

4.2.2 Material Grade Tables

Table 4.2.2_1: Stainless Steels (ferritic, chromium steels)

Material grade no.	Abbreviation	AISI/UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.4003	X2CrNi12 / X2Cr11	S40977	0.030	1.00	1.50	10.50 12.50	—	0.30 1.00	N ≤ 0.030	≥ 250	—	450 650	7.7	Good corrosion resistance to atmospheric corrosion and neutral, low chloride waters, economic stainless structural steel with good weldability and abrasion resistance
1.4512	X2CrTi12	S40910	0.030	1.00	1.00	10.50 12.50	—	—	Ti=6×(C+N) up to 0.65	≥ 210	—	380 560	7.7	Also to be used as heat resisting steel
1.4002	X6CrAl13	405/ S40500	0.08	1.00	1.00	12.00 14.00	—	—	Al= 0.10 0.30	≥ 210	—	400 600	7.7	Petrochemical industry, water turbines
1.4016	X6Cr17	430/ S43000	0.08	1.00	1.00	16.00 18.00	—	—	—	≥ 225	—	430 630	7.7	Also to be used as heat resisting steel
1.4510	X3CrTi17	439/ S43035	0.05	1.00	1.00	16.00 18.00	—	—	Ti=4×(C+N)+0.15 up to 0.80	≥ 230	—	420 600	7.7	Also to be used as heat resisting steel
1.4511	X3CrNb17	430Cb S43040	0.05	1.00	1.00	16.00 18.00	—	—	Nb=12×C up to 1.00	≥ 230	—	420 600	7.7	Welded parts for process equipment, only exposed to low acid and base attacks. High stress corrosion resistance in hot low-chloride waters
1.4509	X2CrTiNb18	S43940	0.030	1.00	1.00	17.50 18.50	—	—	Ti=0.10 up to 0.60 Nb=3×C+0.30 up to 1.00	≥ 230	—	430 630	7.7	Also to be used as heat resisting steel
1.4521	X2CrMoTi18-2	444/ S44400	0.025	1.00	1.00	17.00 20.00	1.80 2.50	—	N ≤ 0.030 Ti=4×(C+N)+0.15 up to 0.80	≥ 280	—	400 640	7.7	High stress corrosion resistance in high-temperature water with some chloride content
1.4575	X1CrNiMoNb28-4-2	S32803	0.015	0.55	0.50	28.00 29.00	1.80 2.50	3.00 4.00	N ≤ 0.020 Nb ≥ 12×(C+N) up to 0.50	≥ 500	—	≥ 600	7.7	High pitting, crevice and stress corrosion resistance

No guarantee for correctness

Table 4.2.2_2: Stainless Steels (austenitic - ferritic)

Material grade no.	Abbreviation/ designation usual to the market	AISI/ UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.4362	X2CrNi23-4/ LeanDuplex	2304/ S32304	0.030	1.00	2.00	22.00 24.00	0.10 0.60	3.50 5.50	N=0.05 Cu=0.10 0.20 0.60	≥ 385	—	600 850	7.8	Also to be used as heat resisting steel
1.4162	X2CrMnNi22-5-2	S32101	0.04	1.00	4.00 6.00	21.00 23.00	1.35 1.70	0.10 0.80	N=0.20 Cu=0.10 0.2 0.80	≥ 450	—	≥ 650	7.7	Higher general corrosion resistance than group 1.4301 up to 1.4550, combined with the high strength of standard duplex steels proper to chemical, paper and pulp industries
1.4462	X2CrNiMoN22-5-3/ Duplex	2205/ S31803/ S32205	0.030	1.00	2.00	21.00 23.00	2.50 3.50	4.50 6.50	N=0.10 0.22	≥ 445	—	640 950	7.8	Chemical and petrochemical industries, sea water desalination, shipbuilding, off-shore and sour-gas applications
1.4410	X2CrNiMoN25-7-4/ Superduplex	2507/ S32750	0.030	1.00	2.00	24.00 26.00	3.00 4.50	6.00 8.00	N=0.20 0.35	≥ 515	—	730 1,000	7.8	Higher strength and corrosion resistance than 1.4462 at least in media containing chloride
1.4501	X2CrNiMoCuWN25-7-4/ Zeron 100, Superduplex	S32760	0.030	1.00	1.00	24.00 26.00	3.00 4.00	6.00 8.00	N=0.20 0.30 Cu=0.50 1.00 W=0.50-1.00	≥ 515	—	730 930	7.8	Higher strength and corrosion resistance than 1.4462 at least in media containing chloride
1.4507	X2CrNiMoCuN25-6-3/ Superduplex	255/ S32550	0.030	0.70	2.00	24.00 26.00	3.00 4.00	6.00 8.00	N=0.20 0.30 Cu=1.00 2.50	≥ 475	—	690 940	7.8	Higher strength and corrosion resistance than 1.4462 at least in media containing chloride

No guarantee for correctness

Table 4.2.2_3: Stainless Steels (austenitic)

Material grade no.	Abbreviation/ designation usual to the market	AISI/ UNS	Chemical composition %							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.4301	X5CrNi18-10	304/ S30400	0.07	1.00	2.00	17.50 19.50	—	8.00 10.50	N ≤ 0.11	≥ 195	≥ 235	520 750	7.9	Pipelines of food and beverage industry, medical technology, chemical industry and to be used as heat resisting steel *
1.4306	X2CrNi19-11	304L/ S30403	0.030	1.00	2.00	18.00 20.00	—	10.00 12.00	N ≤ 0.11	≥ 185	≥ 225	500 670	7.9	Higher IC resistance than 1.4301, food and beverage industry, medical engineering, chemical and pharmaceutical industry *
1.4307	X2CrNi18-9	304L/ S30403	0.030	1.00	2.00	17.50 19.50	—	8.00 10.50	N ≤ 0.11	≥ 185	≥ 225	500 670	7.9	Higher IC resistance than 1.4301, food and beverage industry, medical engineering, chemical and pharmaceutical industry *
1.4541	X6CrNiTi18-10/ Alloy 321	321/ S32100	0.08	1.00	2.00	17.00 19.00	—	9.00 12.00	Ti=5×C up to 0.70	≥ 185	≥ 225	500 720	7.9	Chemical industry, waste water treatment, food and beverage industry, medical technology *
1.4550	X6CrNiNb18-10	347/ S34700	0.08	1.00	2.00	17.00 19.00	—	9.00 12.00	Nb=10×C up to 1.00	≥ 185	≥ 225	500 720	7.9	IC resistance by Nb additive up to 400 °C, applications in nuclear power plants *
1.4401	X5CrNiMo17-12-2	316/ S31600	0.07	1.00	2.00	16.50 18.50	2.00 2.50	10.00 13.00	N ≤ 0.11	≥ 205	≥ 245	520 680	8.0	Higher resistance to chlorides than stainless steels of type 304, chemical and textile industry, paper and pulp industry, transport of corrosive media containing chloride **
1.4404	X2CrNiMo17-12-2/ X2CrNiMo17-13-2	316L/ S31603	0.030	1.00	2.00	16.50 18.50	2.00 2.50	10.00 13.00	N ≤ 0.11	≥ 205	≥ 245	520 680	8.0	Higher resistance to chlorides than stainless steels of type 304, chemical and textile industry, paper and pulp industry, transport of corrosive media containing chloride **
1.4571	X6CrNiMoTi17-12-2	316Ti/ S31635	0.08	1.00	2.00	16.50 18.50	2.00 2.50	10.50 13.50	Ti=5×C up to 0.70	≥ 205	≥ 245	520 690	8.0	Chemical and petrochemical industries, textile, paper and pulp industries, waste water treatment **
1.4580	X6CrNi- MoNb17-12-2	316Cb/ S31640	0.08	1.00	2.00	16.50 18.50	2.00 2.50	10.50 13.50	Nb=10×C up to 1.00	≥ 220	≥ 260	520 720	8.0	Higher general corrosion resistance than group 1.4301 to 1.4450. Preferred in the chemical process equipment, waste water treatment plants, paper industry, at least in case of higher chloride contents **
1.4436	X3CrNiMo17-13-3/ X5CrNiMo17-13-3	316/ 316L/ S31600/ S31603	0.05	1.00	2.00	16.50 18.50	2.50 3.00	10.50 13.00	N ≤ 0.11	≥ 205	≥ 245	530 730	8.0	Higher resistance to chlorides than stainless steels of type 304, chemical and textile industry, paper and pulp industry, transport of corrosive media containing chloride
1.4435	X2CrNiMo18-14-3	316L/ S31603	0.030	1.00	2.00	17.00 19.00	2.50 3.00	12.50 15.00	N ≤ 0.11	≥ 205	≥ 215	520 700	8.0	Higher resistance to chlorides than stainless steels of type 304, chemical and textile industry, paper and pulp industry, transport of corrosive media containing chloride
1.4438	X2CrNiMo18-15-4	317L/ S31703	0.030	1.00	2.00	17.50 19.50	3.00 4.00	13.00 16.00	N ≤ 0.11	≥ 205	≥ 245	520 720	8.0	Textile industry, paper and pulp industry, nautical applications
1.4311	X2CrNiN18-10	304LN/ S30453	0.030	1.00	2.00	17.50 19.50	—	8.50 11.50	N= 0.12 0.22	≥ 255	≥ 295	550 750	7.9	Very high IC resistance up to 400 °C and higher strength than 1.4306
1.4406	X2CrNiMoN17-11-2	316LN/ S31653	0.030	1.00	2.00	16.50 18.50	2.00 2.50	10.00 12.50	N= 0.12 0.22	≥ 265	≥ 305	580 780	8.0	Higher resistance than group 1.4436 to 1.4438 in oxidising media, high stability of microstructure, high strength
1.4432	X2CrNiMo17-12-3	316/ 316L/ S31600/ S31603	0.03	1.00	2.00	16.50 18.50	2.50 3.00	10.50 13.00	N ≤ 0.11	≥ 205	≥ 245	520 700	8.0	Higher resistance to chlorides than stainless steels of type 304, chemical and textile industry, paper and pulp industry, transport of corrosive media containing chloride

* These grades are known as V2A steels

** These grades are known as V4A steels

Continuation →

4.2 MANUFACTURED MATERIALS

Materials
to be used in Practice

Table 4.2.2_3: Stainless Steels (austenitic) continuation

Material grade no.	Abbreviation / designation usual to the market	AISI/ UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.4429	X2CrNiMoN17-13-3	316LN/ S31653	0.030	1.00	1.00	16.50 18.50	2.50 3.00	11.00 14.00	N = 0.12 0.22	≥ 265	≥ 305	580 780	8.0	High resistance to non-oxidising acids and media containing chloride, e.g. sea water, hypochlorite solutions
1.4439	X2CrNiMoN17-13-5	317LMN/ S31726	0.030	1.00	2.00	16.50 18.50	4.00 5.00	12.50 14.50	N = 0.12 0.22	≥ 255	≥ 295	580 780	8.0	
1.4335	X1CrNi25-21	310L	0.020	0.25	2.00	24.00 26.00	≤ 0.20	20.00 22.00	N ≤ 0.11	≥ 200	≥ 240	470 670	7.9	High resistance to nitric acid
1.4465	X1CrNiMoN25-25-2	N08310	0.020	0.70	2.00	24.00 26.00	2.00 2.50	22.00 25.00	N = 0.08 0.16	≥ 260	≥ 295	540 740	8.0	Higher resistance to organic, non-oxidising acids, textile industry, coaltar industry
1.4577	X3CrNiMoTi25-25		0.04	0.50	2.00	24.00 26.00	2.00 2.50	24.00 26.00	Ti = 10 × C up to 0.6	≥ 205	≥ 245	490 740	8.0	
1.4505	X4NiCrMoCuNb20-18-2		0.05	1.00	2.00	16.50 18.50	2.00 2.50	19.00 21.00	Cu = 1.8 2.2 Nb+Ta ≥ 8 × C	≥ 225	≥ 265	490 740	8.0	Improved resistance to sulphuric and phosphoric acids, chemical industry
1.4586	X5NiCrMoCuNb22-18		0.07	0.25 0.45	0.70 1.00	17.00 18.00	3.00 4.00	22.00 23.00	Cu = 1.6 2.0 Nb ≥ 8 × C	≥ 275	—	540 740	8.0	
1.4565	X2CrNiMnMoN25-18-6-5/ Superaustenite	S34565	0.03	1.00	5.00 7.00	24.00 26.00	4.00 5.00	16.00 19.00	Nb+Ta ≤ 0.15 N = 0.30 0.60	≥ 420	≥ 460	800 950	8.0	High strength and very good local and general corrosion resistance, off-shore applications, flue gas desulphurisation plants
1.4529	X1NiCrMoCuN25-20-7/ 6% Moly	N08926	0.020	0.50	1.00	19.00 21.00	6.00 7.00	24.00 26.00	N = 0.15 0.25 Cu = 0.50 1.50	≥ 300	≥ 340	650 850	8.1	Very good stress, pitting, crevice and general corrosion resistance, chemical and petrochemical industries, off-shore applications, flue gas desulphurisation plants, fertilizers industry, paper and pulp industry
1.4539	X1NiCrMoCu25-20-5/ Alloy 904L	904L/ N08904	0.020	0.70	2.00	19.00 21.00	4.00 5.00	24.00 26.00	N ≤ 0.15 Cu = 1.20 2.00	≥ 205	≥ 245	520 730	8.0	Chemical industry, production of phosphoric acid and processes where sulphuric acid is added, paper and pulp industry, fertilizers industry, flue gas desulphurisation plants
1.4563	X1NiCrMoCu31-27-4/ Alloy 28	N08028	0.020	0.70	2.00	26.00 28.00	3.00 4.00	30.00 32.00	N ≤ 0.11 Cu = 0.70 1.50	≥ 220	≥ 260	500 700	8.0	Processes added by nitric acid and chlorides, flue gas desulphurisation plants, paper and pulp industry, fertilizers production
1.4562	X1NiCrMoCu32-28-7/ Alloy 31	N08031	0.015	0.30	2.00	26.00 28.00	6.00 7.00	30.00 32.00	Cu = 1.00 1.40 N = 0.15 0.25	≥ 280	≥ 310	650 850	8.0	Production of phosphoric acids, treatment of mid-concentrated sulphuric acid, naval and off-shore applications, pickling plants, waste water treatment, flue gas desulphurisation plants, sour gas applications
1.4361	X1CrNiSi18-15-4	S30600	0.015	3.70 4.50	2.00	16.50 18.50	≤ 0.20	14.00 16.00	N ≤ 0.11	≥ 220	≥ 260	530 730	7.7	Resistance to high-concentrated nitric acid (HOKO-Säure in German)
1.4558	X2NiCrAlTi32-20	N08880	0.030	0.70	1.00	20.00 23.00	—	32.00 35.00	Al = 0.15 0.45 Ti = 8 × (C+N) up to 0.6	≥ 180	≥ 210	450 700	8.0	Applications up to 550 °C
1.4547	X1CrNiMoCuN20-18-7/ 6% Moly	S31254	0.020	0.70	1.00	19.50 20.50	6.00 7.00	17.50 18.50	N = 0.18 0.25 Cu = 0.50 1.00	≥ 285	≥ 325	650 850	8.0	
1.4591	X1CrNiMoCuN33-32-1/ Alloy 33	R20033	0.015	0.50	2.00	31.00 35.00	0.50 2.00	30.00 33.00	Cu = 0.30 1.20 N = 0.35 0.60	≥ 380	≥ 420	720 920	7.9	Production and transport of concentrated sulphuric acid also at higher temperatures, sea and brack water plants, pickling plants, concentrated caustic soda at high temperatures

No guarantee for correctness

Table 4.2.2_4: Heat-Resisting Steels (ferritic)

Material grade go.	Abbreviation	AISI/UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.4713	X10CrAlSi7		0.12	0.50 1.00	1.00	6.00 8.00	—	—	Al= 0.50 1.00	≥ 220	—	420 620	7.7	Oxidising sulphuric gases
1.4724	X10CrAlSi13 / X10CrAl13	405 / S40500	0.12	0.70 1.40	1.00	12.00 14.00	—	—	Al= 0.70 1.20	≥ 250	—	450 650	7.7	Petrochemical plants

No guarantee for correctness

These steels are sensitive to coarse grain formation, but compared to austenitic steels they have a higher resistance to sulphuric gases.



III. 4.2.2_1: Prefabricated duplex pipes for the shipbuilding industry



III. 4.2.2_2: Waste gas end pieces for a chemical tanker ready for installation

4.2 MANUFACTURED MATERIALS

Materials
to be used in Practice

Table 4.2.2_5: Heat-Resisting Steels (austenitic)

Material grade no.	Abbreviation/ designation usual to the market	AISI/ UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.4835	X9CrNiSiNce21-11-2	S30815	0.05 0.12	1.40 2.50	1.00	20.00 22.00	—	10.00 12.00	N = 0.12 0.20 Ce = 0.03 0.08	≥ 310	≥ 350	650 850	7.8	
1.4878	X8CrNiTi18-10	321/ 321H/ S32100/ S32109	0.10	1.00	2.00	17.00 19.00	—	9.00 12.00	Ti = 5 × C up to 0.80	≥ 190	≥ 230	500 720	7.9	
1.4828	X15CrNiSi20-12	309/ S30900	0.20	1.50 2.00	2.00	19.00 21.00	—	11.00 13.00	N ≤ 0.11	≥ 230	≥ 270	550 750	7.9	For nitrogen containing gases with low oxygen content
1.4841	X15CrNiSi25-21/ X15CrNiSi25-20	310/ 314/ S31000/ S31400	0.20	1.50 2.50	2.00	24.00 26.00	—	19.00 22.00	N ≤ 0.11	≥ 230	≥ 270	550 750	7.9	
1.4845	X8CrNi25-21/ X12CrNi25-21	310S/ 310H/ S31008/ S31009	0.10	1.50	2.00	24.00 26.00	—	19.00 22.00	N ≤ 0.11	≥ 210	≥ 250	500 700	7.9	
1.4833	X12CrNi23-13/ X12CrNi23-12/ X7CrNi23-14	309S/ 309H/ S30908/ S30909	0.15	1.00	2.00	22.00 24.00	—	12.00 14.00	N ≤ 0.11	≥ 210	≥ 250	500 700	7.9	Similar to 1.4845, good weldability
1.4864	X12NiCrSi35-16	N08330	0.15	1.00 2.00	2.00	15.00 17.00	—	33.00 37.00	N ≤ 0.11	≥ 230	≥ 270	550 750	8.0	For nitrogen containing gases with low oxygen content, low carbon pick up
1.4876	X10NiCrAlTi32-21/ X10NiCrAlTi32-20/ Alloy 800	800/ N08800	0.12	1.00	2.00	19.00 23.00	—	30.00 34.00	Al = 0.15 0.60 Ti = 0.15 0.60	≥ 170	≥ 210	450 680	8.0	Application temperature up to 950 °C, resistant to oxidation, carburisation and oxidation, good creep rupture properties

No guarantee for correctness

Table 4.2.2_6: High Corrosion-Resisting Alloys

Material grade no.	Abbreviation/designation usual to the market	UNS	Chemical composition (%)							Mechanical and physical properties					Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	Condition	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
2.4816	NiCr15Fe/ Alloy 600	N06600	0.025 0.10	0.50	1.00	14.00 17.00	—	≥ 72.00	Fe = 6.00 10.00	solution annealed	≥ 180	≥ 210	≥ 500	8.5	High stress corrosion resistance in high temperature water, nuclear reactor building
									Al ≤ 0.30 Ti ≤ 0.30 Cu ≤ 0.50 Co	soft annealed					
2.4851	NiCr23Fe/ Alloy 601	N06601	0.10	0.50	1.00	21.00 25.00	—	58.00 63.00	Fe ≤ 18.00	solution annealed	≥ 205	≥ 235	≥ 550	8.2	Oxidation resistant up to 1,100 °C, good resistance to carburising conditions and in oxidising sulphur containing atmospheres
									Al = 1.00 1.70						
									Cu ≤ 0.50 B ≤ 0.006						
									Ti ≤ 0.50 Co						
2.4633	NiCr25FeAlY/ Alloy 33	N06025	0.15 0.25	0.50	0.50	24.00 26.00	—	rest	Al = 1.80 2.40	solution annealed	≥ 270	≥ 330	≥ 680	7.9	Oxidation resistant up to 1,200 °C also under cyclic strength, uncooled furnace rollers, pipelines in „metal-dusting“ imperilled plants
									Cu ≤ 0.10						
									Fe = 8.00 11.00						
									Ti = 0.10 0.20						
									Y = 0.05 0.12						
Zr = 0.01 0.10															
2.4858	NiCr21Mo/ Alloy 825	N08825	0.025	0.50	1.00	19.50 23.50	2.50 3.50	38.00 46.00	Al ≤ 0.20	soft annealed	≥ 240	≥ 270	≥ 550	8.1	Sulphuric acid containing plants, phosphoric acid production, sea water and sour gas applications
									Co ≤ 1.00						
									Cu = 1.50 3.00						
									Fe = rest Ti = 0.60 1.20						
2.4856	NiCr22Mo9Nb/ Alloy 625	N06625	0.03 0.10	0.50	0.50	20.00 23.00	8.00 10.00	≥ 58.00	Fe ≤ 5.00	solution annealed	≥ 275	≥ 305	≥ 690	8.4	Chemical and pharmaceutical industries, flue gas desulphurisation plants, off-shore and sour gas applications, high wear resistance with good mechanical values
									Al ≤ 0.40						
									Ti ≤ 0.40						
									Cu ≤ 0.50						
									Co ≤ 1.00						
Nb+Ta = 3.15 4.15															
2.4610	NiMo16Cr16Ti/ Alloy C4	N06455	0.015	0.08	1.00	14.00 18.00	14.00 17.00	rest	Co ≤ 2.00	solution annealed	≥ 280	≥ 315	≥ 690	8.6	Chemical and pharmaceutical industries, flue gas desulphurisation plants, off-shore and sour gas applications
									Cu ≤ 0.50						
									Fe ≤ 3.00						
									Ti ≤ 0.70						
2.4819	NiMo16Cr15W/ Alloy C276	N10276	0.010	0.08	1.00	14.50 16.50	15.00 17.00	rest	Co ≤ 2.50	solution annealed	≥ 280	≥ 300	≥ 690	8.9	Chemical and pharmaceutical industries, flue gas desulphurisation plants, off-shore and sour gas applications
									Cu ≤ 0.50						
									Fe = 4.00 7.00						
									V ≤ 0.35 W = 3.00 4.50						
2.4602	NiCr21Mo14W/ Alloy 22	N06022	0.010	0.08	0.50	20.00 22.50	12.50 14.50	rest	Co ≤ 2.50	solution annealed	≥ 310	≥ 335	≥ 690	8.7	Very high resistance to aggressive oxidising and reducing media, also at high temperatures
									Fe = 2.00 6.00						
									V ≤ 0.35						
									W = 2.50 3.50						
2.4605	NiCr23Mo16Al/ Alloy 59	N06059	0.010	0.10	0.50	22.00 24.00	15.00 16.50	rest	Al = 0.10 0.40	solution annealed	≥ 320	≥ 360	≥ 690	8.6	Highest pitting and crevice corrosion resistance, very good microstructural stability and weldability, pharmaceutical industry, polycarbonation, flue gas desulphurisation plants, pesticide production
									Co ≤ 0.30						
									Cu ≤ 0.50						
									Fe ≤ 1.50						

No guarantee for correctness

Continuation →

4.2 MANUFACTURED MATERIALS

Materials
to be used in Practice

Table 4.2.2_6: High Corrosion-Resisting Alloys (Continuation)

Material grade no.	Abbreviation/ designation usual to the market	UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)	
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	Condition	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)		Density (g/cm ³)
2.4600	NiMo29Cr/ Alloy B3/ Alloy B4	N10675	0.010	0.10	3.00	0.50 3.00	26.0 32.0	≥ 65.00	Al = 0.10 0.50 Co ≤ 3.00 Cu ≤ 0.50 Fe = 1.00 6.00 Nb+Ta ≤ 0.40 Ti ≤ 0.20 V ≤ 0.20 W ≤ 3.00	solution annealed	≥ 340	≥ 380	≥ 750	9.2	
2.4617	NiMo28/ Alloy B2	N10445	0.010	0.08	1.00	≤ 1.00	26.0 30.0	rest	Co ≤ 1.00 Cu ≤ 0.50 Fe ≤ 2.00	solution annealed	≥ 340	≥ 380	≥ 750	9.2	High resistance to HCl
CW352H (formerly: 2.0872)	CuNi10Fe1Mn/ Cunifer 10	C70600	0.05	—	0.50 1.00	—	—	9.00 11.00	Cu = rest Fe = 1.00 2.00 Pb ≤ 0.02 Zn ≤ 0.50	R300	≥ 100	—	≥ 300	8.9	High resistance to sea water
CW354H (formerly: 2.0882)	CuNi30Mn1Fe/ Cunifer 30	C71500	0.05	—	0.50 1.50	—	—	30.00 32.00	Cu = rest Fe = 0.40 1.00 Pb ≤ 0.02 Zn ≤ 0.50	R350	≥ 120	—	≥ 350	8.9	High resistance to sea water
2.4360	NiCu30Fe/ Monel 400/ Alloy 400	N04400	0.15	0.50	2.00	—	—	≥ 63	Al ≤ 0.50 Co ≤ 1.00 instead of Ni Cu = 28.00 34.00 Fe = 1.00 2.50 Ti ≤ 0.30	soft annealed	≥ 175	≥ 205	≥ 450	8.8	Corrosion resistant to sea water and chemical plants, stress corrosion resistant, feed water and steam raising unit pipes in power plants, sole heater and sole evaporators in salt works, sulphuric and hydrofluoric alkylation plants, splash pipes at off-shore platforms, piping for production facilities of perchlorethylene and other chloride synthetics
2.4068	LC-Ni99/ Alloy 201	N02201	0.02	0.25	0.35	—	—	99.00	Co ≤ 1.00 instead of Ni Cu ≤ 0.25 Fe ≤ 0.40 Mg ≤ 0.15 Ti ≤ 0.10	soft annealed	≥ 80	≥ 105	≥ 340	8.9	Lowered carbon content against 2.4066 with therefore higher IC resistance, excellent resistance to alkaline media
2.4066	Ni99.2/ Alloy 200	N02200	0.10	0.25	0.35	—	—	99.20	Co ≤ 1.00 instead of Ni Cu ≤ 0.25 Fe ≤ 0.40 Mg ≤ 0.15 Ti ≤ 0.10	soft annealed	≥ 100	≥ 125	≥ 370	8.9	Excellent resistance to alkaline media
2.4650	NiCo20Cr20MoTi/ Alloy C263	N07263	0.04 0.08	0.40	0.60	19.0 21.0	5.60 6.10	rest	Al = 0.30 0.60 B ≤ 0.005 Co = 19.0 21.0 Cu ≤ 0.20 Fe ≤ 0.70 Ti = 1.90 2.40	solution annealed and hardened	≥ 570	—	≥ 970	8.4	Ni-Cr-Co-Mo alloy with high permanent stability which can be hardened, excellent oxidation resistance up to 1,000 °C, good weldability, very good wear attitude

No guarantee for correctness

4.2 MANUFACTURED MATERIALS

Table 4.2.2_7: Creep Resisting Steels (austenitic)

Material grade no.	Abbreviation/ designation usual to the market	AISI/ UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2 % proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.4948	X6CrNi18-10 / X6CrNi18-11	304H/ S30409	0.04 0.08	1.00	2.00	17.00 19.00	—	8.00 11.00	N ≤ 0.11	≥ 190	≥ 230	490 740	7.9	Application also as heat resisting steel
1.4941	X6CrNiTiB18-10/ X8CrNiTi18-10	321H/ S32109	0.04 0.08	1.00	2.00	17.00 19.00	—	9.00 12.00	Ti = 5xC up to 0.80 B = 0.0015 0.0050	≥ 175	≥ 210	490 710	7.9	Application also as heat resisting steel
1.4910	X3CrNiMoBN17-13-3/ X3CrNiMoN17-13	316LN/ S31653	0.04	0.75	2.00	16.00 18.00	2.00 3.00	12.00 14.00	N = 0.10 0.18 B = 0.0015 0.0050	≥ 245	≥ 285	550 780	8.0	High creep rupture properties up to 700 °C
1.4961	X8CrNiNb16-13	347H/ S34709	0.04 0.10	0.30 0.60	1.50	15.00 17.00	—	12.00 14.00	Nb = 10xC up to 1.20	≥ 200	≥ 240	510 690	7.95	High creep rupture properties in welded condition
1.4958	X5NiCrAlTi31-20/ Alloy 800H	N8800	0.03 0.08	0.70	1.50	19.00 22.00	—	30.00 32.50	N ≤ 0.030 Cu ≤ 0.50 Nb ≤ 0.10 Ti = 0.20 0.50 Al = 0.20 0.50 Co ≤ 0.50	≥ 170	≥ 200	500 750	8.0	
1.4959	X8NiCrAlTi32-21/ Alloy 800HP	N08810 N08811	0.05 0.10	0.70	1.50	19.00 22.00	—	30.00 34.00	N ≤ 0.030 Ti = 0.25 0.65 Al = 0.25 0.65 Cu ≤ 0.50	≥ 170	≥ 200	500 750	8.0	

No guarantee for correctness

In case of high requirements to the creep rupture properties at high temperatures, also creep resisting nickel alloy pipes, as e.g. in material grade 2.4816, 2.4856 or 1.4876 can be delivered

Table 4.2.2_8: Non Magnetic Steels

Material grade no.	Abbreviation	AISI/ UNS	Chemical composition (%)							Mechanical and physical properties				Special qualifications and applications (following details are guidelines only)
			C ≤	Si ≤	Mn ≤	Cr	Mo	Ni	Other elements	0.2 % proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)	
1.3952	X2CrNiMoN18-14-3	316LN/ S31653	0.030	1.00	2.00	16.50 18.50	2.50 3.00	13.00 15.00	N = 0.15 0.25	≥ 280	—	580 800	7.95	Applications in submarine construction
1.3964	X2CrNiMnMoNNb21-16-5-3		0.030	1.00	4.00 6.00	20.00 21.50	3.00 3.50	15.00 17.00	N = 0.20 0.35 Nb ≤ 0.25	≥ 365	—	700 950	7.9	High-strength non-magnetic steel with sea water resistance, permeability prel < 1.005 *
1.3974	X2CrNiMnMoNNb23-17-6-3		0.030	1.00	4.50 6.50	21.00 24.50	2.80 3.40	15.50 18.00	N = 0.30 0.50 Nb = 0.10 0.30	≥ 460	—	800 1,050	7.9	High-strength non-magnetic steel with sea water resistance, permeability prel < 1.005 *

No guarantee for correctness

* These values can be exceeded slightly in fabricated condition

4.2 MANUFACTURED MATERIALS

Materials
to be used in Practice

Table 4.2.2_9: Aluminium and aluminium alloys

Numeric designation EN 573-1	Designation with chemical symbols EN 573-2	Chemical composition (%)							Mechanical and physical properties			
		Si	Fe	Cu	Mn	Mg	Cr	Other elements	Condi- tion	0.2% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)
EN AW-1080A (formerly: 3.0285)	EN AW-Al 99.8(A)	≤0.15	≤0.15	≤0.03	≤0.02	≤0.02	—	Zn ≤ 0.06 Ga ≤ 0.03 Ti ≤ 0.02	O/H111	≥15	60 90	2.70
EN AW-1050A (formerly: 3.0255)	EN AW-Al 99.5	≤0.25	≤0.40	≤0.05	≤0.05	≤0.05	—	Zn ≤ 0.07 Ti ≤ 0.05	O/H111	≥20	65 95	2.70
EN AW-5754 (formerly: 3.3535)	EN AW-Al Mg ₃	≤0.40	≤0.40	≤0.10	≤0.50	2.60 3.60	≤0.30	Zn ≤ 0.20 Ti ≤ 0.15	O/H111	≥80	190 240	2.66
EN AW-5049 (formerly: 3.3527)	EN AW-Al Mg ₂ Mn _{0.8}	≤0.40	≤0.50	≤0.10	0.50 1.10	1.60 2.50	≤0.30	Zn ≤ 0.20 Ti ≤ 0.10	O/H111	≥80	190 240	2.71
EN AW-5083 (formerly: 3.3547)	EN AW-Al Mg _{4.5} Mn _{0.7}	≤0.40	≤0.40	≤0.10	0.40 1.00	4.00 4.90	0.05 0.25	Zn ≤ 0.25 Ti ≤ 0.15	O/H111	≥125	275 350	2.66
EN AW-6060 (formerly: 3.3206)	EN AW-Al MgSi	0.30 0.60	0.10 0.30	≤0.10	≤0.10	0.35 0.60	≤0.05	Zn ≤ 0.15 Ti ≤ 0.10	T4	≥60	≥120	2.70
EN AW-6082 (formerly: 3.2315)	EN AW-Al Si ₁ MgMn	0.70 1.30	≤0.50	≤0.10	0.40 1.00	0.60 1.20	≤0.25	Zn ≤ 0.20	O	≤85	≤155	2.70

No guarantee for correctness

Table 4.2.2_10: Copper and copper-zinc alloys

Material grade no.	Abbreviation	UNS	Chemical composition (%)					Mechanical and physical properties		
			Cu	P	Zn	Al	Other elements	0.2% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)
CW008A (formerly: 2.0040)	Cu-OF (formerly: OF-Cu)	C10200	≥99.95	—	—	—	Pb ≤ 0.005 Bi ≤ 0.0005	—	≥200	8.9
CW021A (formerly: 2.0070)	Cu-HCP (formerly: SE-Cu)		≥99.95	0.002 0.007	—	—	Pb ≤ 0.005 Bi ≤ 0.0005	—	≥200	8.9
CW024A (formerly: 2.0090)	Cu-DHP (formerly: SF-Cu)	C12200	≥99.90	0.015 0.040	—	—	—	—	≥200	8.9
CW702R (formerly: 2.0460)	CuZn ₂₀ Al ₂ As (formerly: CuZn ₂₀ Al ₂)	C68700	76.0 79.0	≤0.01	rest	1.80 2.30	As = 0.02 0.06 Fe ≤ 0.07 Pb ≤ 0.05	≥90	≥330	8.4

No guarantee for correctness

Table 4.2.2_11: Titanium and titanium alloys

Material grade no.	Abbrevia- tion	ASTM / UNS	Chemical composition (%)					Mechanical and physical properties			
			Fe	O	Pd	Ni	Mo	0.2% proof strength (MPa)	1% proof strength (MPa)	Tensile strength (MPa)	Density (g/cm ³)
3.7025	Ti1	Grade 1 / R50250	≤0.15	≤0.12	—	—	—	≥180	≥200	290 410	4.5
3.7035	Ti2	Grade 2 / R50400	≤0.20	≤0.18	—	—	—	≥250	≥270	390 540	4.5
3.7235	Ti ₂ Pd	Grade 7 / R52400	≤0.20	≤0.18	0.15 0.25	—	—	≥250	≥270	390 540	4.5
3.7105	TiNi _{0.8} Mo _{0.3}	Grade 12 / R53400	≤0.25	≤0.25	—	0.60 0.90	0.20 0.40	≥345	≥370	≥480	4.7

No guarantee for correctness

4.2.3 Comparison of Standard Materials

In the absence of any more demanding requirements in terms of chemical and mechanical properties, molybdenum-free steels are used for cost reasons. In the German chemical industry and East Europe, the titanium-stabilised steel 1.4541 is preferred, while other industrialised countries use predominantly material TP 304L. There is practically no dif-

ference between these two materials, either in corrosion and processing behaviour or in terms of welding. Another material used, 1.4301 (TP 304) only meets these criteria to a limited extent. We have therefore recently added material 1.4307 to our production programme, a steel equivalent to TP 304L and comparable with 1.4541 in its corrosion-resist-

ing and mechanical properties. On the other hand, where more demanding requirements are placed on the mechanical and chemical properties of stainless steel products, the use of molybdenum containing or higher-strength materials is recommended. Our specialists will be happy to advise you on the choice of material.

Table 4.2.3_1: Comparison of Standard Materials

Material	Standard	Edition	Chemical elements							
			C (%) max.	Cr (%) min.	Cr (%) max.	Mo (%) min.	Mo (%) max.	Ni (%) min.	Ni (%) max.	N (%) max.
V2A										
1.4541	DIN 17441	Feb. 1997	0.08	17.00	19.00	—	—	9.00	12.00	—
	EN 10088-2	Aug. 1995	0.08	17.00	19.00	—	—	9.00	12.00	—
	DIN EN 10217-7	May 2005	0.08	17.00	19.00	—	—	9.00	12.00	—
1.4306	DIN 17441	Feb. 1997	0.03	18.00	20.00	0.00	2.00	10.00	12.00	0.11
	EN 10088-2	Aug. 1995	0.03	18.00	20.00	0.00	2.00	10.00	12.00	0.11
	DIN EN 10217-7	May 2005	0.03	18.00	20.00	—	—	10.00	12.50	—
1.4301	DIN 17441	Feb. 1997	0.07	17.00	19.50	—	—	8.00	10.50	—
	EN 10088-2	Aug. 1995	0.07	17.00	19.50	—	—	8.00	10.50	0.11
	DIN EN 10217-7	May 2005	0.07	17.00	19.50	—	—	8.00	10.50	—
1.4307	EN 10088-2	Aug. 1995	0.030	17.50	19.50	—	—	8.00	10.00	0.11
	DIN EN 10217-7	May 2005	0.030	17.50	19.50	—	—	8.00	10.00	0.11
TP 304	ASTM A240	2006	0.08	18.00	20.00	—	—	8.00	10.50	0.10
TP 304L	ASTM A240	2006	0.030	18.00	20.00	—	—	8.00	12.00	0.10
V4A										
1.4571	DIN 17441	Feb. 1997	0.08	16.50	18.50	2.00	2.50	10.50	13.50	—
	EN 10088-2	Aug. 1995	0.08	16.50	18.50	2.00	2.50	10.50	13.50	—
	DIN EN 10217-7	May 2005	0.08	16.50	18.50	2.00	2.50	10.50	13.50	—
1.4401	DIN 17441	Feb. 1997	0.07	16.50	18.50	2.00	2.50	10.00	13.00	—
	EN 10088-2	Aug. 1995	0.07	16.50	18.50	2.00	2.50	10.00	13.00	0.11
	DIN EN 10217-7	May 2005	0.07	16.50	18.50	2.00	2.50	10.50	13.00	—
1.4404	DIN 17441	Feb. 1997	0.030	16.50	18.50	2.00	2.50	10.00	13.00	—
	EN 10088-2	Aug. 1995	0.030	16.50	18.50	2.00	2.50	10.00	13.00	0.11
	DIN EN 10217-7	May 2005	0.030	16.50	18.50	2.00	2.50	10.00	13.00	—
TP 316	ASTM A240	2006	0.08	16.00	18.00	2.00	3.00	10.00	14.00	0.10
TP 316L	ASTM A240	2006	0.030	16.00	18.00	2.00	3.00	10.00	14.00	0.10