance is due to the chromium oxide film which is formed on the steel surface. This extremely thin layer repairs itself under the right conditions.

Besides chromium other typical alloying elements are molybdenum, nickel and nitrogen. Nickel is usually added to improve the malleability and ductility of stainless steel. The alloying with these elements results in different crystal structures for the different properties for machining operations such as bending, welding, etc.

The structure will determine the mechanical and physical properties, and to some extent also the corrosion properties. Stainless steel grades are usually classified according to their structure at room temperature. Here, the following subdivision is used:

- **Austenitic stainless steel.**
  This group is by far the most used. In austenitic stainless steel is nickel beside chromium, the principal alloying element. Nickel stabilizes the austenite formed at a high temperature, whereby this structure even stays maintained at low temperatures. The austenitic grades show by heat up or cool down therefore no structural transformation so hardening treatments are not possible.
  Increase strength can only be achieved by cold deformation. In essence, these types are not magnetically although they can be slightly magnetic due to cold working. Austenitic stainless steel is used in household appliances, chemical industry and in the food industry.

- **Martensitic stainless steel.**
  The main feature of this group is the ferrite / austenite transformation which is caused by the addition of austenitic forming elements such as carbon. As a result, the possibility arises these qualities to harden or ennoble. The use properties of the martensitic chromium steel (which are distinguished from other groups of stainless steels by a higher hardness and strength) are strongly dependent on the applied heat treatment, and are therefore within very wide limits to be set. Martensitic stainless steels are magnetic.

- **Ferritic stainless steel** is - as austenitic stainless steel - not to harden or ennoble. As low and unalloyed steels show ferritic stainless steel grades a sharp transition from ductile to brittle fracture behaviour at low temperatures. In general, ferritic grades are excellently polishable. The weldability is generally moderately to reasonable. Considering the reduced corrosion resistance ferritic grades are applied in non-aggressive environments. Ferritic stainless steels are used in household appliances, furniture and interiors.

  Austenitic / ferritic (duplex) stainless steel is characterized by a structure that consists of approximately 50% austenite and about 50% of ferrite. As a result, this group has a better resistance to local corrosion and an approximately 2x higher yield. Due the higher strength can be constructed lighter. Compared with austenitic stainless steel, the ductility is less. The weldability is good within certain limits. Duplex stainless steel is used in the chemical and petrochemical and offshore industry

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1.2 Short characterization common qualities

1.4301 (304) (Austenitic)
One of the most commonly used universal stainless steels. It possesses an excellent combination of strength, corrosion resistance and is easy to machine. The quality 1.4301 is moderate to bad machinable as a result of the high toughness, poor thermal conductivity, and high degree of hardening. Use type 1.4306 (304L), due to its lower carbon content, to avoid intergranular corrosion caused by welding.

1.4305 (303) (Austenitic)
Significantly better machinable quality compared to the basic type 1.4301. Due the addition of sulfur - that with the present manganese forms sulfer sulphides - the chips break short. A disadvantage of the addition of the sulfur is reduced corrosion resistance, formability and weldability compared to 1.4301.

1.4401 (316) (Austenitic)
Superior corrosion resistance compared to the other 300 series alloys when used in rough corrosive environments (eg sea water, chemicals, etc.). The quality 1.4401 is good deformable and polishable. The machinability is poor. Use type 1.4404 (316L), to avoid - due to its lower carbon content - intergranular corrosion caused by welding.

1.4571 (316Ti) (Austenitic)
A titanium alloyed 1.4401 (316) with almost the same properties. Titanium is added to guarantee the corrosion resistance, particularly intergranular corrosion in welded condition. Disadvantages of the addition of titanium include the reduced polishability and some decrease in the formability in relation to the type of 1.4401 (316). The machinability is moderate.

1.4541 (321) (Austenitic)
A titanium alloyed 1.4301 (304) with almost the same properties. Titanium is added to guarantee the corrosion resistance, particularly intergranular corrosion in welded condition. It has strength properties that are better than those of 1.4301 (304), making it suitable for components which are not thereafter have to be annealed. Disadvantages of the addition of titanium include the reduced polishability and some decrease in the formability in relation to the type of 1.4301 (304).

1.4016 (430) (Ferritic)
Most used ferritic stainless steel type. Good deep drawing properties and fine polishable. Limited weldable and bendable. The quality 1.4016 has limited corrosion resistance and for this reason is mainly used in non-aggressive environments or where no high demands are made on the corrosion resistance.

1.4462 (329LN) (Duplex)
Austenitic/ ferritic type with good mechanical properties. High resistance against corrosion in general and pitting corrosion in particular. Due the austenitic/ ferrite ratio this type of stainless steel is after welding - without heat treatment - resistant against intergranular corrosion.

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2 Mechanical properties

2.1 Stainless steel bar material and profiles

2.1.1 Mechanical properties of stainless steel bar, wire and profile (EN 10088-3)

Materialnumber (EN)	AISI	EN	Condition	Thickness maximum	Tensile strength N/mm^2	0,2% Yield stress min.	Rp % min.	Brinell hardness max.
1.4000	403		Annealed	25	400-630	230	20 [a]	200
1.4003	-	X 2 CrNi 12	Annealed	100	450-600	260	20 [a]	200
1.4016	430	X 6 Cr 17	Annealed	100	400-630	240	20 [a]	200
1.4021	420	X 20 Cr 13	Annealed	-	≤760 [4]	-	-	230 [d]
			QT800 [c]	≤ 160	800-950	600	12 [a]	-
1.4057	431	X 20 CrNi 17 2	Annealed	-	≤950 [4]	-	-	295 [d]
			QT800 [c]	≤ 60	800-950	600	14 [a]	-
				>60 - ≤ 160			12 [a]	
			QT900 [c]	≤ 60	900-1050	700	12 [a]	-
				>60 - ≤ 160			10 [a]	
1.4104	430F	X 12 CrMoS 17	Annealed	-	≤730 [4]	-	-	220 [d]
			QT650 [c]	≤ 60	650-850	500	12 [a]	-
				>60 - ≤ 160			10 [a]	
1.4105	430F6	X 6 CrMoS 17	Annealed	100	430-630	250	20 [a]	200
1.4113	434		Annealed	100	440-660	280	18 [a]	200
1.4122	420RM	X 35 CrMo 17	Annealed	-	≤900 [4]	-	-	280 [d]
			QT750 [c]	≤ 160	750-950	550	12 [a]	-
1.4301	304	X 5 CrNi 18 10	Solution annealed	≤ 160	500-700	190	45 [a]	215
				>160 - ≤ 250			35 [b]	
1.4303	305	X 5 CrNi 18 12	Solution annealed	≤ 160	500-700	190	45 [a]	215
				>160 - ≤ 250			35 [b]	
1.4305	303	X 10 CrNiS 18 9	Solution annealed	≤ 160	500-750	190	45 [a]	230
1.4306	304L	X 2 CrNi 19 11	Solution annealed	≤ 160	460-680	180	45 [a]	215
				>160 - ≤ 250			35 [b]	
1.4307	304L	X 2 CrNi 18 9	Solution annealed	≤ 160	450-680	175	45 [a]	215
				>160 - ≤ 250			35 [b]	
1.4401	316	X 5 CrNiMo 17 22 2	Solution annealed	≤ 160	500-700	200	40 [a]	215
				>160 - ≤ 250			30 [b]	
1.4404	316L	X 2 CrNiMo 17 13 2	Solution annealed	≤ 160	500-700	200	40 [a]	215
				>160 - ≤ 250			30 [b]	
1.4462	F51 (329LN)	X 2 CrNiMoN 22 5 3	Solution annealed	≤ 160	650-880	450	25 [a]	270
1.4541	321	X 6 CrNiTi 18 10	Solution annealed	≤ 160	500-700	190	40 [a]	215
				>160 - ≤ 250			30 [b]	
1.4571	316Ti	X 10 CrNiMoTi 17 12 2	Solution annealed	≤ 160	500-700	200	40 [a]	215
				>160 - ≤ 250			30 [b]	

[a] Determined in the longitudinal direction of the material
[b] Determined in the transverse direction of the material
[c] QT = quenched and tempered
[d] The maximum HB-values can be increased by 60 units, or the maximum value for the yield strength can be increased by 150 n/mm2 by cold drawing bars and profiles with a thickness less than or equal to 35 mm.

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2.2 Stainless steel plate and band material

2.2.1 Austenitic en austenitic-ferritic (duplex) qualities (EN 10088-2)

Material-number (EN)	AISI	EN	Condition	Type [a]	Thickness maximum	Tensile strength N/mm^2	0,2% Yield stress min. transverse	1% yield strength minimum transverse	Rp % min.
1.4301	304	X 5 CrNi 18 10	Solution annealed	Cold band	6	540-750	230	260	45
				Hot band	12	520-720	210	250	
				Hot plate	75		210	250	
1.4303	305	X 5 CrNi 18 12	Solution annealed	Cold band	6	500-650	220	250	45
1.4305	303	X 10 CrNiS 18 9	Solution annealed	Hot plate	75	500-700	190	230	35
1.4306	304L	X 2 CrNi 19 11	Solution annealed	Cold band	6	520-670	220	250	45
				Hot band	12		200	240	
				Hot plate	75	500-650	200	240	
1.4307	304L	X 2 CrNi 18 9	Solution annealed	Cold band	6	520-670	220	250	45
				Hot band	12		200	240	
				Hot plate	75	500-650	200	240	
1.4310	301	X 12CrNi 17 7	Solution annealed	Cold band	6	600-950	250	280	40
1.4401	316	X 5 CrNiMo 17 22 2	Solution annealed	Cold band	6	530-680	240	270	40
				Hot band	12		220	260	
				Hot plate	75	520-670	220	260	45
1.4404	316L	X 2 CrNiMo 17 13 2	Solution annealed	Cold band	6	530-680	240	270	40
				Hot band	12		220	260	
				Hot plate	75	520-670	220	260	45
1.4438	317L	X 5 CrNiMo 18 16 4	Solution annealed	Cold band	6	550-700	240	270	35
				Hot band	12		220	260	
				Hot plate	75	520-720	220	260	40
1.4462	F51 (329LN)	X 2 CrNiMoN 22 5 3	Solution annealed	Cold band	6	660-950	480	-	20
				Hot band	12		460	-	25
				Hot plate	75	640-840	460	-	25
1.4501	F55	X 2 CrNiMoCuWN 25 7 4	Solution annealed	Hot plate	75	730-930	530	-	25
1.4541	321	X 6 CrNiTi 18 10	Solution annealed	Cold band	6	520-720	220	250	40
				Hot band	12		200	240	
				Hot plate	75	500-700	200	240	
1.4550	347	X 6 CrNiNb 18 10	Solution annealed	Cold band	6	520-720	220	250	40
				Hot band	12		200	240	
				Hot plate	75	500-700	200	240	
1.4571	316Ti	X 10 CrNiMoTi 17 12 2	Solution annealed	Cold band	6	540-690	240	270	40
				Hot band	12		220	260	
				Hot plate	75	520-670	220	260	

[a] Cold fished or hot rolled

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2.2.2 Ferritic en martensitic qualities (EN 10088-2)

Material-number (EN)	AISI	EN	Condition	Type [c]	Thickness maximum	Tensile strength N/mm²	0,2% Yield stress min. along	0,2% Yield stress min transverse	Rp % min.
1.4000	403	X 6 Cr 13	annealed	Cold band	6	400-600	240	250	19
				Hot band	12				
				Hot plate	25 [a]		220	230	
1.4002	405	X 6 CrAl 13	annealed	Cold band	6	400-600	230	250	17
				Hot band	12				
				Hot plate	25 [a]		210	230	
1.4003	-	X 2 CrNi 12	annealed	Cold band	6	450-650			20
				Hot band	12		280	320	
				Hot plate	25 [a]		250	280	18
1.4006	410	X 10 Cr 13	annealed	Cold band	6	≤600			20
				Hot band	12		-	-	
			QT550 [b]	Hot plate	75	550-750	400	400	15
			QT650 [b]	Hot plate		650-850	450	450	12
1.4016	430	X 6 Cr 17	annealed	Cold band	6	450-600	260	280	20
				Hot band	12		240	260	18
				Hot plate	25 [a]	430-630	240	260	20
1.4017	-	X 6 CrNi 17 1	annealed	Cold band	6	650-750	480	500	12
1.4021	420	X 20 Cr 13	QT [b]	Cold band	3	≤600	-	-	-
			annealed	Cold band	6	≤700	-	-	15
			annealed	Hot band	12				
			QT650 [b]	Hot plate	75	650-850	450	450	12
			QT750 [b]	Hot plate		750-950	550	550	10
1.4028	420F	X 30 Cr 13	QT [b]	Cold band	3	-	-	-	-
			annealed	Cold band	6	≤740	-	-	15
			annealed	Hot plate	12				
			QT800 [b]	Hot plate	75	800-1000	600	600	10
1.4113	434	X 6 CrMo 17 1	annealed	Cold band	6	560-630	260	280	18
				Hot band	12				
1.4122	-	X 35 CrMo 17	QT [b]	Cold band	3	-	-	-	12
			annealed	Cold band	6	≤900	-	-	
				Hot band	12				
1.4509	441	X 2 CrTiNb 18	annealed	Cold band	6	430-630	230	250	18
1.4510	-	X 3 CrTi 17	annealed	Cold band	6	420-600	230	240	23
				Hot band	12				
1.4511	-	X 3 CrNb 17	annealed	Cold band	6	420-600	230	240	23
1.4512	409	X 6 CrTi 12	annealed	Cold band	6	380-560	210	220	25
				Hot band	12				
1.4513	-	X 2 CrMoTi 17 1	annealed	Cold band	6	400-550	200	220	23
1.4516	-	X 6 CrNiTi 12	annealed	Cold band	6	450-650	280	320	23
				WGW band	12				
				Hot plate	25 [a]		250	280	20
1.4520	-	X 2 CrTi 17	annealed	Cold band	6	380-530	180	200	24
1.4521	443	X 2 CrMoTi 18 2	annealed	Cold band	6	420-460	300	320	20
				Hot band	12	400-600	280	300	
				Hot plate	25 [a]	420-620			
1.4526	436	X 6 CrMoNb 17 1	annealed	Cold band	6	480-560	280	300	25
1.4590	-	X 2 CrNbZr 17	annealed	Cold band	6	400-550	230	250	23

[a] For thickness above 25 mm the mechanical properties have to be agreed [b] QT = quenched and tempered [c] Cold fished or hot rolled

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3 Various

3.1 Determining working pressure stainless steel seamless pipe

The maximum allowable pressure at 20 ° C can be calculate with the following formula:

$$\frac{200 \times 12 \times g}{d}$$

g = Wall thickness
d = Outside diameter

Example for dimension 50x2:

$$\frac{200 \times 12 \times 2}{50} = 96 \text{ kg/cm}^2 = 96 \text{ ATM en} \approx 96 \text{ bar}$$

3.2 Overview stainless steel welding consumables

MIG / MAG wire	suitable for	AISI	EN	
307	1.4301	304	X 5 CrNi 18 10	
307	1.4303	305	X 5 CrNi 18 12	
307	1.4306	304L	X 2 CrNi 19 11	
307	1.4541	321	X 6 CrNiTi 18 10	
307	1.4550	347	X 6 CrNiNb 18 10	
308	-	308	-	
308	1.4301	304	X 5 CrNi 18 10	
308	1.4303	305	X 5 CrNi 18 12	
308	1.4306	304L	X 2 CrNi 19 11	
308	1.4541	321	X 6 CrNiTi 18 10	
308	1.4550	347	X 6 CrNiNb 18 10	
309	1.4828	309	X 15 CrNiSi 20 12	
310	1.4845	310	X 12 CrNi 25 21	
316L	1.4404	316L	X 2 CrNiMo 17 13 2	
316L	1.4541	321	X 6 CrNiTi 18 10	
316L	1.4571	316Ti	X 10 CrNiMoTi 17 12 2	
316L	1.4016	430	X 6 Cr 17	

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