outokumpu
stainless steel & high performance alloys

Steel Grades, Properties and Global Standards

Outokumpu

Outokumpu is the world's leading stainless steel producer. 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's focus is exclusively on stainless steel and high performance alloys and the company strive for product development in close cooperation with customers. Because we believe in a world that lasts forever.

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 products from Outokumpu Table 1

Product	Code
Hot rolled plate Quarto	P
Hot rolled coil and sheet	H
Cold rolled coil and sheet	C
Bar	B
Rod coil	R
Semi-finished (bloom, billet, ingot, slab)	S
Pipe	T
DUPROF™, High strength profiles	D
Manufactured products	

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National standards within Europe are now being superseded by EN, and the global stainless steel market will be based on EN, ASTM and JIS standards.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

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Steel grades, chemical composition and products

Table 2

Outokumpu steel name	International steel designation				Typical chemical composition, %						Products
	EN	ASTM	UNS	JIS	C	N	Cr	Ni	Mo	Others	
FERRITIC GRADES											
4600	1.4600	–	–	–	0.02		11.2	0.85		Ti	H S
4512	1.4512	409	–	SUS409	0.02		11.5	0.2		Ti	H C S
4003	1.4003	–	S40977	–	0.02		11.5	0.5			P H C S
4000	1.4000	410S	S41008	SUS 403	0.03		12.5				P H C S
4589	1.4589	–	S42035	–	0.045		14	1.65	0.25	Ti	H C S
4016	1.4016	430	S43000	SUS 430	0.05		16.2				H C B R S
4511	1.4511	–	–	–	0.02		16.2			Nb	H C S
4520	1.4520	–	–	–	0.02		16.2			Ti	H C S
4510	1.4510	439	S43035	SUS 430LX	0.02		17			Ti	H C S
4509	1.4509	–	S43940	–	0.02		18			Ti Nb	H C S
4607	1.4607[1]	–	–	–	0.02		19			Ti Nb	H C S
4113	1.4113	434	S43400	–	0.045		16.5		1		H C S
4513	1.4513	–	S43600	–	0.02		17		1	Ti	H C S
4521	1.4521	444	S44400	SUS 444	0.02		18		2	Ti Nb	P H C S
MARTENSITIC AND PRECIPITATION HARDENING GRADES											
4006	1.4006	410	S41000	SUS 410	0.12		12				P H C B R S
4005	1.4005	416	S41600	SUS 416	0.10		13			S	B R S
4021	1.4021	420	S42000	SUS 420J1	0.20		13				P H C B R S
4031	1.4031	420	S42000	–	0.38		13.5				H C S
4034	1.4034	420	S42000	–	0.45		13.7				H C S
4028	1.4028	420	S42000	SUS 420J2	0.30		12.5				H C B S
4313	1.4313	–	S41500	SUS Ti6NM	0.03		12.5	4.1	0.6		P S
4542	1.4542	630	S17400[3]	SUS 630	0.02		15.5	4.8		3.4Cu Nb	B R S
4116	1.4116	–	–	–	0.5		14.4		0.55	V	H C S
4110	1.4110	–	–	–	0.5		14.8		0.63		H C S
4568	1.4568	631	S17700	SUS 631	0.08		17	7		1Al	R S
4122	1.4122	–	–	–	0.41		16.1		1		H C S
4574	1.4574	632	S15700	–	0.08		14.5	7.5	2.2	1.1Al	C S
FERRITIC HIGH TEMPERATURE GRADES											
4713	1.4713	–	–	–	0.06		6.5			0.8Si 0.8Al	P H C S
4724	1.4724	–	–	–	0.07		12.5			1Si 0.9Al	P H C S
4736	1.4736	–	–	–	0.02		17.5			1.8Al Ti	H C S
4742	1.4742	–	–	–	0.07		17.5			1Si 1A	P H C S
4762	1.4762	–	–	–	0.08		23.5			1Si 1.5Al	P H C S
AUSTENITIC HIGH TEMPERATURE GRADES											
4948	1.4948	304H	S30409	SUS 304	0.05		18.1	8.3			P H C B R S T
4878	1.4878[2]	321H	–	SUS 321	0.05		17.3	9.1		Ti	P H C B R S T
153 MA™	1.4818	–	S30415	–	0.05	0.15	18.5	9.5		1.3Si Ce	P C R S T
4833	1.4833[2]	309S[2]	S30908	SUS 309	0.06		22.3	12.6			P H C B R S T
4828	1.4828	–	–	SUH 309	0.04		20	12		2Si	P H C B S
253 MA®	1.4835	–	S30815	–	0.09	0.17	21	11		1.6Si Ce	P H C B R S T
4845	1.4845[2]	310S[2]	S31008	SUS 310S	0.05		25	20			P H C B R S T
4841	1.4841	314	S31400	–	0.07		24.5	19.5		2Si	P H C B R S

[1]designation according to Stahl Eisen Liste (register of European Steels). [2]additional creep resisting grades are: 1.4941, 1.4950, 1.4951. [3]also available as S15500.

153 MA™ and 253 MA® are trademarks owned by Outokumpu.

The grades listed in Tables 2-5 represent the Outokumpu 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 available on request to EN/ASTM/ASME as well as to superseded national standards.

EN steel numbers are listed in: Stahl Eisen Liste. ASTM/ASME steel numbers are listed in: Metals & Alloys in the Unified Numbering System (UNS). ISO steel designation listed in ISO 15510.

Steel grade designations according to different standards

Table 3

Outokumpu steel name	ISO	National designations superseded by EN						
		BS/UK	DIN/Germany	NF/France	SS/Sweden	GB/PR China	KS/Korea	GOST/Russia
FERRITIC GRADES								
4600	–	–	1.4600	–	–	–	–	–
4512	–	409S 19	1.4512	Z3 CT12	–	–	–	–
4003	4003-410-77-I	–	1.4003	–	–	–	–	–
4000	4000-410-08-I	403S17	1.4000	Z8 C12	2301	–	–	08X13
4589	4589-429-70-E	–	1.4589	–	–	–	–	–
4016	4016-430-00-I	430S17	1.4016	Z8 C17	2320	1Cr17	STS 430	12X17
4511	4511-430-71-I	–	1.4511	Z4 CNb17	–	–	–	–
4520	4520-430-70-I	–	1.4520	–	–	–	–	–
4510	4510-430-35-I	–	–	–	–	–	–	–
4509	4509-439-40-X	–	1.4509	Z3 CT Nb 18	–	–	–	–
4607	–	–	1.4607	–	–	–	–	–
4113	4113-434-00-I	434S 17	1.4113	–	–	–	–	–
4513	4513-436-00-J	–	1.4513	–	–	–	–	–
4521	4521-444-00-I	–	1.4521	Z3 CDT 18-02	2326	–	–	–
MARTENSITIC AND PRECIPITATION HARDENING GRADES								
4006	4006-410-00-I	410S21	1.4006	Z10 C13	2302	1Cr12	STS 410	12X13
4005	4005-416-00-I	416S21	1.4005	Z11 CF13	2380	Y1Cr13	STS 416	–
4021	4021-420-00-I	420S29	1.4021	Z20 C13	2303	2Cr13	STS 420J1	20X13
4031	4031-420-00-I	420S45	1.4031	Z33 C13	2304	–	–	–
4034	4034-420-00-I	–	1.4034	Z44 C14	–	–	–	–
4028	4028-420-00-I	420S45	1.4028	Z33 C13	2304	3Cr13	STS 420J2	30X13
4313	4313-415-00-I	–	1.4313	Z6 CN 13-04	2385	–	–	–
4542	–	–	1.4542	Z7 CNU 16-04	–	–	–	–
4116	4116-420-77-E	–	1.4116	Z50 CD15	–	–	–	–
4110	4110-420-69-E	–	1.4110	–	–	–	–	–
4568	–	–	1.4568	Z9 CNA 17-07	2388	–	–	–
4122	4122-434-09-I	–	1.4122	–	–	–	–	–
4574	–	–	1.4574	–	–	–	–	–
FERRITIC HIGH TEMPERATURE GRADES								
4713	–	–	1.4713	–	–	–	–	–
4724	4724-405-77-I	–	1.4724	Z13 C13	–	–	–	10X13CЮ
4736	–	–	1.4736	–	–	–	–	–
4742	4742-430-77-I	–	1.4742	Z12 CAS18	–	–	–	–
4762	4762-445-72-I	–	1.4762	Z12 CAS25	–	–	–	–
AUSTENITIC HIGH TEMPERATURE GRADES								
4948	4948-304-09-I	304S51	1.4948	Z6 CN 18-09	2333	1Cr18Ni9	STS 304	08X18H10
4878	–	321S51	1.4878	Z6 CNT 18-10	2337	1Cr18Ni9Ti	STS 321	08X18H10T
153 MA™	4818-304-15-E	–	–	–	2372	–	–	–
4833	4833-309-08-I	309S16	1.4833	Z15 CN 23-13	–	0Cr23Ni13	STS 309S	20X23H13
4828	4828-305-09-I	–	1.4828	Z17 CNS 20-12	–	1Cr20Ni14Si2	–	08X20H14C2
253 MA®	4835-308-15-U	–	1.4835	–	2368	–	–	–
4845	4845-310-08-E	310S16	1.4845	Z8 CN 25-20	2361	0Cr25Ni20	–	10X23H18
4841	4841-314-00-E	–	1.4841	Z15 CNS 25-20	–	–	–	20X25H2052

PRODUCT CODES: P = Hot rolled plate Quarto. H = Hot rolled coil and sheet. C = Cold rolled coil and sheet. B = Bar. R = Rod coil. S = Semifinished (bloom, billet, ingot, slab). T = Pipe. D = DUPROF™, profiles in high strength stainless steel.

Steel grades, chemical composition and products

Table 4

Outokumpu steel name	International steel designation				Typical chemical composition, %						Products
	EN	ASTM	UNS	JIS	C	N	Cr	Ni	Mo	Others	
DUPLEX GRADES											
LDX 2101®	1.4162	–	S32101	–	0.03	0.22	21.5	1.5	0.3	5Mn Cu	P H C B R S T D
2304[1]	1.4362	–	S32304	–	0.02	0.10	23	4.8	0.3	Cu	P H C B R S T D
LDX 2404®	1.4662*	–	S82441	–	0.02	0.27	24	3.6	1.6	3Mn Cu	P H C B R S T
2205	1.4462	–	S32205[2]	SUS 329J3L	0.02	0.17	22	5.7	3.1		P H C B R S T D
4501	1.4501	–	S32760	–	0.02	0.27	25.4	6.9	3.8	W Cu	P B R S T
2507	1.4410	–	S32750	–	0.02	0.27	25	7	4		P H C B R S T
AUSTENITIC GRADES											
4310	1.4310	301	S30100	SUS 301	0.10		17	7			H C B R S
4618	1.4618	–	–	–	0.06		16.6	4.6		7.9Mn 1.7Cu	H C S
4318	1.4318	301LN	S30153	SUS 301L	0.02	0.14	17.7	6.5			H C S
4376	1.4376	–	–	–	0.035	0.2	17.5	4		6.8Mn	H C S
4372	1.4372	201	S20100	SUS 201	0.05	0.20	17	4		7Mn	H C S
4301	1.4301	304	S30400	SUS 304	0.04		18.1	8.1			P H C B R S T
4307	1.4307	304L	S30403	–	0.02		18.1	8.1			P H C B R S T
4311	1.4311	304LN	S30453	SUS 304LN	0.02	0.14	18.5	9.2			P H C R S
4541	1.4541	321	S32100	SUS 321	0.04		17.3	9.1		Ti	P H C B R S T
4550	1.4550	347	S34700	SUS 347	0.05		17.5	9.5		Nb	P H C B R S T
4305	1.4305	303	S30300	SUS 303	0.05		17.3	8.2		S	P B R S
4303	1.4303	305	S30500	SUS 305J1	0.04		17.7	12.5			H C R S
4306	1.4306	304L	S30403	SUS 304L	0.02		18.2	10.1			P H C B R S T
4567	1.4567	–	S30430	SUS XM7	0.01		17.7	9.7		3Cu	B R S
4640	1.4640	–	–	–	0.06		18	6.5		1.7Cu 1.8Mn	H C S
4401	1.4401	316	S31600	SUS 316	0.04		17.2	10.1	2.1		P H C B R S T
4404	1.4404	316L	S31603	–	0.02		17.2	10.1	2.1		P H C B R S T
4427	1.4427*	–	–	–	0.05		16.9	10.7	2.5	S	P
4436	1.4436	316	S31600	SUS 316	0.04		16.9	10.7	2.6		P H C B R S T
4432	1.4432	316L	S31603	–	0.02		16.9	10.7	2.6		P H C B R S T
4406	1.4406	316LN	S31653	SUS 316LN	0.02	0.14	17.2	10.3	2.1		P H C B R S T
4441	1.4441	–	–	–	0.02		17.6	14.5	2.8		H C S
4429	1.4429	–	S31653	SUS 316LN	0.02	0.14	17.3	12.5	2.6		P R S
4571	1.4571	316Ti	S32100	SUS 316Ti	0.04		16.8	10.9	2.1	Ti	P H C B R S T
4435[3]	1.4435[3]	316L	–	SUS 316L	0.02		17.3	12.6	2.6		P H C B R S T
3952	1.3952*	–	–	–	0.02	0.18	16.9	13.2	2.7		P
HIGH PERFORMANCE AUSTENITIC GRADES											
4438	1.4438	317L[6]	S31703	SUS 317L	0.02		18.2	13.7	3.1		P C B R S T
4439	1.4439	317LMN[4]	S31726	–	0.02	0.14	17.3	13.7	4.1		P H C S T
725LN	1.4466	–	S31050	–	0.01	0.12	25	22.3	2.1		P
3964	1.3964*	–	–	–	0.02	0.27	20.5	15.4	3.2	4.3Mn Nb	P
904L	1.4539	904L	N08904	–	0.01		20	25	4.3	1.5Cu	P H C B R S T
254 SMO®	1.4547	–	S31254	SUS312L	0.01	0.20	20	18	6.1	Cu	P H C B R S T
4529	1.4529	–	N08926[5]	–	0.01	0.20	20.5	24.8	6.5	Cu	P C T
4565	1.4565	–	S34565	–	0.02	0.45	24	17	4.5	5.5Mn	P H C S T
654 SMO®	1.4652	–	S32654	–	0.01	0.50	24	22	7.3	3.5Mn Cu	P C S T

*designation according to Stahl Eisen Liste (Register of European Steels). [1]also available as EDX 2304™ with enhanced properties. [2]also available as S31803. [3]724L is a modifies version of 4435 for Urea applications. [4]317LMN not available in all product forms. [5]also available as N08367. [6]also available as 317L with 11.7% Ni which is not consistent with 1.4438.

PRODUCT CODES: P = Hot rolled plate Quarto. H = Hot rolled coil and sheet. C = Cold rolled coil and sheet. B = Bar. R = Rod coil. S = Semifinished (bloom, billet, ingot, slab). T = Pipe. D = DUPROF™, profiles in high strength stainless steel.

Steel grade designations according to different standards

Table 5

Outokumpu	ISO	National designations superseded by EN						
		BS/ UK	DIN/ Germany	NF/ France	SS/ Sweden	GB/ PR China	KS/ Korea	GOST/ Russia
DUPLEX GRADES								
LDX 2101®	4162-321-01-E	–	–	–	–	–	–	–
2304	4362-323-04-I	–	1.4362	Z3 CN 23-04 Az	2327	–	–	–
LDX 2404®	–	–	–	–	–	–	–	–
2205	4462-318-03-I	318S13	1.4462	Z3 CND 22-05 Az	2377	00Cr22Ni5Mo3N	STS 329J3L	–
4501	4501-327-60-I	–	–	–	–	–	–	–
2507	4410-327-50-E	–	–	Z3 CND 25-06 Az	2328	–	STS 329J4L	–
AUSTENITIC GRADES								
4310	4310-301-00-I	301S21	1.4310	Z11 CN 18-08	2331	1Cr17Ni7	STS 301	07X16H6
4618	4618-201-76-E	–	1.4618	–	–	–	–	–
4318	4318-301-53-I	–	–	Z3 CN 18-07 Az	–	–	STS 301L	–
4376		–	1.4376	–	–	–	–	–
4372	4372-201-00-I	284S16	–	Z12 CMN 17-07 Az	–	1Cr17Mn6Ni5N	STS 201	–
4301	4301-304-00-I	304S31	1.4301	Z7 CN 18-09	2333	0Cr18Ni9	STS 304	08X18H10
4307	4307-304-03-I	304S11	1.4307	Z3 CN 18-10	2352	00Cr19Ni10	STS 304L	03X18H11
4311	4311-304-53-I	304S61	1.4311	Z3 CN 18-10 Az	2371	00Cr18Ni10N	STS 304LN	–
4541	4541-321-00-I	321S31	1.4541	Z6 CNT 18-10	2337	0Cr18Ni10Ti	STS 321	08X18H10T
4550	4550-347-00-I	347S31	1.4550	Z6 CNNb 18-10	2338	0Cr18Ni11Nb	STS 347	08X18H12Б
4305	4305-303-00-I	303S31	1.4305	Z8 CNF 18-09	2346	Y1Cr18Ni9	–	12X18H10E
4303	4303-305-00-I	305S19	1.4303	Z1 CN 18-12	2333	1Cr18Ni12	STS 305	06X18H11
4306	4306-304-03-I	304S11	1.4306	Z3 CN 18-10	2352	00Cr19Ni10	STS 304L	03X18H11
4567	4567-304-30-I	304S17	1.4567	Z3 CNU 18-09 FF	–	0Cr18Ni9Cu3	–	–
4640		–	1.4640	–	–	–	–	–
4401	4401-316-00-I	316S31	1.4401	Z7 CND 17-11-02	2347	0Cr17Ni12Mo2	STS 316	–
4404	4404-316-03-I	316S11	1.4404	Z3 CND 17-11-02	2348	00Cr17Ni14Mo2	STS 316L	03X17H14M2
4427	–	–	–	–	–	–	–	–
4436	4436-316-00-I	316S33	1.4436	Z7 CND 18-12-03	2343	0Cr17Ni12Mo2	STS 316	–
4432	4432-316-03-I	316S13	1.4432	Z3 CND 18-14-03	2353	00Cr17Ni14Mo2	STS 316L	03X17H14M3
4406	4406-316-53-I	316S61	1.4406	Z3 CND 17-11 Az	–	00Cr17Ni12Mo2N	STS 316LN	–
4441	–	–	1.4441	–	–	–	–	–
4429	4429-316-53-I	316S63	1.4429	Z3 CND 17-12 Az	2375	00Cr17Ni13Mo2N	STS 316LN	–
4571	4571-316-35-I	320S31	1.4571	Z6 CNDT 17-12	2350	0Cr18Ni12Mo2Ti	STS 316Ti	08X17H13M2T
4435	4435-316-91-I	316S13	1.4435	Z3 CND 18-14-03	2353	00Cr17Ni14Mo2	STS 316L	03X17H14M3
3952	–	–	–	–	–	–	–	–
HIGH PERFORMANCE AUSTENITIC GRADES								
4438	4438-317-03-I	317S12	1.4438	Z3 CND 19-15-04	2367	00Cr19Ni13Mo3	STS 317L	–
4439	4439-317-26-E	–	1.4439	Z3 CND 18-14-05 Az	–	–	–	–
725LN	4466-310-50-E	–	–	–	–	–	–	–
3964	–	–	–	–	–	–	–	–
904L	4539-089-04-I	904S13	1.4539	Z2 NCDU 25-20	2562	–	STS 317J5L	–
254 SMO®	4547-312-54-I	–	–	–	2378	–	–	–
4529	4529-089-26-I	–	–	–	–	–	–	–
4565	4565-345-65-I	–	1.4565	–	–	–	–	–
654 SMO®	4652-326-54-I	–	–	–	–	–	–	–

Mechanical properties, room temperature

Table 6

Outokumpu steel name		Outokumpu typical values				EN, min. values, RT						ASTM, min. values, RT			
		$R_{p0.2}$ 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	$A_{2"}$ %
FERRITIC GRADES															
4600	H	435	460	545	25	1.4600	375		500	20					
4512	C	255	275	425	33[4]	1.4512	220		380	25[4]		S40910	170	380	20
4003	C	355	375	525	25[4]	1.4003	320		450	20[4]		S40977	280	450	18
4000	P	270	320	490	30	1.4000	230		400	19		S41008	205	415	22
4589	C	470	510	600	20[4]	1.4589	420		550	16[4]		S42035			
4016	C	365	390	520	26[4]	1.4016	320		450	20[4]		S43000	205	450	22
4511	C	320	340	475	30[4]	1.4511	240		420	23[4]		–			
4520	C	265	285	430	34[4]	1.4520	200		380	24[4]		–			
4510	C	285	300	450	34[4]	1.4510	240		420	23[4]		S43035	205	415	22
4509	C	310	330	480	31[4]	1.4509	250		430	18[4]		S43932	205	415	22
4607	C	310	325	470	31[4]	1.4607	250		430	18[4]					
4113	C	390	420	550	24[4]	1.4113	280		450	18[4]		S43400	240	450	22
4513	C	310	325	470	32[4]	1.4513	220		400	23[4]		S43600	240	450	22
4521	C	350	370	525	31[4]	1.4521	320		420	20[4]		S44400	275	415	20
MARTENSITIC AND PRECIPITATION HARDENING GRADES															
4006[1]	P	300	360	560	30	1.4006	450		650	12	–	S41000	205	450	20
4005[1]	R	350	450	550	20	1.4005	–		730[3]	–		–			
4021[1]	R	500	580	650	20	1.4021	–		700[3]	15	–	S42010	–	–	–
4031[1]	C	*	*	*	*	1.4031	–		760[3]	12	–	S42000			
4034[1]	C	375	430	660	24[4]	1.4034	–		780[3]	12	–	S42000			
4028[1]	B	*	*	*	*	1.4028	–		800[3]	–		S42000	–	–	–
4313[2]	P	700	770	850	20	1.4313	630		780	15	70	S41500	620	795	15
4542[1]	R	850	1050	1100	22	1.4542	–		1275[3]	–	–	–			
4116[1]	C	390	430	640	23[4]	1.4116	–		850[3]	12	–	–			
4110[1]	C	410	460	690	24[4]	1.4110	–		850[3]	12	–	–			
4568[1]	R	210	240	700	50	1.4568	–		850[3]	–	–	–			
4122[1]	C	460	490	720	22[4]	1.4122	–		900[3]	12	–	–			
4574	C	320	340	860	25[4]	1.4574						–			
FERRITIC HIGH TEMPERATURE GRADES															
4713	P	320	350	475	30	1.4713	220	–	420	15		–			
4724	P	340	370	515	30	1.4724	250	–	450	15		–			
4736	C	*	*	*	*	1.4736	280	–	500	25		–			
4742	P	375	405	535	25	1.4742	270	–	500	15		–			
4762	P	405	440	555	30	1.4762	280	–	520	15		–			
AUSTENITIC HIGH TEMPERATURE GRADES															
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	P	270	310	610	55	1.4828	230	270	550	30		–			
253 MA®	P	370	410	700	50	1.4835	310	350	650	40		S30815	310	600	40
4845	P	240	310	600	50	1.4845	210	250	500	35		S31008	205	515	40
4841	P	265	315	595	55	1.4841	230	270	550	30		S31400	205	515	40

*to be established. [1]annealed condition. [2]quenched and tempered condition. [3]max value. [4]A_{80}.

Outokumpu 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 A 240, A 176 and ASME Code Cases. Also values from EN 10269 and ASTM A 473.

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 MPa = 0.1450 ksi 1 J = 0.7376 ft·lbf

°C = 5/9 x (°F – 32) °F = 9/5 °C + 32

Mechanical properties, room temperature

Table 7

Outokumpu steel name		Outokumpu typical values				EN, min. values, RT						ASTM, min. values, RT			
		$R_{p0.2}$ 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	$A_{2"}$ %
DUPLEX GRADES															
LDX 2101®	P	500		700	38	1.4162	450		650	30	60/40	S32101	450	650	30
2304	P	450		670	40	1.4362	400		630	25	60	S32304	400	600	25
LDX 2404®	P	520		750	33	1.4662	480		680	25	60	S82441	480	680	25
2205	P	510		750	35	1.4462	460		640	25	60	S32205	450	655	25
4501[1]	P	580		830	35	1.4501	530		730	25	60	S32760	550	750	25
2507	P	580		830	35	1.4410	530		730	20	60	S32750	550	795	15
AUSTENITIC GRADES															
4310	C	300	325	770	56[2]	1.4310	250	280	600	40[2]	–	S30100	205	515	40
4618	C	310	335	640	55[2]	1.4618	230	250	540	45[2]	–	–			
4318	C	360	400	750	50[2]	1.4318	350	380	650	35[2]	–	S30153	240	550	45
4376	H	410	460	715	57	1.4376	400	420	600	40	–	–			
4372	C	430	475	775	65	1.4372	350	380	680	45[2]	–	S20100	310	655	40
4301	P	270	300	600	55	1.4301	210	250	520	45	60	S30400	205	515	40
4307	P	260	300	580	55	1.4307	200	240	500	45	60	S30403	170	485	40
4311	P	310	350	640	55	1.4311	270	310	550	40	60	S30453	205	515	40
4541	P	250	290	570	55	1.4541	200	240	500	40	60	S32100	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
4303	C	260	280	570	56[2]	1.4303	220	250	500	45[2]	–	S30500	170	485	40
4306	P	240	270	580	55	1.4306	200	240	500	45	60	S30403	170	485	40
4567	R	185	215	470	50	1.4567	175	210	450	45		S30430			
4640	C	325	345	650	53[2]	1.4640	230	260	540	45[2]					
4401	P	260	300	570	55	1.4401	220	260	520	45	60	S31600	205	515	40
4404	P	260	300	570	55	1.4404	220	260	520	45	60	S31603	170	485	40
4427	P	260	300	550	22	–						S31620			
4436	P	260	300	590	50	1.4436	220	260	530	40	60	S31600	205	515	40
4432	P	260	280	570	50	1.4432	220	260	520	45	60	S31603	170	485	40
4406	P	300	330	620	50	1.4406	280	320	580	40	60	S31653	205	515	40
4441	C	320	355	630	46[2]	1.4441						–			
4429	P	330	390	670	45	1.4429	280	320	580	40	60	S31653	205	515	40
4571	P	260	300	570	50	1.4571	220	260	520	40	60	S31635	205	515	40
4435	P	260	300	570	55	1.4435	220	260	520	45	60	S31603	170	485	40
3952	P	330	380	670	50	–						–			
HIGH PERFORMANCE AUSTENITIC GRADES															
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	280	300	630	55	1.4466	250	290	540	40	60	S31050	255	540	25
3964	P	460	510	800	40	–						–			
904L	P	260	285	600	50	1.4539	220	260	520	35	60	N08904	220	490	35
254 SMO®	P	320	350	680	50	1.4547	300	340	650	40	60	S31254	310	655	35
4529	P	320	340	700	50	1.4529	300	340	650	40	60	N08926	295	650	35
4565	P	440	480	825	55	1.4565	420	460	800	30	90	S34565	415	795	35
654 SMO®	P	460	490	860	60	1.4652	430	470	750	40	60	S32654	430	750	40

[1]max 31 mm for orders acc. to ASTM. [2]A_{80}.

Mechanical properties, elevated temperatures

Table 8

Outokumpu steel name	EN – min. $R_{p0.2}$, MPa					Max. design stress for pressure equipment σ, MPa								
						EN				ASME VIII-1 (II D)				
	No.	RT	100	200	400°C	RT	100	200	400°C	No.	RT	100	200	400°C
FERRITIC GRADES														
4600	1.4600	375				–	–	–	–	–				
4512	1.4512	220	200	190	–	–	–	–	–	–				
4003	1.4003	320	240	230		187	160	153	–	S40977	–	–	–	–
4000	1.4000	230	220	210	190	–	–	–	–	S41008	118	118	114	101
4589	1.4589	420				–	–	–	–	S42035				
4016	1.4016	280	220	210	190	–	–	–	–	S43000	128	126	120	108
4511	1.4511	240	230	205	–	–	–	–	–	–				
4520	1.4520	200	195	170	–	133	130	113	–	–				
4510	1.4510	240	195	185	–	153	130	123		S43035	–	–	–	–
4509	1.4509	250	230	210	–	166	153	140	–	S43932	–	–	–	–
4607	1.4607	250	250	230	200	–	–	–	–	–				
4113	1.4113	280	250	230	200	–	–	–	–	–				
4513	1.4513	220	250	230	200	–	–	–	–	–				
4521	1.4521	320	250	230	200	175	167	153	–	S44400	118	118	112	–
MARTENSITIC AND PRECIPITATION HARDENING GRADES														
4006	1.4006	450	420	400	305	–	–	–	–	S41000	128	126	120	108
4005	1.4005					–	–	–	–	S41600	–	–	–	–
4021	1.4021	450	420	400	305	–	–	–	–	S42010	–	–	–	–
4031	1.4031									–				
4034	1.4034									–				
4028	1.4028					–	–	–	–	S42000	–	–	–	–
4313	1.4313	630	590	560		325[3]	325[3]	325[3]	–	S41500	–	–	–	–
4542	1.4542		680[2]	640[2]		–	–	–	–	–				
4116	1.4116													
4110	1.4110													
4568	1.4568													
4122	1.4122													
4574	1.4574	–	–	–	–	–	–	–	–	–				

AUSTENITIC HIGH TEMPERATURE GRADES														
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[1]					89	28			S30409[1]	64	27	11	
4878	1.4878	85	30	10		65	22	10	–	S32109[1]	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[1]	49	16	6	
4828	1.4828	80	25	10	4	65	16	7.5	3	–				
253 MA®	1.4835	126	45	19	10	88	35	15	8	S30815[1]	59	22	10	5
4845	1.4845	90	30	10	4	80	18	7	3	S31009[1]	49	16	6	
4841	1.4841	95	35	10	4	80	18	7	3	S31400				

[1]Creep resisting grades for pressure purposes listed in EN 10028-7 and ASME IID. [2]In +P850 condition. [3]Depending on tempering condition.

EN/ASME values: For hot rolled plate from EN 10028-7, EN 10088, EN 10095, ASME IID Tables 1A and 1B, and Code Cases.

Outokumpu 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	$\min\left[\frac{R_{p0.2}T}{1,5};\frac{R_mRT}{2,4}\right]$ or	$\min\left[\frac{R_{p0.2}RT}{1,5};\frac{R_mRT}{3,5}\right]$ or $\min\left[\frac{R_{p0.2}T}{1,5};\frac{R_mT}{3,5}\right]$
Austenitic A>30%	$\min\left[\frac{R_{p1.0}T}{1,5}\right]$	$\min\left[\frac{R_{p0.2}RT}{1,5};\frac{R_mRT}{3,5}\right]$ or $\min\left[\frac{R_{p0.2}T}{1,1};\frac{R_mT}{3,5}\right]$
Austenitic A>35%	$\min\left[\frac{R_{p1.0}T}{1,2};\frac{R_mT}{3,0}\right]$ or $\max\left[\frac{R_{p1.0}T}{1,5}\right]$	

Mechanical properties, elevated temperatures

Table 9

Outokumpu steel name	EN – min. $R_{p0.2}$, MPa					Max. design stress for pressure equipment σ, MPa								
						EN				ASME VIII-1 (II D)				
	No.	RT	100	200	400°C	RT	100	200	400°C	No.	RT	100	200	400°C
DUPLEX GRADES														
LDX 2101®	1.4162	450	380	330		271[1]	253[1]	220[1]	–	S32101[2]	186	184	171	–
2304	1.4362	400	330	280		263	220	187	–	S32304	172	164	150	–
LDX 2404®	1.4662	480	385	325		–	–	–	–	S82441	–	–	–	–
2205	1.4462	460	360	315		267	240	210	–	S31803	177	177	165	–
4501	1.4501	530	450	400		304	300	267	–	S32760	–	–	–	–
2507	1.4410	530	450	400		304	300	267	–	S32750	228	227	208	–
AUSTENITIC GRADES														
4310	1.4310	250	210	190	–	–	–	–	–	S30100	–	–	–	–
4618	1.4618	230	160	125	100	–	–	–	–	–				
4318	1.4318	350	265	185	–	247	177	153	–	S30153	–	–	–	–
4376	1.4376	400	157	127	98	–	–	–	–	–				
4372	1.4372	350	295	230	–	–	–	–	–	S20100	–	–	–	–
4568	1.4568	210	–	–	–	–	–	–	–	–				
4301	1.4301	210	157	127	98	173	150	131	104	S30400	138	137	126	107
4307	1.4307	200	147	118	89	167	137	120	–	S30403	115	115	110	91
4311	1.4311	270	205	157	125	207	163	143	–	S30453	138	137	126	107
4541	1.4541	200	176	157	125	167	147	130	125	S32100	138	138	129	119
4550	1.4550	200	177	157	125	167	145	124	110	S34700	138	137	123	116
4305	1.4305	190				–	–	–	–	S30300	–	–	–	–
4303	1.4303	220	155	127	98	–	–	–	–	S30500	138	137	126	107
4306	1.4306	200	147	118	89	167	137	120	–	S30403	115	115	110	91
4567	1.4567	175	–	–	–	–	–	–	–	S30430	–	–	–	–
4640	1.4640	230	157	127	98									
4401	1.4401	220	177	147	115	173	143	130	–	S31600	138	138	134	111
4404	1.4404	220	166	137	108	173	143	130	113	S31603	115	115	109	91
4427	–					–	–	–	–	S31620	–	–	–	–
4436	1.4436	220	177	147	115	177	153	140	120	S31600	138	138	134	111
4432	1.4432	220	166	137	108	173	143	130	113	S31603	115	115	109	91
4406	1.4406	280	211	167	135	213	173	153	–	S31653	138	138	131	105
4441	1.4441	–	–	–	–	–	–	–	–	–				
4429	1.4429	280	211	167	135	213	173	153	137	S31653	138	138	131	105
4571	1.4571	220	185	167	135	173	147	131	125	S31635	138	138	134	111
4435	1.4435	220	165	137	108	173	140	127	90	S31603	115	115	109	91
3952	–						–	–	–	–				
HIGH PERFORMANCE AUSTENITIC GRADES														
4438	1.4438	220	172	147	115	173	143	130	–	S31703	138	138	131	109
4439	1.4439	270	225	185	150	207	173	153	–	S31726	–	–	–	–
725LN	1.4466	250	195	160		193	163	153	–	S31050	158	155	148	–
3964	–					–	–		–	–				
904L	1.4539	220	205	175	125	173	167	153	103	N08904	140	114	95	–
254 SMO®	1.4547	300	230	190	160	227	205	187	158	S31254	187	186	170	158
4529	1.4529	300	230	190	160	227	183	173	–	N08926[3]	–	–	–	–
4565	1.4565	420	350	270	210	–	–	–	–	S34565	–	–	–	–
654 SMO®	1.4652	430	350	315	295	–	–	–	–	S32654	214	214	199	178

[1]Not yet included in EN 10028-7, but European Approval of Materials, EAM-0045-01:2012/01, is available. [2]Values according to code case No.: 2418.
[3]Also available as N08367.

Mechanical properties, low temperatures

Table 10

Outokumpu steel name	EN No.	EN min. values, MPa and %											
		–196°C				–80°C				RT			
		$R_{p0.2}$	$R_{p1.0}$	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	390	470	1200	30	260	290	855	35	200	240	500	40
4404	1.4404	350	450	1200	35	275	355	840	40	220	260	520	45
4406	1.4406	600	700	1150	30	380	450	800	35	280	320	580	40
4429	1.4429	600	700	1150	30	380	450	800	30	280	320	580	35

From EN 10028-7 Annex E.

Common design codes for stainless steel

Table 11

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	ASME (American Society of Mechanical Engineers) 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

Ferrite

Ferritic stainless steels have good corrosion resistance, in particular regarding stres corrosion cracking. Lower carbon and nitrogen contents improve both weldability and toughness which otherwise can be limited.

Martensite

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

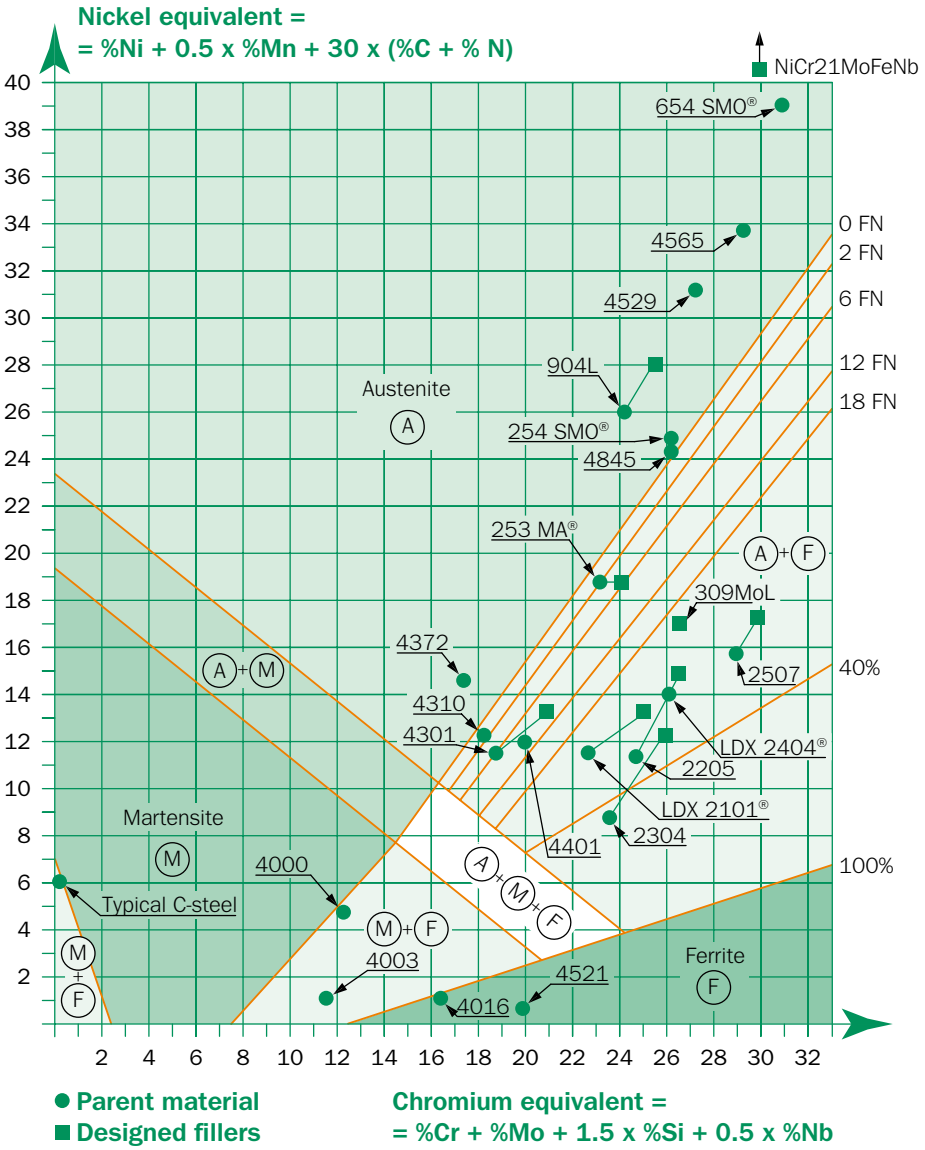
Duplex (ferrite-austenite)

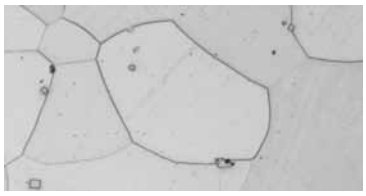
Duplex stainless steels have high strength, good toughness and very good corrosion resistance, in particular regarding stress corrosion cracking and corrosion fatigue. These steels also have good weldability and reasonable formability.

Austenite

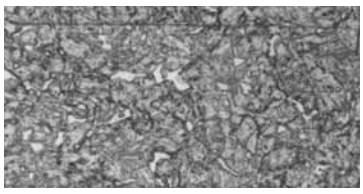
Good to excellent corrosion resistance combined with very good weldability and formability characterise the austenitic stainless steels. The austenitic structure has good creep resistance and good oxidation resistance that makes them useful at elevated temperatures. Austenitic steel can also be used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

Schaeffler diagram and microstructures

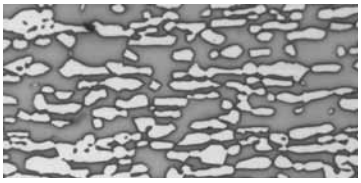




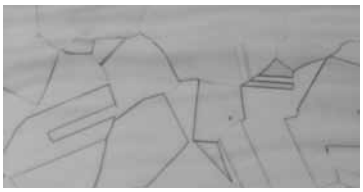
Ferrite (α-iron). Body centered cubic with 8 atom neighbours. 68% packing.



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



Duplex (ferrite-austenite). 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.



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

Shaeffler diagram

The Schaeffler diagram, here a version modified by Outokumpu, 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.

Calculation of ferrite number, FNA

One common way to calculate the ferrite number, FNA, is by using the below formulas, where

F = 1.55Si + Cr + Mo + 2Ti + 0.5Nb
A = 30(C + N) + 0.5 Mn + Ni + 0.5(Cu + Co)

FNA = 3.34F – 2.46A – 28.6 for FNA = max. 5.9
FNA = 4.44F – 3.39A – 38.4 for FNA = 6.0 to 11.9
FNA = 4.06F – 3.23A – 32.2 for FNA = min. 12

Physical properties

Table 12

Outokumpu steel name	EN	Density, ρ kg/dm³	Modulus of elasticity, E GPa		Coefficient of thermal expansion between 20°C and T, 10^{-6}/°C		Thermal conductivity, λ W/m°C		Thermal capacity, c J/kg°C	Electrical resistivity, ρ µΩm	Magnet-izable
		RT	RT	400°C	100°C	400°C	RT	400°C	RT	RT	RT
Non alloy steel	1.0345	7.8	210	175	12.0	14.0	55	44	460	0.18	Y
FERRITIC GRADES											
4600	1.4600	7.7	220	195	10.5	–	25		460	0.60	Y
4512	1.4512	7.7	220		10.5	12.0	25		460	0.60	Y
4003	1.4003	7.7	220	195	10.4	11.6	25		430	0.60	Y
4000	1.4000	7.7	220	195	10.5	12.0	30		460	0.60	Y
4589	1.4589	7.7	220	165	10.5	12.0	25		460	0.60	Y
4016	1.4016	7.7	220	195	10.0	10.5	25	25	460	0.60	Y
4511	1.4511	7.7	220	195	10.0	10.5	25		460	0.60	Y
4520	1.4520	7.7	220	195	10.4	11.6	20		430	0.70	Y
4510	1.4510	7.7	220	195	10.0	10.5	25		460	0.60	Y
4509	1.4509	7.7	220	195	10.0	10.5	25		460	0.60	Y
4607	1.4607	7.7	220	195	10.3	11.1	18		390	0.65	Y
4113	1.4113	7.7	220	195	10.0	10.5	25		460	0.70	Y
4513	1.4513	7.7	220	195	10.0	10.5	25		460	0.70	Y
4521	1.4521	7.7	220	195	10.4	11.6	23		430	0.80	Y
MARTENSITIC AND PRECIPITATION HARDENING GRADES											
4006	1.4006	7.7	215	190	10.5	12.0	30		460	0.60	Y
4005	1.4005	7.7	215	190	10.5	12.0	30		460	0.60	Y
4021	1.4021	7.7	215	190	10.5	12.0	30	25	460	0.60	Y
4031	1.4031	7.7	215	190	10.5	12.0	30		460	0.55	Y
4034	1.4034	7.7	215	190	10.5	12.0	30		460	0.55	Y
4028	1.4028	7.7	215	190	10.5	12.0	30	25	460	0.65	Y
4313	1.4313	7.7	200	170	10.5	11.6	25		430	0.60	Y
4542	1.4542	7.8	200	170	10.9	–	16		500	0.71	Y
4116	1.4116	7.7	215	190	10.5	11.5	30		460	0.65	Y
4110	1.4110	7.7	215	190	10.5	12.0	30		460	0.62	Y
4568	1.4568	7.8	200	170	13.0		16		500	0.80	Y
4122	1.4122	7.7	215	190	10.4	11.6	15		430	0.80	Y
4574	1.4574										
FERRITIC HIGH TEMPERATURE GRADES											
					400°C	1000°C	RT	500°C			
4713	1.4713	7.7			12.0	–	23	25	450	0.70	Y
4724	1.4724	7.7			11.5	–	21	23	500	0.75	Y
4736	1.4736	7.7			10.8	13.0	21	23	500	0.60	Y
4742	1.4742	7.7			11.5	13.5	19	25	500	0.93	Y
4762	1.4762	7.7			11.5	13.5	17	23	500	1.10	Y
AUSTENITIC HIGH TEMPERATURE GRADES											
			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	582	0.71	N
4878	1.4878	7.9	158		18.4	20.5	21.6		582	0.74	N
153 MA™	1.4818	7.8	163	120	18.2	19.5	21.2	29.0	585	0.84	N
4833	1.4833	7.8	158	120	18.4	20.0	20.5	27.5	582	0.87	N
4828	1.4828	7.8	158	120	18.4	20.0	20.5	27.5	582	0.87	N
253 MA®	1.4835	7.8	163	120	18.2	19.5	21.2	29.0	585	0.84	N
4845	1.4845	7.8	158	120	18.4	20.0	19.8	27.1	582	0.96	N
4841	1.4841	7.8	158	120	18.8	20.0	19.0	27.8	582	0.96	N

[1]Outokumpu typical values

Non alloy steel is added for comparison in Tables 12 to 15.

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, EN 10095 or typical values.

Physical properties

Table 13

Outokumpu steel name	EN	Density, ρ kg/dm³	Modulus of elasticity, E GPa		Coefficient of thermal expansion between 20°C and T, 10^{-6}/°C		Thermal conductivity, λ W/m°C		Thermal capacity, c J/kg°C	Electrical resistivity, ρ µΩm	Magnet-izable
		RT	RT	400°C	100°C	400°C	RT	400°C	RT	RT	RT
Non alloy steel	1.0345	7.8	210	175	12.0	14.0	55	44	460	0.18	Y
DUPLEX GRADES											
LDX 2101®	1.4162	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
2304	1.4362	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
LDX 2404™	1.4662	7.7	205		13.0	14.5	15		500	0.80	Y
2205	1.4462	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
4501	1.4501	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
2507	1.4410	7.8	200	172	13.0	14.5	15	20	500	0.80	Y
AUSTENITIC GRADES											
4310	1.4310	7.9	200	172	16.0	18.0	15	20	500	0.73	N
4618	1.4618	7.9	200	172	16.0	17.5	15		500	0.73	N
4318	1.4318	7.9	200	172	16.0	17.5	15	20	500	0.73	N
4376	1.4376	7.9	200	172	16.0	17.5	15		500	0.73	N
4372	1.4372	7.8	200	172			15	20		0.70	N
4568	1.4568	7.8	200	170	13.0		16		500	0.80	Y
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	7.9	200	172	16.0	17.5	15		500	0.73	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
4640	1.4640	7.9	200	172	16.0	17.5	15		500	0.73	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
4427[1]	–	8.0	200	172	16.5	18.5	15		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*
4441	1.4441										
4429	1.4429	8.0	200	172	16.0	17.5	15	20	500	0.75	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
3952[1]	–	7.9	200		16.5		15		500	0.75	N
HIGH PERFORMANCE AUSTENITIC GRADES											
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	195	166	15.7		14	17	500	0.80	N
3964[1]	–	7.9	195	165	15.7	17.8	14		475	0.81	N
904L	1.4539	8.0	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
4529	1.4529	8.1	195	166	15.8	16.9	12	18	450	1.00	N
4565	1.4565	8.0	190	165	14.5	16.8	12	18	450	0.92	N
654 SMO®	1.4652	8.0	190	164	15.0	16.2	8.6		500	0.78	N

[1]Outokumpu typical values

*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 10^6 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

Fabrication and use characteristics

Table 14

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		
FERRITIC GRADES								
4600	1.4600	A 675 ± 25	13 4				N/N	< 10
4512	1.4512	A 800 ± 30	13 or 19 9L				N/N	< 10
4003	1.4003	A 730 ± 30	13 or 19 9L			EN	N/N	< 10
4000	1.4000	A 780 ± 30	13 or 19 9L			ASME	N/N	< 10
4589	1.4589	A 775 ± 25	18 8 Mn				Y/Y	< 10
4016	1.4016	A 800 ± 30	19 9L or 23 12L	0.2/20		ASME	Y/N	< 10
4511	1.4511	A 820 ± 30	18 Nb L				Y/Y	< 10
4520	1.4520	A 850 ± 30	17 Ti			EN	Y/Y	< 10
4510	1.4510	A 800 ± 30	19 9L or 18L Nb			EN	Y/Y	< 10
4509	1.4509	A 900 ± 30	19 9 Nb or 18 8 Mn			EN	Y/Y	< 10
4607	1.4607	A 900 ± 30	18 8 Mn				Y/Y	< 10
4113	1.4113	A 820 ± 30	18 8 Mn				Y/N	< 10
4513	1.4513	A 850 ± 30	18 Nb L			EN	Y/Y	< 10
4521	1.4521	A 850 ± 30	19 12 3L or 23 12 2L			EN ASME	Y/Y	< 10
MARTENSITIC AND PRECIPITATION HARDENING GRADES								
4006	1.4006	A 780 ± 30	13 or 18 9			ASME		< 10
4005	1.4005		248 SV**					< 10
4021	1.4021	T 740 ± 40	248 SV**					< 10
4031	1.4031	T 275 ± 75	Not suitable for welding					< 10
4034	1.4034	A 760 ± 30	Not suitable for welding					< 10
4028	1.4028	T 690 ± 40	248 SV**					< 10
4313	1.4313	T 600 ± 40	248 SV**			EN		< 10
4542	–	T 620 ± 10*	248 SV**					< 10
4116	1.4116	A 800 ± 30	Not suitable for welding					< 10
4110	1.4110	T 275 ± 75	Not suitable for welding					< 10
4568	1.4568	T 510 ± 10	19 9L					< 10
4122	1.4122	T 275 ± 75	19 12 3 Nb Si					< 10
4574	1.4574		19 12 3 L Si or 19 12 3 Nb Si					
FERRITIC HIGH TEMPERATURE GRADES								**Max. temp,[8] °C**
4713	1.4713	A 810 ±30	18 8 Mn or 18.9 MnMo or 309					800
4724	1.4724	A 830 ±30	22 12 or 25 4					850
4736	1.4736		23 12 L					1000
4742	1.4742	A 830 ±30	22 12 L or 21 10 N					1000
4762	1.4762	A 830 ±30	25 20 or 22 12					1150
AUSTENITIC HIGH TEMPERATURE GRADES								**Max. temp,[8] °C**
4948	1.4948	A 1080 ± 30	19 9	0.6/40	105	EN ASME	N/N	800
4878	1.4878	A 1070 ± 50	19 9 Nb	0.6/40	100	ASME		850
153 MA™	1.4818	A 1070 ± 50	21 10 N or 253 MA-NF**	0.6/40	70			1050
4833	1.4833	A 1100 ± 50	22 12 or 253 MA-NF**	0.6/35	95	ASME		1000
4828	1.4828	A 1100 ± 50	21 10 N or 253 MA-NF**	0.6/35	95			1000
253 MA®	1.4835	A 1070 ± 50	21 10 N or 253 MA-NF**	0.6/35	70	ASME		1150
4845	1.4845	A 1100 ± 50	25 20 or 21 10 N	0.6/35	95	ASME		1050
4841	1.4841	A 1100 ± 50	25 20 or 21 10 N					1150

*precipitation hardening temperature in the +P850 condition. [1]Heat treatment temperature: A = Annealing. T = Tempering from EN 10088-2, EN 10095, EN 10028-7 (N = Normalising). [2]Covered electrodes, ISO 3581/ISO 14172, **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 in relation to 4404. 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 resistance (IGC) from EN 10088-2, tested according to EN ISO 3651-2. Y=yes and N=no, for delivery condition/welded condition. Data for grade 4948 according to EN 10027-7, delivery/sensitized. [7]Typical Critical Pitting Temperature (CPT): From potentiostatic testing at +700 mV_{SCE} with the Avesta Cell method in 1M NaCl, test surface ground to P 320 mesh (ASTM G 150). Other surfaces/products may, other methods (ASTM G 48 etc.) will, give other CPT values. [8]Maximum service temperature in dry air. [9]Outokumpu typical values.

Fabrication and use characteristics

Table 15

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		
DUPLEX GRADES								
LDX 2101®	1.4162	A 1050 ± 30	23 7 NL or 22 9 3 NL	0.4/20	130	ASME	Y/Y	17±3
2304	1.4362	A 1000 ± 50	23 7 NL or 22 9 3 NL	0.4/20	75	EN ASME	Y/Y	25±3
LDX 2404®	1.4662	A 1100 ± 20	22 9 3 NL	0.4/20	80		Y/Y	43±2
2205	1.4462	A 1060 ± 40	22 9 3 NL	0.4/20	55	EN ASME	Y/Y	52±3
4501	1.4501	A 1080 ± 40	25 9 4 NL	0.4/20		EN	Y/Y	84±2
2507	1.4410	A 1080 ± 40	25 9 4 NL	0.4/20	45	EN ASME	Y/Y	84±2
AUSTENITIC GRADES								
4310	1.4310	A 1050 ± 40	19 9L	0.8/35			N/N	< 10
4618	1.4618	A 1050 ± 50	18 8 Mn				Y/N	< 10
4318	1.4318	A 1060 ± 40	19 9L	0.8/35		EN	Y/Y	< 10
4376	1.4376	A 1060 ± 40	19 9 L or 18 8 Mn				Y/N	< 10
4372	1.4372	A 1050 ± 50	18 8 Mn or 23 12L	0.8/35			Y/N	< 10
4301	1.4301	A 1050 ± 50	19 9L	0.6/40	105	EN ASME	Y/N*	< 10
4307	1.4307	A 1050 ± 50	19 9L	0.6/40	105	EN ASME	Y/Y	< 10
4311	1.4311	A 1050 ± 50	19 9L	0.6/40	80	EN ASME	Y/Y	< 10
4541	1.4541	A 1050 ± 50	19 9 Nb or 19.9 L	0.6/40	100	EN ASME	Y/Y	< 10
4550	1.4550	A 1070 ± 50	19 9 Nb or 19 9 L			EN ASME	Y/Y	< 10
4305	1.4305	A 1050 ± 50	19 9L	0.6/40			N/N	< 10
4303	1.4303	A 1050 ± 50	19 9L	0.6/40	105	ASME	Y/N*	< 10
4306	1.4306	A 1050 ± 50	19 9L	0.6/40	105	EN ASME	Y/Y	< 10
4567	1.4567	A 1050 ± 50	19 9L	0.6/40				< 10
4640	1.4640	A 1050±50	19 9 L Si				Y/N	< 10
4401	1.4401	A 1070 ± 40	19 12 3L	0.6/35	100	EN ASME	Y/N*	20±2
4404	1.4404	A 1070 ± 40	19 12 3L	0.6/35	100	EN ASME	Y/Y	20±2
4427[9]	–	A 1060 ± 40	19 12 3L					
4436	1.4436	A 1070 ± 40	19 12 3L	0.6/35	100	EN ASME	Y/N*	27±3
4432	1.4432	A 1070 ± 40	19 12 3L	0.6/35	100	EN ASME	Y/Y	27±3
4406	1.4406	A 1070 ± 40	19 12 3L	0.6/35	75	EN ASME	Y/Y	23±2
4441	1.4441		19 12 3L Si					
4429	1.4429	A 1070 ± 40	19 12 3L	0.6/35	100	EN ASME	Y/Y	
4571	1.4571	A 1070 ± 40	19 12 3 Nb or 19 12 3L	0.6/35	95	EN ASME	Y/Y	15±2
4435	1.4435	A 1070 ± 40	19 12 3L	0.6/35	100	EN ASME	Y/Y	21±2
3952[9]	–	A 1075 ± 25	20 16 3 Mn L					
HIGH PERFORMANCE AUSTENITIC GRADES								
4438	1.4438	A 1110 ± 40	317	0.6/35	90	EN ASME	Y/Y	33±3
4439	1.4439	A 1100 ± 40	19 13 4 NL or 20 25 5 CuL	0.6/35	70	EN	Y/Y	50±3
725LN	1.4466	A 1110 ± 40	25 22 2 N L			EN ASME	Y/Y	
3964[8]	–	A 1055 ± 25	20 16 3 Mn L					
904L	1.4539	A 1100 ± 40	20 25 5 CuL	0.6/30	75	EN ASME	Y/Y	62±3
254 SMO®	1.4547	A 1175 ± 25	Ni Cr 21 Mo Fe Nb or Ni Cr 25 Mo 16 or P54**	0.6/30	45	EN ASME	Y/Y	87±3
4529	1.4529	A 1150 ± 30	Ni Cr 21 Mo Fe Nb or Ni Cr 25 Mo 16 or P54**	0.6/30		EN	Y/Y	> 90
4565	1.4565	A 1145 ± 25	Ni Cr 21 Mo Fe Nb or Ni Cr 25 Mo 16 or P54**	0.6/30			Y/Y	> 90
654 SMO®	1.4652	A 1180 ± 30	Ni Cr 25 Mo 16 or P54**	0.6/30	15	ASME	Y/Y	> 90

[1]Heat treatment temperature: A = Annealing. T = Tempering from EN 10088-2, EN 10095, EN 10028-7 (N = Normalising). [2]Covered electrodes, ISO 3581/ISO 14172, **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 in relation to 4404. 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 resistance (IGC) from EN 10088-2, tested according to EN ISO 3651-2. Y=yes and N=no, for delivery condition/sensitized condition. [7]Typical Critical Pitting Temperature (CPT): From potentiostatic testing at +700 mV$_{SCE}$ with the Avesta Cell method in NaCl, test surface ground to P 320 mesh (ASTM G 150). Other surfaces/products may, other methods (ASTM G 48 etc.) will, give other CPT values. [8]Outokumpu typical values. * = May be multi-certified as Y/Y.

Ordering and classification principles

Table 16

Ordering concepts	Classification principles	Typical codes
MATERIAL STANDARD	Stainless steel: Iron major element. Cr min. 10.5%	
	– Corrosion resisting grades	EN 10088-2, EN 10028-7
	– Heat and creep resisting grades, for use over 550°C	EN 10095, EN 10302, EN 10028-7
Additional specification	– Customer specification	
	– Technical approval of new material	VdTÜV WB418
	– Multi-certification of other global standard	ASTM A 240, JIS G4304
	– Multi-certification of withdrawn national standard	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 optimised fabrication properties	See table 17
PRODUCT	– Flat products	P/Hot rolled plate Quarto,
		H/Hot rolled coil and sheet,
		C/Cold rolled coil and sheet (KBR, Sendzimir),
		N/Cold rolled narrow strip
	– Long products	S/Semi-finished products, B/Bar, R/Rod coil
	– Pipe	T/Welded pipe
Product condition	EN 10088 codes for process route/surface finish	See table 17
Dimensions	Thickness x width x length	8 x 2000 x 5000
Special tolerances	EN codes for special tolerance classes	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	3.1
	– Notified body inspection or third party inspection	3.2
QUALIFICATION	Some orders may require approval of the manufacturer:	
	– Production system for pressure purpose materials	AD 2000 W0, EN 13445
	– Quality system	ISO 9001:2000
	– Customer list of approved suppliers	
MATERIAL DECLARATIONS	– Safety Information Sheet (SIS)	1005EN-GB
	– Declarations for certain branches, orders and products: Building, food, water piping etc. products: Building, food, water piping etc.	Avesta Research Centre

Steel and product conditions

Table 17

Outokumpu	Special steel conditions	EN	Product conditions
LIC	for improved steel cleanness	1D	Hot rolled, heat treated, pickled
PRODEC®	for improved machinability	1E	Hot rolled, heat treated, mechanically descaled
HyTens®	for improved mechanical properties	1G	Hot rolled, ground
CCS®	for improved mechanical properties	1Q	Hot rolled, quenched and tempered, pickled
VKS®	for improved thickness tolerances	2H	Work hardened
RAP™2E	for improved thickness tolerances and improved surface finish	2E	Cold rolled, heat treated, mech. desc. pickl.
		2D	Cold rolled, heat treated, pickled
Multicertification is available on request to EN/ASTM/ ASME as well as to superseded national standards		2B	Cold rolled, heat treated, pickled, skin passed
		2BB*	Cold rolled, heat treated, bright pickled, skin passed
		2F	Cold rolled, heat treated, pickled, skin passed on roughened rolls
		2R	Cold rolled, bright annealed
		2G	Ground
		2J	Brushed or dull polished
		2K	Satin polished
		2M	Patterned
		2W	Profile rolled
		2L	Coloured
		2S	Coated

*Outokumpu designation. The 2BB product confirms with standard surface finish 2B

Product properties and test methods

Table 18

Property			Test methods		Reported result	
Delivery testing at RT						
0.2% Proof strength			EN ISO 6892-1	ASTM A 370, E8	$R_{p0.2}$	MPa
1.0% Proof strength			EN ISO 6892-1	–	$R_{p1.0}$	MPa
Tensile strength			EN ISO 6892-1	ASTM A 370, E 8	R_m	MPa
Elongation[1]		A_5, A_2.	EN ISO 6892-1	ASTM A 370, E 8	A	%
Impact energy[2]		also LT	EN 10045-1	ASTM A 370, E 23	KV	J
Hardness[3]		conv. to HB	EN 10109-1	ASTM A 370, E 18	HRB	
		for martensite	EN 10109-1	ASTM A 370, E 18	HRC	
			EN 10003-1	ASTM A 370, E 10	HB	
		for < 1.5 mm	ISO 6507-1	ASTM E 92	HV	
Mechanical properties at HT, LT						
Tensile strength at HT		max. 600°C	EN ISO 6892-2	ASTM E 21	$R_{p0.2}$ $R_{p1.0}$ R_m	MPa
Derivation of yield strengths for HT			EN 10314			
IGC resistance	Strauss	4301/4401	ISO 3651-2 A	ASTM A 262 E	Approved	
	Strauss	> 20Cr/Mo	ISO 3651-2 B	ASTM A 262 E	Approved	
	Streicher	for high-alloy	ISO 3651-2 C	ASTM A 262 B	Approved or	mpy/g/m^{2}h
	Huey	for urea	ISO 3651-1	ASTM A 262 C		g/m^{2}h

Explanations, see below Table 20

Stainless steel material standards – Basic EN and ASTM documents

Table 19

Stainless steel – referenced standards for flat products (chemical compositions, product tolerances, typical properties)	
EN ISO 18286	Hot-rolled stainless steel plates – Tolerances on dimensions and shape
EN 10051	Hot rolled steel strip. Tolerances
EN 10088-1	Stainless steels. – List of stainless steels
ISO 15510	Stainless steels – Chemical composition
EN ISO 9445	Cold rolled stainless narrow strip, wide strip, plate/sheet and cut lengths. Tolerances
ASTM A 480	General requirements for flat-rolled stainless and heat restisting steel (+ASME SA480)
ASTM A 959	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 10088-4	Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction 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 A 167	Stainless and heat-resisting Cr-Ni steel plate, sheet and strip
ASTM A 176	Stainless and heat-resisting Cr steel plate, sheet and strip
ASTM A 240	Heat-resisting Cr and Cr-Ni stainless steel plate, sheet and strip for pressure vessels (+ASME SA240)
ASTM A 666	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 10059	Dimensions and tolerances, hot rolled square steel bars
EN 10060	Hot rolled round steel bars. Tolerances
EN 10088-3	Stainless steels. – Semi-finished products, bars, rods, sections for general purposes
EN 10088-5	Technical delivery conditions for bars, rods wire, sections and bright products of corrosion resisting steels for construction purposes
EN 10263-5	Steel rod, bars and wire for cold heading and extrusion. – Stainless steel
EN 10269	Steels and nickel alloys for fasteners with specified properties at elevated or low temperatures
EN 10272	Stainless steel bars for pressure purposes
EN 10278	Dimensions and tolerances of bright steel products
ASTM A 193	Alloy and stainless steel bolting material for high-temperature service
ASTM A 276	Stainless and heat-resisting steel bars and shapes
ASTM A 479	Stainless steel bars for boilers/pressure vessels (+ASME SA479)
ASTM A 484	General requirements for stainless and heat-resisting steel bars, billets, forgings (+ASME SA484)
ASTM A 493	Stainless and heat-resisting steel rod and wire for cold heading and forging
ASTM A 555	General requirements for stainless and heat resistant steel wire and wire rod
ASTM A 564	Specification for hot-rolled and cold-finished age-hardening stainless steel bars and shapes
Pipe	
ASTM A 312	Seamless, welded, and heavily cold worked austenitic stainless steel pipes
ASTM A 358	Electric fusion-welded austenitic CrNi stainless steel pipe for high-temperature service and general applications
ASTM A 790	Seamless and welded duplex stainless steel pipe
ASTM A 928	Duplex stainless steel pipe electric fusion welded with addition of filler metal

Microstructure characterisation and test methods

Table 20

Parameter	Test methods		Reported result
Grain size[4]	ISO 643	ASTM E 112	µm, mean value, s, 95% conf int, %rel accuracy; ASTM grain size number G
Austenite spacing		ASTM E 112 with amendments	µm
Phase content		ASTM E 562, E 1245	vol% ± 95% conf int; %rel accuracy
Inclusion content[5]	ISO 4967	ASTM E 45	At r, Ah s; Bt t, Bh u; Ct v, Ch w; Dt x, Dh y
	DIN 50602 M		SS x, OA y, OS z, OG w
	DIN 50602 K		K0; K1; K2; K3; K4, resp.
	EN 10247		Length µm/mm^2, number/mm^2, area µm^2/mm^2
	SS111116		Area%, length mm/mm^2, number/mm^2 (total, per types A, B, C, D and thickness groups Thick, Medium, Heavy)
Carbides[6]	ASTM A 262 A		Approved
Intermetallic phases[6]	ASTM 923 A (for duplex)		Approved

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/cm^2).

[3] Hardness is converted according to ASTM E 140.

[4] Conversion from ASTM No. to EN according to ASTM E 112: 5 = 64 µm; 6 = 45 µm; 7 = 32 µm; 8 = 23 µm; 9 = 16 µm.

[5] Type A = ductile, B = brittle, C = brittle/ductile, D = undeformed. Assessment and conversion according to SS 111116.

[6] Indirect method for approval only.

Common acronyms and abbreviations

Table 21

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

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