

Steel Grades, Properties and Global Standards

Outokumpu Stainless

Outokumpu is one of the world's leading stainless steel producers. The Group combines cost-efficient production with a global sales and distribution network and offers customers one of the broadest product ranges on the market.

Outokumpu Stainless focus is exclusively on stainless steel and the company strive for product development in close co-operation with customers.

The vision is to become "The undisputed number one in Stainless".

Technical support is provided by:

- Sales companies and production units
- Avesta Research Centre, Applications department
Tel: +46 (0)226 810 00; Fax: +46 (0)226 810 77
- Tornio Research Centre
Tel: +358 (0)16 4521; Fax: +358 (0)16 452 350
- www.outokumpu.com

Data

The data in this publication are from the latest EN and ASTM standards or drafts. They are complemented with Outokumpu typical values, generally for hot rolled plate, 10–20 mm, transverse direction and a standard test method.

Materials data for other products forms and fabricated conditions are available in separate brochures.

Stainless Steel Standards

National standards within Europe are now being superseded by EN, and the global stainless steel market will be based on EN, ASTM and JIS standards.

Outokumpu Stainless supports further harmonisation of data and document structures within ISO to improve quality and efficiency of technical communication and facilitate growth of the total stainless steel market.

Harmonised standards and new designations are gradually being implemented in our systems. This overview is a guideline. It will be updated continuously.

Information about standards is provided by:

- Avesta Research Centre, Applications department
Tel: +46 (0)226 810 00; Fax: +46 (0)226 810 77
- Tornio Works, Quality Control
Tel: +358 (0)16 45 25 70; Fax: +358 (0)16 45 23 50
- Outokumpu Plate Inc., New Castle, USA
Tel: +1 765 529 0120; Fax: +1 765 529 8177

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Stainless Steel Products from Outokumpu Stainless

Table 1

Product	Code	Production unit or subsidiary
Semi-finished products		Melting shops in Tornio, Sheffield, Avesta
Hot rolled plate (Quarto)	P	Degerfors, New Castle
Hot rolled strip/sheet (CPP)	H	Tornio Works, Avesta Works/Steckel and supplying units
Cold rolled strip/sheet	C	Tornio Works, Avesta Works, Coil Products Nyby, Coil Products Kloster
Cold rolled narrow strip	N	Sheffield Special Strip (Stocksbridge, Meadowhall)
Bar	B	Outokumpu Stainless Bar (Richburg)
Rod	R	Fagersta Stainless (Fagersta), Alloy Steel Rods (Sheffield)
Tube and pipe		Outokumpu Stainless Tubular Products (Fagersta, Torshälla, Storfors, Molkom, Sorsakoski, Jakobstad, Treorchy, Wildwood)
Fittings and flanges		Outokumpu Stainless Tubular Products (Örnsköldsvik, Molkom, Sorsakoski, Westerlo)
Manufactured products		Outokumpu Prefab (Avesta), Outokumpu Press Plate (Avesta), ÖMV (Örnsköldsvik),

Steel Grades, Chemical Composition, Products

Table 2

	International steel designation			Outokumpu steel name	Typical chemical composition, %						Products	
	EN	ASTM	JIS		C	N	Cr	Ni	Mo	Others		
WET CORROSION AND GENERAL SERVICE	Ferritic	1.4016	430	SUS 430	4016	0.04	–	16,5	–	–	–	N B R
	Mart.	1.4021	420	SUS 420J1	4021	0.20	–	13	–	–	–	H N B R
		1.4028	420	SUS 420J2	4028	0.30	–	12.5	–	–	–	N R
		1.4313	S41500	SUS Ti6NM	4313	0.05	–	13	4	0.5	–	P
	Duplex	1.4162	S32101	–	LDX 2101®	0.03	0.22	21.5	1.5	0.3	5Mn	P H C R
		1.4362	S32304	–	SAF 2304®	0.02	0.10	23	4.8	0.3	–	P H C R
		1.4462	S32205 ¹⁾	SUS 329J3L	2205	0.02	0.17	22	5.7	3.1	–	P H C N B R
		1.4501	S32760	–	4501	0.02	0.27	25	7	3.8	0.5W,Cu	P
		1.4410	S32750	–	SAF 2507®	0.02	0.27	25	7	4	–	P C
	Austenitic	1.4310	301	SUS 301	4310	0.10	–	17	7	–	–	H C N B R
		1.4318	301LN	SUS 301L	4318	0.02	0.14	17.7	6.5	–	–	H C
		1.4372	201	SUS 201	4372	0.05	0.15	17	5	–	6.5Mn	H C N R
		1.4301	304	SUS 304	4301	0.04	–	18.1	8.3	–	–	P H C N B R
		1.4307	304L	SUS 304L	4307	0.02	–	18.1	8.3	–	–	P H C N B R
		1.4311	304LN	SUS 304LN	4311	0.02	0.14	18.5	10.5	–	–	P H C N B R
		1.4541	321	SUS 321	4541	0.04	–	17.3	9.1	–	–	P H C N B R
		1.4550	347	SUS 347	4550	0.05	0.04	17.5	9.5	–	Nb	P R
		1.4305	303	SUS 303	4305	0.05	–	17.3	8.2	–	S	B R
		1.4303	305	SUS 305J1	4303	0.04	–	17.7	12.5	–	–	P H C N B R
		1.4306	304L	SUS 304L	4306	0.02	–	18.2	10.1	–	–	P H C N B R
		1.4567	S30430	SUS XM7	4567	0.01	–	17.7	9.7	–	3Cu	B R
		1.4401	316	SUS 316	4401	0.04	–	17.2	10.2	2.1	–	P H C N B R
		1.4404	316L	SUS 316L	4404	0.02	–	17.2	10.1	2.1	–	P H C N B R
		1.4436	316	SUS 316	4436	0.04	–	16.9	10.7	2.6	–	P H C N B R
		1.4432	316L	SUS 316L	4432	0.02	–	16.9	10.7	2.6	–	P H C N B R
		1.4406	316LN	SUS 316LN	4406	0.02	0.14	17.2	10.3	2.1	–	P H C N B R
		1.4429	S31653	SUS 316LN	4429	0.02	0.14	17.3	12.5	2.6	–	P C R
		1.4571	316Ti	SUS 316Ti	4571	0.04	–	16.8	10.9	2.1	Ti	P H C N B R
		1.4435 ²⁾	316L	SUS 316L	4435 ²⁾	0.02	–	17.3	12.6	2.6	–	P H C N B R
		1.4438	317L	SUS 317L	4438	0.02	–	18.2	13.7	3.1	–	P H C N B R
1.4439		317LMN	–	4439	0.02	0.14	17.8	12.7	4.1	–	P H C	
1.4466		S31050	–	725LN	0.02	0.13	25	22	2.2	–	P	
1.4539		904L	–	904L	0.01	–	20	25	4.3	1.5Cu	P H C N B R	
1.4529		N08926	–	4529	0.02	0.2	20	25	6.5	0.5Cu	P	
1.4547		S31254	–	254 SMO®	0.01	0.20	20	18	6.1	Cu	P H C N B R	
1.4565		S34565	–	4565	0.02	0.45	24	17	4.5	5.5Mn	P	
HEAT AND CREEP	Ferritic	1.4713	–	–	4713	0.12	–	7	–	–	0.5Al	P
		1.4724	–	–	4724	0.12	–	13	–	–	0.7Al	P
		1.4742	–	–	4742	0.12	–	18	–	–	0.7Al	P
		1.4762	S44600	–	4762	0.12	–	24	–	–	1.2Al	P
	Austenitic	1.4948	304H	SUS 304	4948	0.05	–	18.1	8.3	–	–	P H C B R
		1.4878 ³⁾	321	SUS 321	4878	0.05	–	17.3	9.1	–	Ti	P H C N B R
		1.4818	S30415	–	153MA™	0.05	0.15	18.5	9.5	–	1.3Si, Ce	P C N B R
		1.4833 ³⁾	309S ³⁾	SUS 309	4833	0.06	–	22.3	12.6	–	–	P H C N B R
		1.4828	–	SUH 309	4828	0.04	–	20	12	–	2Si	P H C N B R
		1.4835	S30815	–	253MA®	0.09	0.17	21	11	–	1.6Si, Ce	P H C N B R
		1.4845 ³⁾	310S ³⁾	SUS 310S	4845	0.05	–	25	20	–	–	P H C N B R
		1.4841	314	–	4841	0.02	–	25	20	–	–	P
		1.4854	S35315	–	353MA®	0.05	0.17	25	35	–	1.3Si, Ce	P

1) Also available as S31803

2) 724L is a modified version of 4435 for Urea applications

3) Additional creep resisting grades are: 1.4941, 1.4950, 1.4951

The grades listed represent the Outokumpu Stainless steel programme. Other grades are also available. The Outokumpu steel names are generic and cover corresponding steel numbers/names, which may not have the same chemical composition limits.

Multicertification is made on request to EN/ASTM/

ASME as well as to superseded national standards.

EN steel numbers are listed in: Stahl Eisen Liste – Ed 10, 1999. ASTM/ASME steel numbers are listed in: Metals & Alloys in the Unified Numbering System (UNS) – Ed. 9, 2001.

Traditional Steel Designations

Table 3

Outokumpu steel name	National designations, superseded by EN			
	BS/UK	DIN/Germany	NF/France	SS/Sweden
4016	430S17	1.4016	Z8 C17	2320
4021	420S29	1.4021	Z20 C13	2303
4028	420S45	1.4028	Z33 C13	2304
4313	–	1.4313	Z6 CN 13-04	2385
LDX 2101®	–	–	–	–
SAF 2304®	–	1.4362	Z3 CN 23-04 Az	2327
2205	318S13	1.4462	Z3 CND 22-05 Az	2377
4501	–	1.4501	–	–
SAF 2507®	–	–	Z3 CND 25-06 Az	2328
4310	301S21	1.4310	Z11 CN 18-08	2331
4318	–	–	Z3 CN 18-07 Az	–
4372	–	–	Z12 CMN 17-07 Az	–
4301*	304S31	1.4301	Z7 CN 18-09	2333
4307*	304S11	1.4307	Z3 CN 18-10	2352
4311*	304S61	1.4311	Z3 CN 18-10 Az	2371
4541	321S31	1.4541	Z6 CNT 18-10	2337
4550	347S31	1.4550	Z6 CNNb 18-10	2338
4305	303S31	1.4305	Z8 CNF 18-09	2346
4303	305S19	1.4303	Z1 CN 18-12	–
4306*	304S11	1.4306	Z3 CN 18-10	2352
4567	304S17	1.4567	Z3 CNU 18-09 FF	–
4401*	316S31	1.4401	Z7 CND 17-11-02	2347
4404*	316S11	1.4404	Z3 CND 17-11-02	2348
4436*	316S33	1.4436	Z7 CND 18-12-03	2343
4432*	316S13	1.4435	Z3 CND 18-14-03	2353
4406*	316S61	1.4406	Z3 CND 17-11 Az	–
4429*	316S63	1.4429	Z3 CND 17-12 Az	2375
4571	320S31	1.4571	Z6 CNDT 17-12	2350
4435*	316S13	1.4435	Z3 CND 18-14-03	2353
4438	317S12	1.4438	Z3 CND 19-15-04	2367
4439	–	1.4439	Z3 CND 18-14-05 Az	–
725LN	–	1.4466	Z2 CND 25-22 Az	–
904L	904S13	1.4539	Z2 NCDU 25-20	2562
4529	–	1.4529	–	–
254 SMO®	–	–	–	2378
4565	–	1.4565	–	–
4713	–	1.4713	–	–
4724	–	1.4724	Z13 C13	–
4742	–	1.4742	Z12 CAS18	–
4762	–	1.4762	Z12 CAS25	2322
4948	304S51	1.4948	Z6 CN 18-09	2333
4878	321S51	1.4878	Z6 CNT 18-10	2337
153MA™	–	–	–	2372
4833	309S16	1.4833	Z15 CN 24-13	–
4828	–	1.4828	Z17 CNS 20-12	–
253MA®	–	–	–	2368
4845	310S16	1.4845	Z8 CN 25-20	2361
4841	314S25	1.4841	Z15 CNS 25-20	–
353MA®	–	–	–	–

* Available in compositions optimised for forming operations.

PRODUCT CODES

P = Hot rolled plate (Quarto)
 H = Hot rolled strip/sheet (CPP)
 C = Cold rolled strip/sheet B = Bar
 N = Cold rolled narrow strip R = Rod

SAF 2304 and SAF 2507 are trademarks owned by SANDVIK AB.

Mechanical Properties, Room Temperature

Table 4

Outokumpu steel name		Outokumpu typical values				EN, min. values						ASTM, min. values				
		R _{p0.2} MPa	R _{p1.0} MPa	R _m MPa	A ₅ %	No.	R _{p0.2} MPa	R _{p1.0} MPa	R _m MPa	A ₅ %	KV J	No.	R _{p0.2} MPa	R _m MPa	A ₂ %	
4016	C	380		520	25	1.4016	260		450	20		S43000	205		450	22
4021 ¹⁾	P	500	580	650	20	1.4021	450		650	12		S42010				
4028	P					1.4028	600		800	10		S42000		690		15
4313 ²⁾	P	700	770	850	20	1.4313	650		780	14	70	S41500	620	795		15
LDX 2101®	P	480		700	38	1.4162	450	490	650	30	60	S32101	450	650		30
SAF 2304®	P	450		670	40	1.4362	400		630	25	60	S32304	400	600		25
2205	P	510		750	35	1.4462	460		640	25	60	S32205	450	655		25
4501	P	507		805	35	1.4501	530		730	25	60	S32760	550	750		25
SAF 2507®	P	590		830	35	1.4410	530		730	20	60	S32750	550	795		15
4310	C	300	330	800	50	1.4310	250	280	600	40		S30100	205	515		40
4318	C	360	395	765	47	1.4318	350	380	650	40	60	S30153	240	550		45
4372	C	390	420	720	45	1.4372	330	370	750	40	60	S20100	310	655		40
4301	P	290	330	600	55	1.4301	210	250	520	45	60	S30400	205	515		40
4307	P	280	320	580	55	1.4307	200	240	500	45	60	S30403	170	485		40
4311	P	320	360	640	55	1.4311	270	310	550	40	60	S30453	205	515		40
4550	P	260	290	595	45	1.4550	200	240	500	40	60	S34700	205	515		40
4305	P	275	–	585	35	1.4305	190	230	500	35		S30300	205	515		40
4541	P	250	290	570	55	1.4541	200	240	500	40	60	S32100	205	515		40
4303	N	250	280	570	50	1.4303	220	250	500	45		S30500	205	515		40
4306	P	280	320	580	55	1.4306	200	240	500	45	60	S30403	170	485		40
4567	B					1.4567	175	–	450	45		S30430				
4401	P	280	320	570	55	1.4401	220	260	520	45	60	S31600	205	515		40
4404	P	280	320	570	55	1.4404	220	260	520	45	60	S31603	170	485		40
4436	P	300	340	590	50	1.4436	220	260	530	40	60	S31600	205	515		40
4432	P	280	320	570	50	1.4432	220	260	520	45	60	S31603	170	485		40
4406	P	320	360	620	50	1.4406	280	320	580	40	60	S31653	205	515		40
4429	P	350	390	670	45	1.4429	280	320	580	40	60	S31653	205	515		40
4571	P	270	310	570	50	1.4571	220	260	520	40	60	S31635	205	515		40
4435	P	270	310	570	55	1.4435	220	260	520	45	60	S31603	170	485		40
4438	P	300	340	610	50	1.4438	220	260	520	40	60	S31703	205	515		40
4439	P	310	350	640	50	1.4439	270	310	580	40	60	S31726	240	550		40
725LN	P	290	320	630	55	1.4466	250	290	540	40	60	S31050	270	580		25
904L	P	260	300	600	50	1.4539	220	260	520	35	60	N08904	220	490		35
4529	P	360	430	750	55	1.4529	300	340	650	40	60	N08926	295	650		35
254 SMO®	P	340	380	680	50	1.4547	300	340	650	40	60	S31254	310	655		35
4565	P	440	480	825	55	1.4565	420	460	800	30	90	S34565	415	795		35
4713	P	320	350	475	30	1.4713	220	–	420	20		–				
4724	P	340	370	515	30	1.4724	250	–	450	15		–				
4742	P	375	405	535	25	1.4742	270	–	500	15		–				
4762	P	405	440	555	30	1.4762	280	–	520	15		S44600	275	515		20
4948	P	290	330	600	55	1.4948	190	230	510	45	60	S30409	205	515		40
4878	P	250	290	570	55	1.4878	190	230	500	40		S32109	205	515		40
153 MA™	P	340	380	660	55	1.4818	290	330	600	40		S30415	290	600		40
4833	P	300	340	620	50	1.4833	210	250	500	35		S30908	205	515		40
4828	C	270	310	610	55	1.4828	230	270	550	30		S30900	205	515		40
253 MA®	P	370	410	700	50	1.4835	310	350	650	40		S30815	310	600		40
4845	P	270	310	600	50	1.4845	210	250	500	35		S31008	205	515		40
4841	P	275	315	595	55	1.4841	230	270	550	30		S31400	205	515		40
353 MA®	H	360	400	720	50	1.4854	300	340	650	40		S35315	270	650		40

1) annealed condition 2) quenched and tempered condition

Outokumpu Stainless' typical values apply for the product listed. Cold and hot rolled strip values are generally higher than plate and bar.

EN/ASTM values: Mainly for hot rolled plate, transverse direction, from EN 10088, EN 10095, EN 10028-7, ASTM A240, A176 and ASME Code Cases. Also values from EN 10269 and ASTM A473.

EN min. values for cold rolled strip are 10 – 20 MPa higher. Hot rolled strip may on request be certified to the higher level.

Conversion from EN to ASTM, ASME:

$$1 \text{ MPa} = 0.1450 \text{ ksi} \qquad 1 \text{ J} = 0.7376 \text{ ft}\cdot\text{lb}$$

$$^{\circ}\text{C} = 5/9 \times (^{\circ}\text{F} - 32) \qquad ^{\circ}\text{F} = 9/5 \text{ }^{\circ}\text{C} + 32$$

Mechanical Properties, High Temperatures

Table 5

Outokumpu steel name	EN – min. R _{p0.2} MPa					Max. design stress for pressure equipment σ, MPa									
						EN				ASME VIII-1					
	No.	RT	100	200	400°C	RT	100	200	400°C	No.	RT	100	200	400°C	
4016	1.4016	260	220	210	190						S43000	128	126	120	108
4021	1.4021	450	420	400	365						S42010				
4028	1.4028	600									S42000				
4313	1.4313	650	590	560	530						S41500				
LDX 2101®	1.4162	450	380	330			253				S32101 ¹⁾		198		
SAF 2304®	1.4362	400	330	280		263	220	187			S32304	172	164	150	
2205	1.4462	460	360	315		267	240	210			S31803	187	176	165	
4501	1.4501	530	450	400							S32760				
SAF 2507®	1.4410	530	450	400		304	300	267			S32750	228	226	208	
4310	1.4310	250	210	190							S30100				
4318	1.4318	350	265	185		217	177	153			S30153				
4372	1.4372	350	295	230							S20100				
4301	1.4301	210	157	127	98	173	150	131	104		S30400	138	137	127	107
4307	1.4307	200	147	118	89	167	137	120			S30403	115	115	109	92
4311	1.4311	270	205	157	125	183	163	143			S30453	138	137	127	107
4541	1.4541	200	176	157	125	167	147	130	125		S32100	138	137	129	119
4550	1.4550	200	176	157	125						S34700				
4303	1.4303	220	155	127	98						S30500	138	137	127	107
4306	1.4306	200	147	118	89	167	137	120			S30403	115	115	109	92
4401	1.4401	220	177	147	115	173	150	133			S31600	138	138	133	111
4404	1.4404	220	166	137	108	173	143	130	113		S31603	115	115	109	91
4436	1.4436	220	177	147	115	177	153	140			S31600	138	138	133	111
4432	1.4432	220	166	137	108	173	143	130	113		S31603	115	115	109	91
4406	1.4406	280	211	167	135	193	173	153			S31653	138	138	131	105
4429	1.4429	280	211	167	135	193	173	153			S31653	138	138	131	104
4571	1.4571	220	185	167	135	173	147	131	125		S31635	138	138	131	105
4435	1.4435	220	165	137	108	173	140	127			S31603	115	115	109	91
4438	1.4438	220	172	147	115	173	143	130			S31703	138	138	131	109
4439	1.4439	270	225	185	150	193	173	153			S31726	157	157	155	
725LN	1.4466	250	195	160	135						S31050				
904L	1.4539	220	205	175	125	173	157	137			N08904	140	114	95	
4529	1.4529	300	230	190	160	217	183	173			N08926				
254 SMO®	1.4547	300	230	190	160	217	205	187	158		S31254	185	184	168	156
4565	1.4565	420	350	270	210						S34565				
Steel name	EN R _{p1.0} /10 000h, MPa					EN R _m /100 000h, MPa				ASME max. design stress σ, MPa					
No.	600	700	800	900°C		600	700	800	900°C	No.	600	700	800	900°C	
4948	1.4948 ²⁾					89	28				S30409 ²⁾	64	27	11	
4878	1.4878	85	30	10		65	22	10	–	S32109 ²⁾	59	23	9		
153 MA™	1.4818	126	42	15	5	88	35	14	5	S30415					
4833	1.4833	70	25	10	5	65	16	7,5	3	S30909 ²⁾	49	16	6		
4828	1.4828	80	25	10	4	65	16	7,5	3	S30900					
253 MA®	1.4835	126	45	19	10	88	35	15	8	S30815 ²⁾	59	22	10	5	
4845	1.4845	90	30	10	4	80	18	7	3	S31009 ²⁾	49	16	6		
4841	1.4841	95	35	10	4	80	18	7	3	S31400					
353 MA®	1.4854	88	34	15	8	80	36	18	9,2	S35315					

- 1) Values according to code case no: 2418
- 2) Creep resisting grades for pressure purposes listed in EN 10028-7 and ASME IID.

EN/ASME values: For hot rolled plate from EN 10028-7, EN 10088, EN 10095, ASME IID and Code Cases.

Outokumpu Stainless offers multi-certification of the grades 4307/4301 and 4404/4401.

Max allowed values of the nominal design stress		
Steel type	EN 13445	ASME VIII
Ferritic, Mart. Duplex	$\min\left[\frac{R_{p0.2T}}{1,5}; \frac{R_{mRT}}{2,4}\right]$	$\min\left[\frac{R_{p0.2RT}}{1,5}; \frac{R_{mRT}}{3,5}\right]$ or $\min\left[\frac{R_{p0.2T}}{1,5}; \frac{R_{mT}}{3,5}\right]$ m
Austenitic A>30%	R _{p1.0T}	$\min\left[\frac{R_{p0.2RT}}{1,5}; \frac{R_{mRT}}{3,5}\right]$ or $\min\left[\frac{R_{p0.2T}}{1,5}; \frac{R_{mT}}{3,5}\right]$
Austenitic A>35%	$\min\left[\frac{R_{p1.0T}}{1,2}; \frac{R_{mT}}{3,0}\right]$ or	$\min\left[\frac{R_{p0.2RT}}{1,5}; \frac{R_{mRT}}{3,5}\right]$ or $\min\left[\frac{R_{p0.2T}}{1,1}; \frac{R_{mT}}{3,5}\right]$

Mechanical Properties, Low Temperatures

Table 6

Outokumpu steel name	EN min. values, MPa and %												
	-196°C					-80°C				RT			
	No.	R _{p0.2}	R _{p1.0}	R _m	A ₅	R _{p0.2}	R _{p1.0}	R _m	A ₅	R _{p0.2}	R _{p1.0}	R _m	A ₅
4307	1.4307	300	400	1200	30	220	290	830	35	200	240	500	45
4301	1.4301	300	400	1250	30	270	350	860	35	210	250	520	45
4311	1.4311	550	650	1250	35	350	420	850	40	270	310	550	40
4541	1.4541	200	240	1200	30	200	240	855	35	200	240	500	40

From EN 10028-7 Annex F.

Common Design Codes for Stainless Steel

Table 7

EN 13445	Unfired pressure vessels
EN 13480	Metallic industrial piping
EN 13458-2C	Cryogenic vessels. Annex C Pressure strengthening of vessels from austenitic stainless steel
EN 12285-C	Tanks for underground storage. Annex C Positive liquid-list of material/liquid combinations
ADR	International carriage of dangerous goods by road (Accord européen... Dangereuses par Route)
RID	International carriage of dangerous goods by rail (Règlement... International... Dangereuses)
IMDG	International Maritime Dangerous Goods code
UN ST/SG/AC.10/1	Recommendations on the transport of dangerous goods (United Nations)
ENV 1993-1.4	Eurocode 3: Design of steel structures – Supplementary rules for stainless steel
ENV 1090-6	Execution of steel structures – Supplementary rules for stainless steel
ASME VIII-1	American boiler and pressure vessel code
AD 2000	Arbeitsgemeinschaft Druckbehälter Regelwerk
CODAP	Code Français de construction des Appareils à Pression
BS 5500	Unfired fusion welded pressure vessels

Microstructures

Austenite

Good to excellent corrosion resistance combined with very good weldability and formability characterize the austenitic stainless steels. The austenitic structure has good creep resistance and good oxidations resistance that makes them useful in elevated temperatures. Austenitic steel can also be used in cryogenic applications and is in annealed condition the only non-magnetic steel.

Martensite

These stainless steels are characterized by high strength and high wear resistance. The corrosion resistance is limited and the weldability degrades with increasing strength, i.e. increasing carbon content.

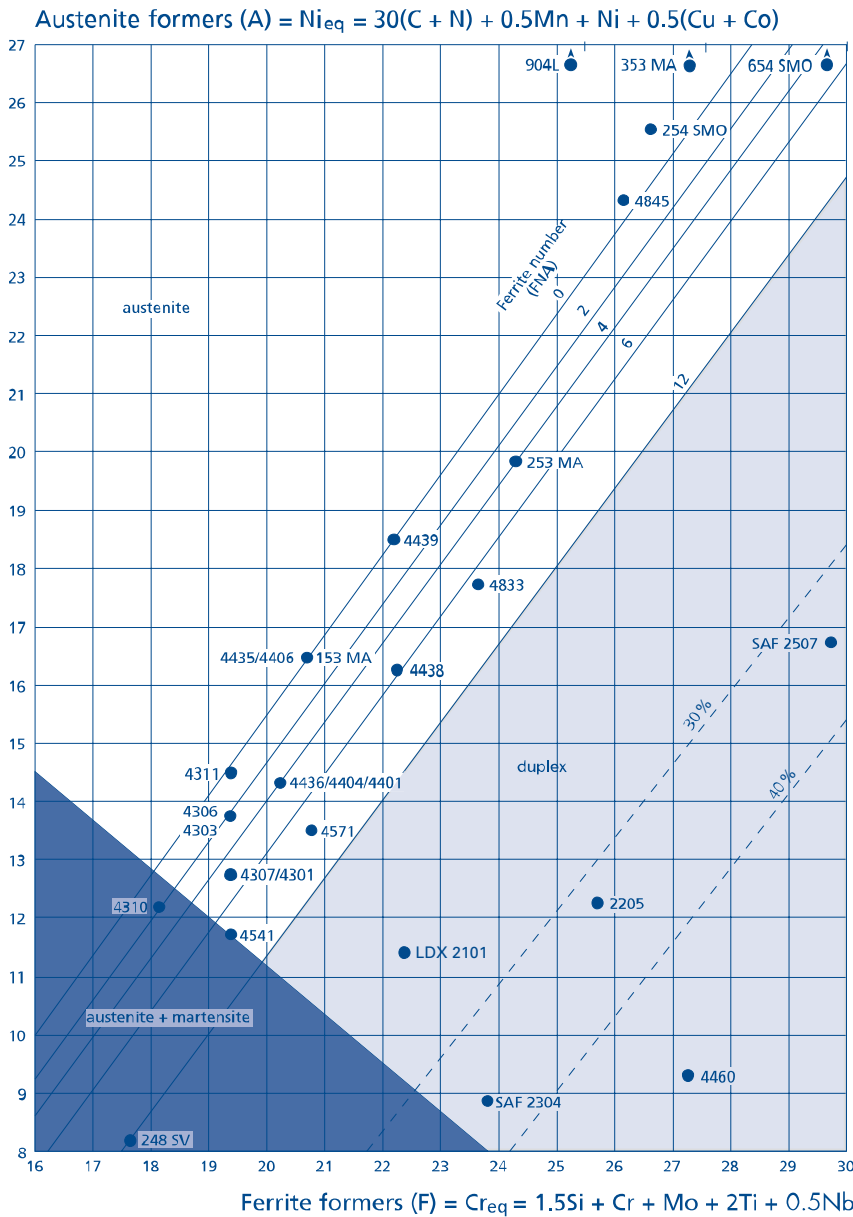
Ferrite

Ferritic stainless steels have good corrosion resistance, especially towards stress corrosion cracking. Lower carbon and nitrogen contents improve both weldability and toughness which otherwise can be limited.

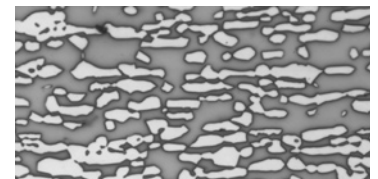
Duplex (Austenite-ferrite)

Duplex stainless steels have high strength, good toughness and very good corrosion resistance, especially towards stress corrosion cracking and corrosion fatigue. These steels have also good weldability and reasonable formability.

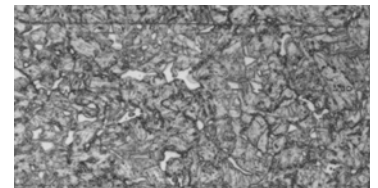
Schaeffler Diagram and Microstructures



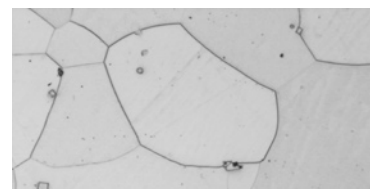
Austenite (γ -iron). Face centered cubic with 12 atom neighbours. 74% close packing.



Duplex. (Austenitic-ferrite). Wellbalanced two-phase structure with ferrite content between 30-50%.



Martensite. Undercooled, oversaturated solution of carbon in ferrite, achieved by heat treatment or cold working.



Ferrite (α -iron). Body centered cubic with 8 atom neighbours. 68% packing.

The Schaeffler diagram (from ASME III-1) is traditionally used to predict delta ferrite content in weld metal from chemical composition. It may also be used to characterise stainless steel microstructures (ferritic, martensitic, austenitic), and to compare the structural balance in similar grades or casts with the same processing history.

Cr and Ni equivalents are slightly modified above, in line with Outokumpu Stainless' standard, and the resulting ferrite number is designated FNA. The following empirical formulas have been derived from the diagram:

$$\begin{aligned} \text{FNA} &= 3.34F - 2.46A - 28.6 \text{ for FNA} = \text{max. } 5.9 \\ &= 4.44F - 3.39A - 38.4 \text{ for FNA} = 6.0 - 11.9 \\ &= 4.06F - 3.23A - 32.2 \text{ for FNA} = \text{min. } 12 \end{aligned}$$

The Schaeffler diagram has been revised (WRC-1992 diagram by Kotecki, Sievert). Outokumpu Stainless has complemented with SM, Solidification Mode. Grades may be considered fully austenitic for SM below -2, where:

$$\text{SMAF/A} = F - 1.3A - 2.0$$

$$\text{with } F = Cr + Mo + 2Ti + 0.7Nb$$

$$A = 35C + 20N + Ni + 0.25Cu$$

The martensite balance is traditionally determined from the Md30 formula (Angel, Nohara), predicting the temperature ($^{\circ}C$), at which 30% deformation gives 50% martensite. Outokumpu Stainless designates this number MNA. Grades may be considered unstable austenitic for MNA above 0, where:

$$\text{MNA} = 551 - 462(C + N) - 9.2Si - 8.1Mn - 13.7Cr - 29(Ni + Cu) - 18.5Mo - 68Nb$$

Physical Properties

Table 8

Outokumpu steel name	EN	Density, ρ kg/dm ³ RT	Modulus of elasticity, E GPa		Thermal expansion, α x 10 ⁻⁶ /°C, (RT →T)		Thermal conductivity, λ W/m°C		Thermal capacity, c J/kg°C RT	Electrical resistivity, ρ μΩm RT	Magnet-izable RT
			RT	400°C	100°C	400°C	RT	400°C			
Non alloy steel	1.0345	7.8	210	175	12.0	14.0	55	44	460	0.18	Y
4016	1.4016	7.7	220	195	10.0	10.5	25	25	460	0.60	Y
4021	1.4021	7.7	215	190	10.5	12.0	30	25	460	0.55	Y
4028	1.4028	7.7	215	190	10.5	12.0	30	25	460	0.65	Y
LDX 2101®	1.4162	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
SAF 2304®	1.4362	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
2205	1.4462	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
4501	1.4501	7.7	200	172	13.0	14.5	15	20	500	0.80	Y
SAF 2507®	1.4410	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
4310	1.4310	7.9	200	172	16.0	18.0	15	20	500	0.73	N
4318	1.4318	7.9	200	172	16.0	17.5	15	20	500	0.73	N
4372	1.4372	7.8	200	172	16.0	17.5	15	20	500	0.70	N
4301	1.4301	7.9	200	172	16.0	17.5	15	20	500	0.73	N
4307	1.4307	7.9	200	172	16.0	18.0	15	20	500	0.73	N
4311	1.4311	7.9	200	172	16.0	17.5	15	20	500	0.73	N*
4541	1.4541	7.9	200	172	16.0	17.5	15	20	500	0.73	N
4550	1.4550										N
4305	1.4305	7.9	200	172	16.0	17.5	15	20	500	0.73	N
4303	1.4303	7.9	200	172	16.0	17.5	15	20	500	0.73	N*
4306	1.4306	7.9	200	172	16.0	17.5	15	20	500	0.73	N
4567	1.4567	7.9	200	172	16.7	18.1					N
4401	1.4401	8.0	200	172	16.0	17.5	15	20	500	0.75	N
4404	1.4404	8.0	200	172	16.0	17.5	15	20	500	0.75	N
4436	1.4436	8.0	200	172	16.0	17.5	15	20	500	0.75	N
4432	1.4432	8.0	200	172	16.0	17.5	15	20	500	0.75	N
4406	1.4406	8.0	200	172	16.0	17.5	15	20	500	0.75	N*
4429	1.4429	8.0	200	172	16.0	17.5	14	20	500	0.85	N
4571	1.4571	8.0	200	172	16.5	18.5	15	20	500	0.75	N
4435	1.4435	8.0	200	172	16.0	17.5	15	20	500	0.75	N
4438	1.4438	8.0	200	172	16.0	17.5	14	20	500	0.85	N
4439	1.4439	8.0	200	172	16.0	17.5	14	20	500	0.85	N
725LN	1.4466	8.0	200	170	15.5	17.0	12	17	440	0.75	N
904L	1.4539	8.0	195	166	15.8	16.9	12	18	450	1.00	N
4529	1.4529	8.1	195	166	15.8	16.9	12	18	450	1.00	N
254 SMO®	1.4547	8.0	195	166	16.5	18.0	14	18	500	0.85	N
4565	1.4565	8.0	190	165	14.5	16.8	12	18	450	0.92	N
			500°C	1000°C	500°C	1000°C	500°C	1000°C	500°C		
4948	1.4948	7.9	158	120	18.4	20.0	21.9	28.8	530	0.71	N
4878	1.4878	7.9	158		18.4	20.5	21.6	27.5	530	0.74	N
153 MA™	1.4818	7.8	163	120	18.2	19.5	21.2	29.0	580	0.84	N
4833	1.4833	7.9	158	120	18.4	20.0	20.5	27.5	530	0.78	N
4828	1.4828	7.9	158	120	18.4	20.0	20.5	27.5	530	0.87	N
253 MA®	1.4835	7.8	163	120	18.2	19.5	21.2	29.0	580	0.84	N
4845	1.4845	7.9	158	120	18.4	20.0	19.8	27.1	530	0.96	N
4841	1.4841	7.8	158	120	18.8	20.0		27.8	530	0.96	N
353 MA®	1.4854	7.9	160	130	16.6	18.2	18.5	26.0	580	1.00	N

Magnetizable: Y = Magnetizable ferritic, martensitic, duplex grades, N = Non-magnetizable austenitic grades with a typical magnetic permeability μ = 1.05 – 1.2.

Small amounts of ferrite or martensite from composition or cold deformation will increase the magnetizability.

Data from EN 10088

* Grades suitable for low permeability requirements, i.e., μ = max. 1.005.

Conversion from EN to ASTM, ASME:

1 kg/dm³ = 0.361 lb/in³

1 GPa = 0.145 x 10⁶ psi

1x10⁻⁶/°C = 0.556 in/in °F

1 W/m °C = 0.578 Btu/h ft °F

1 J/kg °C = 0.000239 Btu/lb °F

Non alloy steel are added for comparison in Table 8 and Table 9.

Fabrication and Use Characteristics

Table 9

Outokumpu steel name	EN	Fabrication				Use		
		Heat treatment temperature ¹⁾ °C	Welding consumables ²⁾	Forming ³⁾ n/A ^{hom}	Machining index ⁴⁾	Pressure purpose ⁵⁾	IGC resistance ⁶⁾	CPT ⁷⁾ °C
Non alloy steel	1.0345	N 920 ± 30	P5	0.2/20		EN ASME		
4016	1.4016	A 800 ± 30	308L/MVR or 309L	0.2/20		ASME	A Y/-	< 5
4021	1.4021	T 740 ± 40	739 S					< 5
4028	1.4028	T 690 ± 40	739 S					< 5
LDX 2101®	1.4162	A 1050 ± 30	LDX 2101		130/140	ASME	A Y/Y	15
SAF 2304®	1.4362	A 1000 ± 50	2304	0.4/20	75/100	EN ASME	A Y/Y	15
2205	1.4462	A 1060 ± 40	2205	0.4/20	55/85	EN ASME	C Y/Y	50
4501	1.4501	A 1080 ± 40	2507/P100					90
SAF 2507®	1.4410	A 1080 ± 40	2507/P100	0.4/20	45/80	EN ASME	C Y/Y	90
4310	1.4310	A 1050 ± 40	308L/MVR	0.8/35			A N/-	< 5
4318	1.4318	A 1060 ± 40	308L/MVR	0.8/35		EN	A Y/Y	< 5
4372	1.4372	A 1050 ± 50	307 or 309L	0.8/35			A Y/-	< 5
4301	1.4301	A 1050 ± 50	308L/MVR	0.6/40	105/105	EN ASME	A Y/-*	< 5
4307	1.4307	A 1050 ± 50	308L/MVR	0.6/40	105/105	EN ASME	A Y/Y	< 5
4311	1.4311	A 1050 ± 50	308L/MVR	0.6/40	80/70	EN ASME	A Y/Y	< 5
4541	1.4541	A 1050 ± 50	308L/MVR	0.6/40	100/105	EN ASME	A Y/Y	< 5
4550	1.4550	A 1070 ± 50	347/MVNB				A Y/Y	
4305	1.4305	A 1050 ± 50	308L/MVR	0.6/40			A N/-	< 5
4303	1.4303	A 1050 ± 50	308L/MVR	0.6/40	105/105	ASME	A Y/-*	< 5
4306	1.4306	A 1050 ± 50	308L/MVR	0.6/40	105/105	EN ASME	A Y/Y	< 5
4567	1.4567	A 1050 ± 50	308L/MVR	0.6/40				< 5
4401	1.4401	A 1070 ± 40	316L/SKR	0.6/35	100/100	EN ASME	A Y/-*	15
4404	1.4404	A 1070 ± 40	316L/SKR	0.6/35	100/100	EN ASME	A Y/Y	15
4436	1.4436	A 1070 ± 40	316L/SKR	0.6/35	100/100	EN ASME	A Y/-*	25
4432	1.4432	A 1070 ± 40	316L/SKR	0.6/35	100/100	EN ASME	A Y/Y	25
4406	1.4406	A 1070 ± 40	316L/SKR	0.6/35	75/70	EN ASME	A Y/Y	20
4429	1.4429	A 1070 ± 40	316L/SKR	0.6/35	100/100	EN ASME	A Y/Y	25
4571	1.4571	A 1070 ± 40	316L/SKR	0.6/35	95/105	EN ASME	A Y/Y	10
4435	1.4435	A 1070 ± 40	316L/SKR	0.6/35	100/100	EN ASME	A Y/Y	25
4438	1.4438	A 1110 ± 40	317L/SNR	0.6/35	90/100	EN ASME	C Y/Y	35
4439	1.4439	A 1100 ± 40	904L	0.6/35	70/70	EN ASME	C Y/Y	50
904L	1.4539	A 1100 ± 40	904L or P12	0.6/30	75/95	EN ASME	C Y/Y	60
4529	1.4529	A 1150 ± 30	P12	0.6/30		EN	C Y/Y	90
254 SMO®	1.4547	A 1180 ± 30	P12 or P16	0.6/30	45/70	EN ASME	C Y/Y	90
4565	1.4565	A 1145 ± 25	P16	0.6/30			C Y/Y	> 90
								Scaling temp.⁸⁾ °C
4948	1.4948	A 1080 ± 30	308/308H	0.6/40	105/105	EN ASME	A Y/-	850
4878	1.4878	A 1070 ± 50	347/MVNB	0.6/40	100/105	ASME	A Y/Y	850
153 MATM	1.4818	A 1070 ± 50	253 MA	0.6/40	70/70		A Y/-	1050
4833	1.4833	A 1100 ± 50	309	0.6/35	95/105	ASME	A Y/-	1000
4828	1.4828	A 1100 ± 50	253 MA	0.6/35	95/105		A Y/-	1000
253 MA®	1.4835	A 1070 ± 50	253 MA	0.6/35	70/70	ASME	A Y/-	1150
4845	1.4845	A 1100 ± 50	310	0.6/35	95/105	ASME	A Y/-	1050
4841	1.4841	A 1100 ± 50						1150
353 MA®	1.4854	A 1125 ± 25	353 MA	0.6/35	65/65		A Y/-	1170

1) Heat treatment temperature: A = Annealing. T = Tempering from EN 10088-2, EN 10095 (N = Normalising).

2) Welding consumables: Avesta Welding designations.

3) Cold forming characteristics: Strain-hardening exponent (n) and homogeneous elongation (A^{hom}) in tension test.

4) Machining index: From Outokumpu Machining Guidelines, for carbide tools/high speed steel tools in relation to 4436. PRODEC[®] steel conditions have some 30% higher machining index.

5) Pressure purpose grades: From EN 10028-7, ASME IID and ASME Code Cases.

6) Intergranular corrosion (IGC) resistance: From EN 10088. Tested in highly acidic solution according to ISO 3651-2 Method A, B or C with Y = Yes and N = No for delivery/sensitised conditions.

7) Critical Pitting Temperature (CPT): From potentiostatic testing with the Avesta Cell method in 1M NaCl (ASTM G150). Other test conditions (ASTM G48 etc.) will give other CPT values. Pitting Resistance Equivalent PRE = Cr + 3.3Mo + 16N.

8) Scaling temperature in air (°C): Measured according to MFK 710 (Weight increase at 45 h oxidation test with 5 cycles RT-HT).

* = May be multi-certified as Y/Y.

Ordering and Classification Principles

Table 10

Ordering concepts	Classification principles	Typical codes
MATERIAL STANDARD	Stainless steel: Iron major element. Cr min. 10.5% – Corrosion resisting grades – Heat and creep resisting grades, for use over 550°C	EN 10088-2, EN 10028-7 EN 10095, EN 10302, EN 10028-7
Additional specification	– Customer specification – Technical approval of new material – Multi-certification of other global standard – Multi-certification of withdrawn national standard	VdTÜV WB418 ASTM A240, JIS G4304 DIN 17440, BS 1501-3, SS 2333-28
STEEL GRADE	– Ferritic – Martensitic – Precipitation hardening – Duplex – Austenitic – Multi-certification of two grades	Example, 1.4404+1.4401 (316L+316)
Special steel condition	Outokumpu Stainless optimised fabrication properties	See table 11 below
PRODUCT	– Flat products – Long products – Tube, pipe – Forgings – Castings – Articles	P/Hot rolled plate (Quarto), H/Hot rolled strip/sheet (CPP), C/Cold rolled strip/sheet (KBR, Sendzimir), N/Cold rolled narrow strip S/Semi-finished products, B/Bar, R/Rod T/Welded and seamless tubes Welding consumables, fittings, fasteners...
Product condition	EN 10088 codes for process route/surface finish	See table 11 below
Dimensions Special tolerances	Thickness x width x length EN codes for special tolerance classes	8 x 2000 x 5000 B (pressure purpose) C, D in EN 10029, S in EN 10259, F, P in EN 10258
CERTIFICATE	EN 10204 codes for inspection documents: – Manufacturers' inspection – Notified body inspection or third party inspection	3.1 3.2
QUALIFICATION	Some orders may require approval of the manufacturer: – Production system for pressure purpose materials – Quality system – Customer list of approved suppliers	AD 2000 W0, EN 13445 ISO 9001:2000
MATERIAL DECLARATIONS	– Material Safety Data Sheet – Declarations for certain branches, orders and products: Building, food, water piping etc.	Info no 1005 Avesta Research Centre

Steel and Product Conditions

Table 11

Outokumpu Stainless Special Steel Conditions		EN Product Conditions	
LIC	for improved steel cleanliness	1D	Hot rolled, heat treated, pickled
PRODEC®	for improved machinability	1G	Hot rolled, ground
HyClad®	for a decorative surface	1Q	Hot rolled, quenched and tempered, pickled
HyClean®	for improved cleaning properties	2H	Work hardened
HyDraw®	for improved deepdrawing	2E	Cold rolled, heat treated, mech. desc. pickl.
HyStretch®	for improved stretchforming	2D	Cold rolled, heat treated, pickled
HyTens®	for improved mechanical properties	2B	Cold rolled, heat treated, pickled, skin passed
		2F	Cold rolled, heat treated, pickled, skin passed on roughened rolls
CCS®	for improved mechanical properties	2R	Cold rolled, bright annealed
VKS®	for improved thickness tolerances	2G	Ground
		2J	Brushed or dull polished
		2K	Satin polished
		2M	Patterned
		2W	Profile rolled
		2L	Coloured

Multicertification is made on request to EN/ASTM/ASME as well as to superseded national standards

**Stainless Steel Material Standards –
Basic EN and ASTM Documents**

Table 12

Stainless steel – referenced standards for flat products (chemical compositions, product tolerances, typical properties)

EN 10029	Hot rolled steel plates. Tolerances
EN 10051	Hot rolled steel strip. Tolerances
EN 10088-1	Stainless steels. – List of stainless steels
EN 10258	Cold rolled stainless steel narrow strip. Tolerances
EN 10259	Cold rolled stainless steel wide strip. Tolerances
ASTM A480	General requirements for flat-rolled stainless and heat resisting steel (+ASME SA480)
ASTM A959	Harmonized standard grade compositions for wrought stainless
ASME IID	Materials – Physical properties tables

Flat (and long) products

EN 10028-7	Flat products for pressure purposes. – Stainless steels
EN 10088-2	Stainless steels. – Sheet/plate and strip for general purposes
EN 10095	Heat resisting steels and nickel alloys
EN 10151	Stainless steel strip for springs
EN 10302	Creep resisting steels, nickel and cobalt alloys
ASTM A167	Stainless and heat-resisting Cr-Ni steel plate, sheet and strip
ASTM A176	Stainless and heat-resisting Cr steel plate, sheet and strip
ASTM A240	Heat-resisting Cr and Cr-Ni stainless steel plate, sheet and strip for pressure vessels (+ASME SA240)
ASTM A666	Austenitic stainless steel sheet, strip, plate, bar for structural and architectural applications (+ASME SA666)
ASME IIA	Materials. Part A – Ferrous Material Specifications

Long products

EN 10058	Hot rolled flat steel bars. Tolerances
EN 10060	Hot rolled round steel bars. Tolerances
EN 10088-3	Stainless steels. – Semi-finished products, bars, rods, sections for general purposes
EN 10263-5	Steel rod, bars and wire for cold heading and extrusion. – Stainless steel
EN 10270-3	Steel wire for springs. – Stainless steels
EN 10269	Steels and nickel alloys for fasteners with specified properties at elevated or low temperatures
EN 10272	Stainless steel bars for pressure purposes
ASTM A193	Alloy and stainless steel bolting material for high-temperature service
ASTM A276	Stainless and heat-resisting steel bars and shapes
ASTM A479	Stainless steel bars for boilers/pressure vessels (+ASME SA479)
ASTM A484	General requirements for stainless and heat-resisting steel bars, billets, forgings (+ASME SA484)
ASTM A493	Stainless and heat-resisting steel rod and wire for cold heading and forming
ASTM A555	General requirements for stainless and heat resistant steel wire and wire rod
ASTM A580	Stainless and heat-resisting steel wire

Tube and Pipe

EN 10217-7	Welded steel tubes for pressure purposes. – Stainless steels
EN 10296-2	Welded steel tubes for construction purposes. – Stainless steels
ASTM A249	Welded austenitic steel boiler, superheater, heat exchanger and condenser tubes
ASTM A269	Seamless and welded austenitic stainless steel tubing for general service
ASTM A270	Seamless and welded austenitic stainless steel sanitary tubing
ASTM A312	Seamless and welded austenitic stainless steel pipe
ASTM A358	Electric fusion-welded austenitic CrNi alloy steel pipe for high temperature
ASTM A789	Seamless and welded duplex stainless steel tubing for general service
ASTM A790	Seamless and welded duplex stainless steel pipe
ASTM A928	Duplex stainless steel pipe welded with addition of filler metal

12 Steel Grades, Properties and Global Standards

Product Properties and Test Methods

Table 13

Property	Test methods		Reported result	
Delivery testing at RT				
0.2% Proof strength	R _{p0.2} MPa	EN 10002-1 ASTM A370, E8	283	
1.0% Proof strength	R _{p1.0} MPa	EN 10002-1 –	321	
Tensile strength	R _m MPa	EN 10002-1 ASTM A370, E8	578	
Elongation ¹⁾	A %	EN 10002-1 ASTM A370, E8	54	
Impact energy ²⁾	KV J	EN 10045-1 ASTM A370, E23	162, 164, 167 = 164	
Hardness ³⁾	HRB	EN 10109-1 ASTM A370, E18	82	
	HRC	EN 10109-1 ASTM A370, E18	32/14	
	HB	EN 10003-1 ASTM A370, E10	160	
	HV	ISO 6507-1 ASTM E92	160	
Microstructure characterisation				
Grain size ⁴⁾	d mm	ISO 643 ASTM E112	70	
Ferrite	F _m %	MFS 211 –	3.5	
	F _a % area	MFS 241 for duplex	38	
Inclusions ⁵⁾	IC type A – D	ISO 4967 ASTM E45, E1122	A0 B1.5 C1.0 D1.5	
Carbides	GBC index 0 – 4	MFS 311 for carbides	Approved (max. 1)	
Intermetallic phases	GBP index A – D	MFS 316 for high-alloy	Approved (max. B)	
	IM mm/mm ²	MFS 315 for high-alloy	Approved (max. 0.6)	
	IM mm/mm ²	MFS 315 for duplex	Approved (max. 0.0)	
	IM-A index 1 – 4	MFS 342 for duplex	Approved (max. 1)	
	IM-B J at –40°C	–	Approved (min. 54)	
IM-C mmd at 25°C	–	ASTM A923	Approved (max. 10)	
IGC resistance	Strauss	4301/4401	ISO 3651-2 ASTM A262	Approved
	Strauss	> 20Cr/Mo	ISO 3651-2 ASTM A262	Approved
	“Streicher”	for high-alloy	ISO 3651-2 ASTM A262	Approved
	Huey g/m ² h	for urea	ISO 3651-1 ASTM A262	0.37
Mechanical properties at HT, LT				
Tensile strength at HT	R _{p0.2} R _{p1.0} R _m	max. 600°C	EN 10002-5 ASTM E21	
Tensile strength at LT	R _{p0.2} R _{p1.0} R _m	min. –196°C	EN 10002-5	
Derivation of yield strengths for HT			EN 10314	

Test methods: MFS = Outokumpu Stainless internal test method.
 Reported result: Format of the test result which is dependent on specified requirements.

- ¹⁾ Elongation is converted according to ISO 2566-2.
- ²⁾ Impact energy with 10x10 mm test pieces: 1 KV (J) = 1.25 KCV (J/cm²).
- ³⁾ Hardness is converted according to ASTM E140.
- ⁴⁾ Conversion from ASTM No. to EN according to ASTM E112:
 5 = 64 m; 6 = 45 m; 7 = 32 m; 8 = 23 m; 9 = 16 m.
- ⁵⁾ Type A = ductile, B = brittle, C = brittle/ductile, D = undeformed.
 Assessment and conversion according to SS 111116.

Common Acronyms and Abbreviations

Table 14

ASTM	American Society for Testing and Materials	JIS	Japanese Industrial Standard	CPP	Continuously Produced Plate
ASME	American Society of Mechanical Engineers	NF	Norme Française	KBR [®]	Cold rolled 2 m wide stainless
BS	British Standard	SS	Svensk Standard	VKS [®]	Hot rolled with cold pass
DIN	Deutsches Institut für Normung	TÜV	Technischer Überwachungs-Verein	CCS [®]	Continuously Cold Stretched
EN	Europäische Norm	RT	Room Temperature	PRODEC [®]	PRODUCTION ECONOMY in machining
ISO	International Organization for Standardization	HT	High (elevated) Temperatures	LIC	Low Inclusion Content
		LT	Low (cryogenic) Temperatures		

Outokumpu is an international stainless steel and technology company. Our vision is to be the undisputed number one in stainless, with success based on operational excellence. Customers in a wide range of industries use our metal products, technologies and services worldwide. We are dedicated to helping our costumers gain competitive advantage.

Outokumpu Stainless AB, Avesta Research Centre
 Box 74, SE-774 22 Avesta, Sweden
 Tel. +46 (0)226 810 00, Fax +46 (0)226 810 77

www.outokumpu.com