

STEEL GRADES

Other Material Data

The table below shows typical temperatures and temperature ranges of interest in connection with fabrication and application.

Quench annealing

Refers to recommended material temperature. Cooling shall be carried out rapidly in air or water to avoid undesirable precipitations. Steel used for pressure vessel fabrication does not normally require heat treatment after welding or cold forming less than 15% for austenitic and 10% for duplex grades. When quench annealing is necessary, the temperatures shown in the table are recommended.

Pressure vessel application

Refers to temperature ranges within which the steel can normally be used, provided that no corrosion problems are encountered. Specific pressure vessel standards may prescribe values for general approval.

Table 6: Other material data

STEEL GRADE		SCALING TEMPERATURE IN AIR C°	HOT FORMING C°	QUENCH ANNEALING COOLING IN AIR (A) OR WATER (W) C°	PRESSURE VESSEL APPLICATION C°
EN	ASTM				
1.4301	304	850	1150-900	1050 A/W	(-270) - 800
1.4307	304L	850	1150-900	1050 A/W	(-270) - 800
1.4311	304LN	850	1150-900	1050 A/W	(-270) - 800
1.4541	321	850	1150-900	1050 A/W	(-270) - 800
1.4401	316	850	1150-900	1070 A/W	(-160) - 750
1.4404	316LN	850	1150-900	1070 A/W	(-160) - 750
1.4406	316LN	850	1150-900	1070 A/W	(-270) - 750
1.4571	316Ti	850	1150-900	1070 A/W	(-160) - 750
1.4436	316	850	1150-900	1070 A/W	(-160) - 750
1.4432	316LN	850	1150-900	1070 A/W	(-160) - 750
1.4418	317L	850	1150-900	1100 A/W	(-60) - 500
1.4439	-	850	1150-900	1100 W	(-60) - 550
1.4539	904L	1000	1200-950	1120 W	(-60) - 400
1.4547	S31254	1000	1200-1000	1170 W	(-60) - 400
1.4652	S32654	1000	1200-1100	1170 W	(-60) - 400
1.4162	S32101	850	1100-900	1050 A/W	(-40) - 280
1.4362	S32304	1100	1100-950	1000 A/W	(-40) - 280
1.4462	S32205	1000	1150-950	1050 A/W	(-10) - 280
1.4410	S32750	1000	1120-1020	1070 A/W	(-10) - 280
1.4845	310S	1150	1150-900	1070 W	(-60) - 1000
1.4818	S30415	1050	1150-900	1070 A/W	600 - 850
1.4835	S30815	1150	1150-900	1070 A/W	800 - 1000
1.4854	S35315	1170	1150-900	1070 A/W	-

TABLE 4: Stength (elevated temperatures)

STEEL GRADE		PROOF STRESS AT ELEVATED TEMPERATURES					
EN	ASTM	R 0.2M MIN N/mm ²					
		50°C	100°C	200°C	300°C	400°C	500°C
1.4301	304	186	163	137	123	114	105
1.4307	304L	168	148	124	111	103	94
1.4311	304LN	228	198	160	138	125	117
1.4541	321	191	173	150	137	129	124
1.4401	316	196	175	148	133	124	117
1.4404	316L	187	164	137	123	114	105
1.4406	316LN	250	211	175	155	140	130
1.4571	316Ti	197	180	159	145	136	129
1.4436	316	196	175	148	133	124	117
1.4432	316L	187	164	137	123	114	105
1.4438	317L	196	172	144	129	119	110
1.4439	-	260	225	185	165	150	140
1.4539	904L	190	176	155	136	125	120
1.4547	S31254	270	235	195	175	160	150
1.4652	S32654	385	350	315	300	295	280
1.4162	S32101	430	380	330	300	-	-
1.4362	S32304	370	330	290	260	-	-
1.4462	S32205	415	360	310	280	-	-
1.441	S32750	-	470	420	380	-	-
1.4845	310S	186	163	137	123	114	105
1.4818	S30415	245	200	165	150	140	130
1.4835	S30815	280	230	185	170	160	150

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The tables for tensile strength at room temperature (Table 3) and strength at elevated temperatures (Table 4) give minimum values in accordance with Swedish and British standard. In cases where such a standard is lacking, values are based on Outokumpu's own test data.

The tensile properties pertain to transverse specimens and maximum plate thickness 30mm.




Design values stipulated in national standards apply to pressure vessel plate. The design values are based on the material's proof stress and/or tensile strength.

The strength properties of standard austenitic grades can be approved-

- by nitrogen addition; indicated by an N in the designation for standard grades
- by cold deformation (i.e. Cold stretching or rolling).

Table 3: Mechanical properties (room temperature)

EN	STEEL GRADE ASTM	TENSILE PROPERTIES-20°C				TYPICAL VALUES					
		$R_p 0.2$ N/mm ²	$R_p 1.0$ N/mm ²	R_m N/mm ²	A_5 %	HOT ROLLED PLATE THICKNESS 10-30MM			COLD ROLLED SHEET THICKNESS 2.5-5MM		
		MIN	MIN	MIN	MIN	$R_p 0.2$	R_m	HB	$R_p 0.2$	R_m	HB
1.4307	304L	190	220	480	45	280	590	170	310	600	170
1.4301	304	210	240	510	45	290	610	170	310	620	170
1.4311	304LN	270	300	550	40	340	660	190	360	670	190
1.4541	321	210	240	510	40	250	580	170	300	600	170
1.4401	316	220	250	510	45	280	590	160	320	620	170
1.4404	316L	210	240	490	45	290	600	170	330	620	170
1.4406	316LN	290	325	600	40	320	620	180	360	680	190
1.4571	316Ti	220	250	510	40	260	570	160	320	600	170
1.4436	316	220	50	510	45	300	610	170	340	640	170
1.4432	316L	210	240	490	45	280	580	160	320	600	160
1.4438	317L	220	250	490	40	290	600	170	320	610	160
1.4439	-	290	325	600	40	310	640	180	370	680	180
1.4539	904L	220	250	500	35	270	600	160	310	610	160
1.4547	S31254	300	340	650	35	340	700	180	360	720	180
1.4652	S32654	430	470	750	40	470	840	215	520	890	235
1.4162	S32101	450	-	650	30	480	700	230	600	840	230
1.4362	S32304	400	-	640	25	450	690	210	520	720	230
1.4462	S32205	480	-	680	25	510	760	240	290	810	260
1.4410	S32750	540	-	780	25	590	830	-	650	870	-
1.4845	310S	210	240	500	30	280	610	160	300	610	160
1.4818	S30415	290	325	600	40	330	650	190	360	660	200
1.4835	S30815	310	345	650	40	370	700	190	390	710	200
1.4854	S35315	270	310	650	40	300	670	-	350	710	-

	Austenitic		Duplex		Heat Resisting
R_p	=	Proof (Yield) Stress		1 N/mm ²	= 1 MPa
R_m	=	Tensile Strength			= 10 BAR
A_5	=	Elongation			= 145.04 psi

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Physical Properties

The table below gives typical values at room temperature.

Corrosion resistance

The corrosion resistance in different media is given in corrosion tables and isocorrosion charts (e.g. Avesta Corrosion Handbook for Stainless Steels, 1994).

Table 5: Physical properties (room temperature)

STEEL GRADE		MODULUS DENSITY g/cm ³	EXPANSION OF ELASTICITY kN.mm ²	LINEAR THERMAL 20-100°C x 10 ⁻⁶ /°C	HEAT CONDUCTIVITY W/m°C	ELECTRICAL CAPACITY J/Kg°C	RESISTIVITY nΩm
EN	ASTM						
1.4301	304	7.9	200	17	15	500	700
1.4307	304L	7.9	200	17	15	500	700
1.4311	304LN	7.9	200	17	15	500	700
1.4541	321	7.9	200	17	15	500	700
1.4401	316	8.0	200	16.5	13.5	500	750
1.4404	316L	8.0	200	16.5	13.5	500	750
1.4406	316LN	8.0	200	16.5	13.5	500	750
1.4571	316Ti	8.0	200	16.5	13.5	500	750
1.4436	316	8.0	200	16.5	13.5	500	750
1.4432	316L	8.0	200	16.5	13.5	500	750
1.4438	317L	8.0	200	16	13.5	500	750
1.4439	-	8.0	200	16	13.5	500	850
1.4539	904L	8.0	200	15	13	500	850
1.4547	S31254	8.0	200	15	13	500	850
1.4652	S32654	8.0	200	15	9	500	850
1.4162	S32101	7.8	200	13	15	500	750
1.4362	S32304	7.8	200	13	15	500	850
1.4462	S32205	7.8	200	13	15	500	850
1.4410	S32750	7.8	200	13	15	500	850
1.4845	310S	7.8	200	15.5	12	500	800
1.4818	S30415	7.8	200	16.5	15	500	850
1.4835	S30815	7.8	200	17	15	500	850
1.4854	S35315	8.0	200	15	12	450	1000

 Austenitic

 Duplex

 Heat Resisting

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Table 1: Chemical Composition - product range

Steel Grade			Chemical Composition, average %						Outokumpu products
EN	ASTM	OTK NAME	C	N	Cr	Ni	Mo	Others	
1.4016	430	4016	0.04	-	16.5	-	-	-	CNBR
1.4510	S43035	4510	0.04	-	18	-	-	Ti	CR
1.4021	420	4021	0.20	-	13	-	-	-	HNBR
1.4028	420	4028	0.30	-	12.5	-	-	-	NR
1.4418	-	248 SV	0.03	0.04	16	5	1	-	PBR
1.4162	S32101	LDX 2101	0.04	0.20	21	1.35	0.1	4Mn	On Request
1.4362	S32304	SAF 2304®	0.02	0.10	23	4.8	0.3	-	PHC
1.4462	S32205	2205	0.02	0.17	22	5.7	3.1	-	PHCNR
1.4501	S32760	4501	0.03	0.20	24	6	3	0.2W	P
1.4410	S32750	SAF 2507®	0.02	0.27	25	7	4	-	PC
1.4310	301				17	7	-	-	HCNBR
1.4318	301LN				17	7	-	-	HCNBR
1.4382	201				17	5	-	6.5Mn	HCNR
1.4301	304				18.1	8.3	-	-	PHCNBR
1.4307	304L				18.1	8.3	-	-	PHCNBR
1.4311	304LN				18.5	10.5	-	-	PHCNBR
1.4541	321				17.3	9.1	-	Ti	PHNBR
1.4305	303				17.3	8.2	-	S	BR
1.4306	304L				18.2	10.1	-	-	PHCNBR
1.4303	305				17.7	11.2	-	-	HCNBR
1.4568	S30430				17.7	9.7	-	3.3Cu	BR
1.4401	316				17.2	10.2	2.1	-	PHCNBR
1.4404	306L				17.2	10.1	2.1	-	PHCNBR
1.4406	306LN				17.2	10.3	2.1	-	PHCNBR
1.4571	316Ti				16.8	10.9	2.1	Ti	PHCNBR
1.4436	316				16.9	10.7	2.6	-	PHCNBR
1.4432	316L				16.9	10.7	2.6	-	PHCNBR
1.4435	316L				17.3	12.6	2.6	-	PHCNBR
1.4429	S31653				17.3	12.5	2.6	-	P
1.4438	317L				18.2	13.7	3.1	-	PHCNR
1.4439	317MN				17.8	12.7	4.1	-	PHC
1.4539	904L				20	25	4.3	1.5Cu	PHYCNBR
1.4547	S31254				20	18	6.1	Cu	PHCBNBR
1.4652	S32654				24	22	7.3	3.5Mn,Cu	On Request
1.4948	304H				18.1	8.3	-	-	PHCNR
1.4878	321H				17.3	9.1	-	Ti	PHCNBR
1.4818	S30415				18.5	9.5	-	1.3Si,Ce	PCNBR
1.4833	309S				22.3	12.6	-	-	PHCNBR
1.4828	-				20	12	-	2Si	CNBR
1.4835	S30815				21	11	-	1.6Si,Ce	PHCNBR
1.4845	310S				25	20	-	-	PHCNBR
1.4854	S35315				25	35	-	1.3Si,Ce	PC

Austenitic
Duplex

Ferritic
Heat Resisting

Martensitic



Outokumpu Products:

C = Cold rolled strip/sheet

P = Hot rolled plate (Quarto)

N = Cold rolled narrow strip

H = Hot rolled strip/sheet (CPP)

B = Bar

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Product Standards

As a rule production is carried out in accordance with common national product standards and the steel designations used in these standards. Production to other standards and specifications is carried out by special agreement.

Table 2: Steel designations

En	Steel Grade	OTK steel name	National steel designation superseded by EN			
	ASTM		BS	DIN	SS	NF
1.4162	S32101	LDX 2101	-	-	-	-
1.4362	S32304	SAF 2304	-	1.4362	2327	Z3 CN 23-04 Az
1.4462	S32205	2205	318S13	1.4462	2377	Z3 CND 25-05 Az
1.4410	S32750	SAF 2507	-	-	2328	Z3 CND 25-06 Az
1.4310	301	4310	301S21	1.4310	2331	Z11 CN 18-08
1.4372	201	4372	-	-	-	Z12 CMN 17-07 Az
1.4301	304	4301	304S31	1.4301	2333	Z7 CN 18-09
1.4307	304L	4307	304S11	-	2352	Z3 CN 18-10
1.4311	304LN	4311	304S61	1.4311	2371	Z3 CN 18-10 Az
1.4541	321	4541	321S31	1.4541	2337	Z6 CNT 18-10
1.4306	304L	4306	304S11	1.4306	2352	Z3 CN 18-10
1.4303	305	4303	305S19	1.4303	-	Z1 CN 18-12
1.4401	316	4401	316S31	1.4401	2347	Z7 CND 17-11-02
1.4404	316L	4404	316S11	1.4404	2348	Z3 CND 17-11-02
1.4406	316LN	4406	316S61	1.4406	-	Z3 CND 17-11 Az
1.4571	316Ti	4571	320S31	1.4571	2350	Z6 CNDT 17-12
1.4436	316	4436	316S33	1.4436	2343	Z7 CND 18-12-03
1.4432	316L	4432	316S13	-	2353	Z3 CND 17-12-03
1.4435	316L	4435	316S13	1.4435	2353	Z3 CND 18-14-03
1.4429	S31653	4429	316S63	1.4429	2375	Z3 CND 17-12 Az
1.4438	317L	4438	317S12	1.4438	2367	Z3 CND 19-15-04
1.4439	317LMN	4439	-	1.4439	-	Z3 CND 18-14-05 Az
1.4539	904L	904L	904S13	1.4539	2562	Z2 NCDU 25-20
1.4547	S31254	254 SMO	-	-	2387	-
1.4948	304H	4948	304S51	14948	2333	Z6 CN 18-09
1.4818	S30415	153 MA	-	-	2372	-
1.4828	-	4828	-	1.4828	-	Z17 CNS 20-12
1.4835	S30815	253 MA	-	-	2368	-
1.4854	S35315	353 MA	-	-	-	-