



TATA

Tata Steel International (Australasia) Ltd

Service Centre & Technical Info

Stainless Steel

The background of the entire page is a photograph of a steel mill. A large ladle, marked with '2A', is tilted, pouring molten metal into a mold. A massive spray of bright orange sparks falls from the point of contact. The scene is illuminated by the intense heat of the metal, creating a dramatic, industrial atmosphere.

TATA STEEL

CUT TO LENGTH LINE

Corus Metals was the first company in New Zealand to install a dedicated Stainless steel Cut to Length line.

Corus recognised the need in the industry to assist designers, engineers and fabricators by giving them the ability to design with the added flexibility of a wide range of sheet sizes.



Specifications:

Width: up to 1524mm
Thickness: 0.45 tp 3.00mm
Length: Standard lengths up to 3658mm and by arrangement up to 6000mm

Economy:

Custom lengths can eliminate expensive wastage = Savings

No Contamination:

Dedicated to Stainless Steel: Low risk to cross metallic contamination

Materials:

304-2B, 316-2B, 430-2B, 304-Satin, 316-Satin, 430 Satin, 304 BA, 430 BA,
Deco - Patterned and Embossed Stainless Steel
Other Stainless Steel material by arrangement.

Protection:

Polyethylene or PVC coating of finished product can be applied to protect the surface.
This can be applied to one or both sides as required.
Laser quality film available

Benefits:

NEW ZEALAND'S ONLY DEDICATED STAINLESS STEEL CUT TO LENGTH LINE.
Low risk to cross metallic contamination
Added Degree of Flexibility in design.
Cost savings

SHEET POLISHING

New Zealand's only commercial Stainless Steel Sheet Polisher giving the advantage of consistent finish.

All sheets supplied are polished on the same machine.

Stainless Steel:

Finish: Satin, often referred to as No4, Brushed, Linished. The sheets are supplied polished one side only as standard. Both sides can be polished by arrangement

Width: up to 1524mm

Thickness: 0.70 to 3.00mm

Length: Minimum length = 650mm. Standard stock lengths up to 3658mm and by arrangement up to 6000mm. Please check with your local Corus Office regarding availability of lengths prior to specifying.



Materials:

304 - Satin, 316 Satin, 430 Satin, Deco - Aluminium - Brass other Stainless Steel material by arrangement

Economy:

Custom Lengths can eliminate expensive wastage = Savings

Benefits:

Consistent Finish

Flexibility in widths and lengths

Eliminate expensive wastage

Added flexibility in design

Aluminium:

This is a service offered to Aluminium merchants and is supplied as a polishing service only.

Finish: No4 (240grit) using Ali Oxide Belts

Thickness: 1.20 to 3.00mm

Width: Subject to merchant's range up to 1524mm

Length: Subject to merchant's range and by arrangement up to 6000mm

Benefits:

Adds an attractive decorative finish to the surface.

Surface Protection:

Polyethylene or PVC coating is applied to the finished product to protect the surface. This is applied to one side as standard to protect the surface during transportation and fabrication. Laser quality film available.

FLAT BAR AND ANGLE POLISHING

Stainless Steel Flat Bar and Angle is widely specified in architectural applications for structural and aesthetic reasons. Corus Metals, with its in - house Flat Bar and Angle Polisher enhances the standard finish with an attractive No4 or No6 Scotchbrite Polish.



Flat Bar:

Sizes: 12mm x 3mm to 300mm x12mm (other thicknesses subject to availability)

Width: 12mm to 260mm

Thickness: 3mm to 12mm (Thicker material can be polished subject to availability)

Edges: To a maximum width of 150mm

Finishes: No4 (240 Grit)

No6 (Scotchbrite Finish)

Other sizes and finishes by arrangement

Note: Quality of finish is subject to base surface condition of material. As part of the process both faces must be polished.

Angle:

Sizes: 20x20x3 to 100x100x10

Outside faces only

Finish: No4 (Standard 120 Grit)

Other finishes by arrangement

Note: Quality of finish is subject to base surface condition of material

Protection:

Polyethylene or PVC coatings of finished products are applied to protect the surface

Laser quality film available

Benefits:

Decorative finish to Flat Bar / Angle

Consistent finish

Saving in time to polish

SERVICE CENTRE FACILITIES

Continued

OTHER SERVICES AVAILABLE THROUGH CORUS METALS BRANCHES

- PLASMA CUTTING
- FOLDING
- WELDING
- TUBE POLISHING
- GUILLOTINING
- LASER CUTTING
- MACHINING
- SCHEDULE PIPE POLISHING

NB PLEASE CONTACT CORUS METALS REGARDING THESE SERVICES

SURFACE FINISHES

No. 1 Finish Hot Rolled Annealed and Pickled. Usually found on flat bar and on thick plate.

No. 2A Finish (To BS1449) referred to as "BA" or "Bright Annealed". Cold Rolled and Bright Annealed through inert gases which react with chromium to impart a highly reflective surface.

No. 2B Finish (To BS1449) cold rolled, softened and descaled and lightly rolled on polished rolls. Similar to 2D but may be smoother and brighter.

No. 2D Finish (To BS1449) cold rolled softened and descaled. Giving a uniform matt grey finish.

No. 2E Finish Cold rolled, annealed, shotblasted and pickled. (2205/2304/253 MA).

Satin Finish Mechanical polishing with abrasives of between 120-150 grit depending on manufacturer's procedures. Commonly referred to as "No. 4", "Brush" or "Linished" finish.

**WITH THIS FACILITY CORUS METALS DEMONSTRATES A COMMITMENT
TO MEETING THE NEEDS OF THE NEW ZEALAND MARKET**

STEEL GRADES

Corrosion Resisting - Heat and Creep Resisting

Stainless Steels from Outokumpu

Outokumpu is one of the world's leading manufacturers of stainless steel. The Group offers a wide range of austenitic grades, including high-alloy special steels for demanding corrosive environments. The production range also includes duplex (ferritic-austenitic), ferritic and martensitic grades.

Outokumpu steel melting practice includes melting in electric arc furnaces, refining in AOD or CLU converters and continuous casting or ingot casting.

Outokumpu stainless steels are available in a wide range of product forms such as sheet, plate, tube, etc. Table 1 provides at a glance information; more detailed data is given in specific product folders and leaflets.

Technical and other data in this publication are typical for wrought products and may not be regarded as guaranteed maximum or minimum values for a given product, unless otherwise specifically stated.

Austenitic and Duplex Steel Grades

The most common Outokumpu steels (austenitic and duplex) are given in Table 1 with typical values for chemical composition. Besides the steels presented here, other variants and less common steels intended for special purposes or tailored to special customer specifications are manufactured by agreement. .

Structure

A ferrite number (FN) can be calculated from the heat analysis, providing a measure of the steel's tendency to form ferrite upon rapid solidification. In the final product, however, the ferrite content is negligible in the austenitic steels.

Steels that have to meet high requirements of purity and structure are remelted in an ESR plant (electroslag refining).

Improved properties for machining are obtained through special metallurgical practice that alters the steel structure. Standard steels treated by this method are marketed with the suffix PRODEC®.

Outokumpu Stainless

The logo for Outokumpu, featuring the word "OUTOKUMPU" in a bold, sans-serif font. The letters are arranged in two rows: "OUTO" on top and "KUMPU" below it. The letters are a light gray color.

STEEL GRADES

Table 1: Chemical composition - product range

Steel Grade			Chemical Composition, average %						Outokumpu products
EN	ASTM	OTK NAME	C	N	Cr	Ni	Mo	Others	
1.4016	430	4016	0.04	-	16.5	-	-	-	CNBR
1.4510	S43035	4510	0.04	-	18	-	-	Ti	CR
1.4021	420	4021	0.20	-	13	-	-	-	HNBR
1.4028	420	4028	0.30	-	12.5	-	-	-	NR
1.4418	-	248 SV	0.03	0.04	16	5	1	-	PBR
1.4162	S32101	LDX 2101	0.04	0.20	21	1.35	0.1	4Mn	On request
1.4362	S32304	SAF 2304®	0.02	0.10	23	4.8	0.3	-	PHC
1.4462	S32205	2205	0.02	0.17	22	5.7	3.1	-	PHCBR
1.4501	S32760	4501	0.03	0.2	24	6.0	3.0	0.2W	P
1.4410	S32750	SAF 2507®	0.02	0.27	25	7	4	-	PC
1.4310	301	4310	0.10	0.03	17	7	-	-	HCNBR
1.4318	301LN	4318	0.02	0.15	17	7	-	-	HC
1.4372	201	4372	0.05	0.15	17	5	-	6.5Mn	HCNR
1.4301	304	4301	0.04	0.05	18.1	8.3	-	-	PHCNBR
1.4307	304L	4307	0.02	0.06	18.1	8.3	-	-	PHCNBR
1.4311	304LN	4311	0.02	0.14	18.5	10.5	-	-	PHCNBR
1.4541	321	4541	0.04	0.01	17.3	9.1	-	Ti	PHCNBR
1.4305	303	4305	0.05	0.06	17.3	8.2	-	S	BR
1.4306	304L	4306	0.02	0.04	18.2	10.1	-	-	PHCNBR
1.4303	305	4303	0.02	0.02	17.7	11.2	-	-	HCNBR
1.4567	S30430	4567	0.01	0.02	17.7	9.7	-	3.3Cu	BR
1.4401	316	4401	0.04	0.04	17.2	10.2	2.1	-	PHCNBR
1.4404	316L	4404	0.02	0.04	17.2	10.1	2.1	-	PHCNBR
1.4406	316LN	4406	0.02	0.14	17.2	10.3	2.1	-	PHCNBR
1.4571	316Ti	4571	0.04	0.01	16.8	10.9	2.1	Ti	PHCNBR
1.4436	316	4436	0.04	0.05	16.9	10.7	2.6	-	PHCNBR
1.4432	316L	4432	0.02	0.05	16.9	10.7	2.6	-	PHCNBR
1.4435	316L	4435	0.02	0.06	17.3	12.6	2.6	-	PHCNBR
1.4429	S31653	4429	0.02	0.14	17.3	12.5	2.6	-	P
1.4438	317L	4438	0.02	0.07	18.2	13.7	3.1	-	PHCNBR
1.4439	317LMN	4439	0.02	0.14	17.8	12.7	4.1	-	PHC
1.4539	904L	904L	0.01	0.06	20	25	4.3	1.5Cu	PHCNBR
1.4547	S31254	254 SMO®	0.01	0.20	20	18	6.1	Cu	PHCNBR
1.4652	S32654	654 SMO®	0.01	0.50	24	22	7.3	3.5Mn, Cu	On request
1.4948	304H	4948	0.05	0.06	18.1	8.3	-	-	PHCBR
1.4878	321H	4878	0.05	0.01	17.3	9.1	-	Ti	PHCNBR
1.4818	S30415	153 MATM	0.05	0.15	18.5	9.5	-	1.3Si, Ce	PCNBR
1.4833	309S	4833	0.06	0.08	22.3	12.6	-	-	PHCNBR
1.4828	-	4828	0.04	0.04	20	12	-	2Si	CNBR
1.4835	S30815	253 MA®	0.09	0.17	21	11	-	1.6Si, Ce	PHCNBR
1.4845	310S	484S	0.05	0.04	25	20	-	-	PHCNBR
1.4854	S35315	353 MA®	0.05	0.17	25	35	-	1.3Si, Ce	PC

Austenitic
 Ferritic
 Martensitic
 Duplex
 Heat Resisting

Outokumpu Products

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

STEEL GRADES

Product Standards

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

Table 2: Steel designations

Steel Grade		OTK steel name	National steel designation superseded by EN			
En	ASTM		BS	DIN	SS	NF
1.4162	S32101	LDX 2101	-	-	-	-
1,4362	S32304	SAF 2304	-	1,4362	2327	Z3 CN 23-04 Az
1,4462	S32205	2205	318S13	1,4462	2377	Z3 CND 22-05 Az
1,4410	S32750	SAF 2507	-	-	2328	Z3 CND 25-06 Az
1,4310	301	4310	301S21	1,4310	2331	Z11 CN 18-08
1,4372	201	4372	-	-		Z12 CMN 17-07 Az
1,4301	304	4301	304S31	1,4301	2333	Z7 CN 18-09
1,4307	304L	4307	304S11		2352	Z3 CN 18-10
1,4311	304LN	4311	304S61	1,4311	2371	Z3 CN 18-10 Az
1,4541	321	4541	321S31	1,4541	2337	Z6 CNT 18-10
1,4306	304L	4306	304S11	1,4306	2352	Z3 CN 18-10
1,4303	305	4303	305S19	1,4303	-	Z1 CN 18-12
1,4401	316	4401	316S31	1,4401	2347	Z7 CND 17-11-02
1,4404	316L	4404	316S11	1,4404	2348	Z3 CND 17-11-02
1,4406	316LN	4406	316S61	1,4406	-	Z3 CND 17-11 Az
1,4571	316Ti	4571	320S31	1,4571	2350	Z6 CNDT 17-12
1,4436	316	4436	316S33	1,4436	2343	Z7 CND 18-12-03
1,4432	316L	4432	316S13	-	2353	Z3 CND 17-12-03
1,4435	316L	4435	316S13	1,4435	2353	Z3 CND 18-14-03
1,4429	S31653	4429	316S63	1,4429	2375	Z3 CND 17-12 Az
1,4438	317L	4438	317S12	1,4438	2367	Z3 CND 19-15-04
1,4439	317LMN	4439	-	1,4439	-	Z3 CND 18-14-05 Az
1,4539	904L	904L	904S13	1,4539	2562	Z2 NCDU 25-20
1,4547	S31254	254 SMO	-	-	2378	-
1,4948	304H	4948	304S51	1,4948	2333	Z6 CN 18-09
1,4818	S30415	153 MA	-	-	2372	-
1,4828	-	4828	-	1,4828	-	Z17 CNS 20-12
1,4835	S30815	253 MA	-	-	2368	-
1,4854	S35315	353 MA	-	-	-	-

STEEL GRADES

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

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

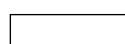
Design values stipulated in national standards apply to pressure vessel plate. The design values are based on the material's proof stress and/or tensile strength.

The strength properties of standard austenitic grades can be approved –

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

Table 3: Mechanical properties (room temperature)

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



Austenitic



Duplex



Heat Resisting

R_p = Proof (Yield) Stress
R_m = Tensile Strength
A₅ = Elongation

1 N/mm² = 1 MPa
= 10 bar
= 145.04 psi

Table 4: Strength (elevated temperatures)

STEEL GRADE		PROOF STRESS AT ELEVATED TEMPERATURES					
EN	ASTM	R _p 0.2, MIN N/mm ²					
		50°C	100°C	200°C	300°C	400°C	500°C
1.4301	304	186	163	137	123	114	105
1.4307	304L	168	148	124	111	103	94
1.4311	304LN	228	198	160	138	125	117
1.4541	321	191	173	150	137	129	124
1.4401	316	196	175	148	133	124	117
1.4404	316L	187	164	137	123	114	105
1.4406	316LN	250	211	175	155	140	130
1.4571	316Ti	197	180	159	145	136	129
1.4436	316	196	175	148	133	124	117
1.4432	316L	187	164	137	123	114	105
1.4438	317L	196	172	144	129	119	110
1.4439	–	260	225	185	165	150	140
1.4539	904L	190	176	155	136	125	120
1.4547	S31254	270	235	195	175	160	150
1.4652	S32654	385	350	315	300	295	280
1.4162	S32101	430	380	330	300	-	-
1.4362	S32304	370	330	290	260	-	-
1.4462	S32205	415	360	310	280	-	-
1.4410	S32750	-	470	420	380	-	-
1.4845	310S	186	163	137	123	114	105
1.4818	S30415	245	200	165	150	140	130
1.4835	S30815	280	230	185	170	160	150

STEEL GRADES

Physical Properties

The table below gives typical values at room temperature.

Corrosion resistance

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

Table 5: Physical properties (room temperature)

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

Austenitic

Duplex

Heat Resisting

STEEL GRADES

Other Material Data

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

Quench annealing

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

Pressure vessel application

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

Table 6: Other material data

STEEL GRADE		SCALING TEMPERATURE IN AIR °C	HOT FORMING °C	QUENCH ANNEALING, COOLING IN AIR (A) OR WATER (W) °C	PRESSURE VESSEL APPLICATION °C
EN	ASTM				
1.4301	304	850	1150 – 900	1050 A/W	(-270) – 800
1.4307	304L	850	1150 – 900	1050 A/W	(-270) – 800
1.4311	304LN	850	1150 – 900	1050 A/W	(-270) – 800
1.4541	321	850	1150 – 900	1050 A/W	(-270) – 800
1.4401	316	850	1150 – 900	1070 A/W	(-160) – 750
1.4404	316L	850	1150 – 900	1070 A/W	(-160) – 750
1.4406	316LN	850	1150 – 900	1070 A/W	(-270) – 750
1.4571	316Ti	850	1150 – 900	1070 A/W	(-160) – 750
1.4436	316	850	1150 – 900	1070 A/W	(-160) – 750
1.4432	316L	850	1150 – 900	1070 A/W	(-160) – 750
1.4438	317L	850	1150 – 900	1100 A/W	(-60) – 500
1.4439	–	850	1150 – 900	1100 W	(-60) – 550
1.4539	904L	1000	1200 – 950	1120 W	(-60) – 400
1.4547	S31254	1000	1200 – 1000	1170 W	(-60) – 400
1.4652	S32654	1000	1200 – 1100	1170 W	(-60) – 400
1.4162	S32101	850	1100 – 900	1050 A/W	(-40) – 280
1.4362	S32304	1100	1100 – 950	1000 A/W	(-40) – 280
1.4462	S32205	1000	1150 – 950	1050 A/W	(-10) – 280
1.4410	S32750	1000	1120 – 1020	1070 A/W	(-10) – 280
1.4845	310S	1150	1150 – 900	1070 W	(-60) – 1000
1.4818	S30415	1050	1150 – 900	1070 A/W	600 – 850
1.4835	S30815	1150	1150 – 900	1070 A/W	800 – 1000
1.4854	S35315	1170	1150 – 900	1070 A/W	–

STEEL GRADES

Welding

Austenitic stainless steels possess very good welding ability. Ferritic steels are more difficult to weld and ferritic consumables are not available. Austenitic filler metals type 309L and Avesta P5 (309LMo) can sometimes be used. The table below gives recommended filler materials produced by Avesta Welding AB.

Ferrite and Martensite Numbers

These numbers reflect the structural stability of stainless steels and their tendency of forming ferrite or martensite. They are primarily used to balance the compositions of stainless steel grades in order to influence desired properties with respect to, for instance, welding, hot forming, cold forming or permeability.

The ferrite number FN is an empirical value which describes the amount of ferrite obtained after rapid solidification of an austenitic melt (weld metal or ingot). This number is calculated with the aid of equivalents for the ferrite and austenite forming elements in the steel composition and the use of a Schaeffler diagram.

In the Schaeffler diagram opposite the following formulae for calculating ferrite numbers (FNA) have been used. Some typical Outokumpu grades are plotted in this diagram. There are also other formulae for this calculation.

Table 11: Welding Consumables

STEEL GRADE		AVESTA WELDING CONSUMABLES	
EN	ASTM	ELECTRODES	WIRE
1.4301	304	308L/MVR	308L-Si/MVR-Si ¹⁾
1.4307	304L	308L/MVR	308L-Si/MVR-Si ¹⁾
1.4311	304L	308L/MVR	308L-Si/MVR-Si ¹⁾
1.4541	321	347/MVR	347-Si/MVR-Si ¹⁾
1.4401	316	316L/SKR	316L-Si/SKR-Si ²⁾
1.4404	316L	316L/SKR	316L-Si/SKR-Si ²⁾
1.4406	316LN	316L/SKR	316L-Si/SKR-Si ²⁾
1.4571	316Ti	316L/SKR	316L-Si/SKR-Si ²⁾
1.4436	316	316L/SKR	316L-Si/SKR-Si ²⁾
1.4432	316L	316L/SKR	316L-Si/SKR-Si ²⁾
1.4438	317L	317L/SNR	318/SKNb ⁴⁾
1.4439	–	SLR-NF	SLR-NF
1.4539	904L	904L	904L
1.4547	S31254	P12	P12 alt. P16
1.4652	S32654	P16	P16
1.4162	S32101	LDX 2101	LDX 2101
1.4362	S32304	2205, 2304	2205
1.4462	S32205	2205	2205
1.4410	S32750	2507/P100	2507/P100
1.4845	310S	310	–
1.4818	S30415	253 MA	253 MA
1.4835	S30815	253 MA	253 MA
1.4854	S35315	353 MA	253 MA

1) 308L/MVR when low Si content is necessary, e.g. by submerged-arc welding.

2) 316L/SKR when Si content is necessary, e.g. by submerged-arc welding.

3) 308L/MVR respectively 316L/SKR if the operating temperature of the construction is maximum.

4) 308L-Si/MVR-Si respectively 316L-Si/SKR-Si if the operating temperature of the construction is maximum 400°C.

5) Matching filler metals are recommended for nitric acid environments. Contact our welding specialists for instructions.

Austenitic

Duplex

Heat Resisting

STEEL GRADES

Welding (cont.)

Chromium equivalent: $F = 1.5 \text{ Si} + \text{Cr} + \text{Mo} + 2 \text{ Ti} + 0.5 \text{ Mb}$.

Nickel equivalent: $A = 30 (\text{C} + \text{N}) + 0.5 \text{ Mn} + \text{Ni} + 0.5 \text{ Cu} + 0.5 \text{ Co}$.

Ferrite number: $\text{FNA} = 3.34 \text{ F} - 2.46 \text{ A} - 28.6$.

Formulae are applicable to most standard austenitic grades having FNA = maximum 6.0.

For alloys with higher FNA and for duplex grades, modified FNA formulae are used.

The martensite numbers MN describes the tendency for austenite to form martensite upon cold deformation. A high figure indicates low austenite stability and vice versa.

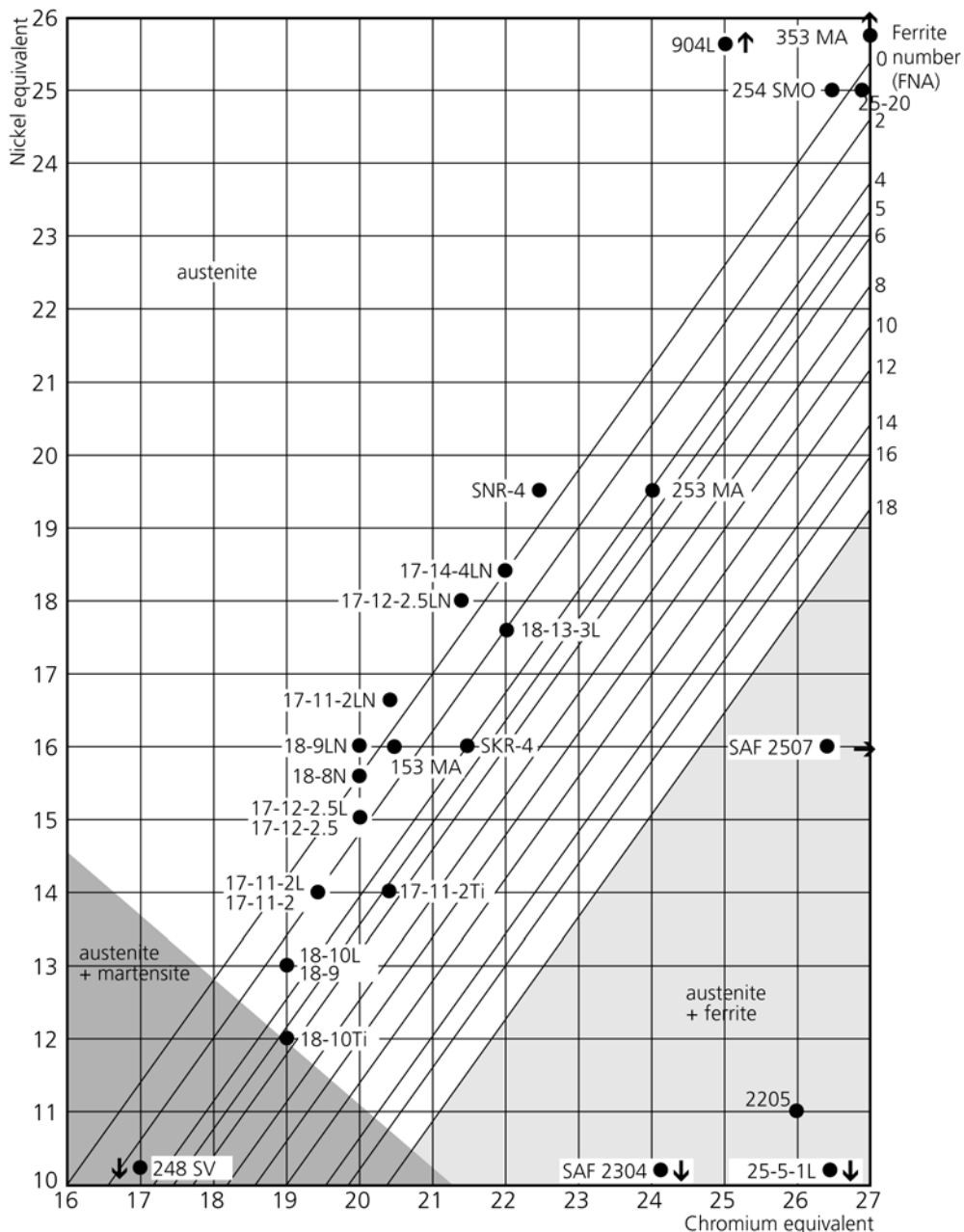
Angel and Norah determined an empirical number (Md30) for the temperature (°C) at which 30% deformation gives 50% martensite. Within Outokumpu this number is called MNA and calculated as follows:

$\text{MNA} = 551 - 462 (\text{C} + \text{N}) - 9.2 \text{ Si} - 8.1 \text{ Mn} - 1.37 \text{ Cr} - 29 (\text{Ni} + \text{Cu}) - 18.5 \text{ Mo} - 68 \text{ Nb}$

Typical MNA-values for some stainless steels grades are:

17-7 = +30; 17-11-2L = -100; 18-9 = -20; 254 SMO = -480; 18-9LN = -80.

Schaeffler diagram



DESIGN CONSIDERATIONS WHEN SPECIFYING STAINLESS STEEL

Corrosion may be defined as the chemical interaction between a metal and its environment to form compounds. The reaction of metals with gases (sometimes referred to as dry corrosion) can be distinguished from the reaction of metals with aqueous solutions (wet corrosion) which involves complex electro-chemical processes. Generally, stainless steels as a group of alloy steels are susceptible to both types of attack mentioned, depending on the grade of material selected, the structural design chosen, the method of fabrication used and the service conditions prevailing.

An alloy consists of a homogeneous mixture of two or more elements, of which at least one is a metal and all the resulting phases have metallic properties. The high alloy stainless steels are usually chosen as structural materials because of their corrosion resistance and attractive surface finish and because they require minimum maintenance in operation. These properties of the stainless alloys are intimately related, because the surface of a stainless steel is covered with a very thin, tenacious film of chromium oxide which "passivates" the metal surface, giving to it the "stainless" qualities. If mechanically damaged, the film will reform (i.e. re-passivate) in the presence of oxygen, or other oxidants, as long as the chromium content exceeds about 12%.

Although passive oxide films on metals and alloys give excellent protection against corrosion, they have the disadvantage that a change in the service conditions can lead to destruction of the protective oxide film and consequently to rapid general or localised corrosion. In this condition the alloy is said to be "active" and it may suffer from a rate of corrosive attack comparable with that for plain mild steel. This relatively rare problem may be overcome by careful selection of a grade of stainless steel which is more corrosion-resistant because of the addition of alloying elements such as molybdenum, copper, titanium and niobium.

Corrosion problems encountered with stainless steels

Several types of corrosion impair the successful use of stainless steels. Many failures can be prevented by the early recognition of corrosion damage and by taking the necessary steps to avoid them. Stainless steels can suffer several types of corrosion damage:

- high temperature corrosion
- general corrosion
- pitting corrosion
- crevice corrosion
- galvanic corrosion
- inter-granular corrosion
- stress corrosion cracking
- M.I.C micro-biologically induced corrosion

High temperature corrosion

If stainless steel comes into contact with hot gases, direct chemical reaction may occur between the gas and one of more of the alloying elements in the steel. The products of these reactions depend on the gas (or vapour) and the type of stainless steel. But a surface film will be formed which may protect the underlying metal against attack, as long as it does not become a scale or cause a metallurgical phase change to occur. The **scaling** temperature of ferritic and austenitic stainless alloys is about **850°C**, above which deleterious thermal stresses may lead to cracking and scaling of the protective film. Some points about oxidation of stainless steel in hot gases that should be remembered are:

- (1) Extended **exposure** at **high** temperatures can result in **embrittlement** of austenitic stainless steels, or in "**sensitisation**" which diminishes the ability of the alloy to withstand corrosion, particularly in **acid-chloride** conditions.
- (2) **Thermal cycling**, particularly in the presence of **moisture** and **condensation**, has a deleterious effect on some stainless steels. **Ferritic** steels are less affected by this problem than are **austenitics**, owing to a **lower coefficient of thermal expansion**.
- (3) The choice of stainless steels for high temperature use requires a knowledge of the service conditions, such as the likely operating temperature and the composition of any gases present.
- (4) Stainless steels **containing** nickel (i.e. the 300 series austenitic alloys) are **susceptible** to a special type of corrosive attack in the presence of a **reducing** atmosphere containing **sulphur** compounds, such as **hydrogen sulphide**. This atmosphere can be generated in a flue by combustion of oil, coal or coke and flue gases are thus frequently very corrosive towards type 304 stainless steel.

DESIGN CONSIDERATIONS

continued

General corrosion

Stainless steels require adequate access to air (oxygen) to maintain the passive oxide film. If the surface of the steel becomes active through contact with reducing agents (such as hydrogen sulphide and sulphur dioxide) in acidic conditions, then general corrosion of the steel can result. **Passivity** of the surface can be **restored** by **removal** of any **corrosion** products and treatment with a solution of an oxidising acid such as **nitric acid**. **Hydrochloric acid** should **not** be used for this purpose as chlorides have a deleterious effect on the passive film, which can lead to localised pitting.

Pitting corrosion

If there is a highly localised loss of passivity, such as may occur in the presence of chlorides, bromides or fluorides, then pitting can take place. This produces cavities penetrating deeply into the metal at a much faster rate than general corrosion. A small anode inside the pit becomes acidic and very active, leading to rapid metal dissolution and insidious attack at weak points across the surface. Pitting may be controlled by the following methods:

- Select Type 316 (containing molybdenum) stainless steel or a proprietary duplex grade, which have increased resistance to pitting attack.
- Aerate or agitate aqueous solutions in contact with stainless steel to eliminate stagnant pockets.
- Design **out** any **crevices** from structures and maintain a **good surface finish** which provides the best resistance to pitting.
- Where possible **avoid** contact with **chlorides** and other **foreign ions** which may initiate localised corrosion.

Crevice corrosion

This form of corrosive attack **concentrates** in narrow fissures where **oxygen** access is **poor**. Inside the crevice a small anode forms and remains active while the large cathodic surface outside the crevice remains passive and accentuates the attack. Stainless steels are very **susceptible** to **crevice** corrosion which can occur in **welds** that **fail** to **penetrate**, in flange joints and under deposits on the steel surface. Essentially, pitting and crevice corrosion are the same phenomenon, but the attack starts more easily in a fissure than on a clean surface. Therefore, to minimise this problem, attention should be paid to the same details that reduce pitting. However, if crevices **cannot** be avoided, then they should be **sealed off** with mastic or silicone rubber to **eliminate** moisture ingress. In certain situations the use of a welded overlay in susceptible areas, involving a more corrosion-resistant alloy type, may be considered, particularly if erosion by moving liquid corrodents is also a potential problem. The **use** of stainless steels **embedded** in concrete should present **few** problems **except** at the steel-concrete interface with the atmosphere, where a **crevice-type** situation could develop and contaminants might accumulate. It would be advisable to seal these crevices with a mastic or butyl rubber to avoid any possibility of localised attack at this junction.

Intergranular corrosion

Intergranular corrosion occurs along the **grain boundaries** of a metal without appreciable attack within the grains. Metals affected by intergranular corrosion may **lose** their metallic properties such a ductility and crack easily when bent. This damage is usually not visible and is minimal compared with the amount of metal oxidised.

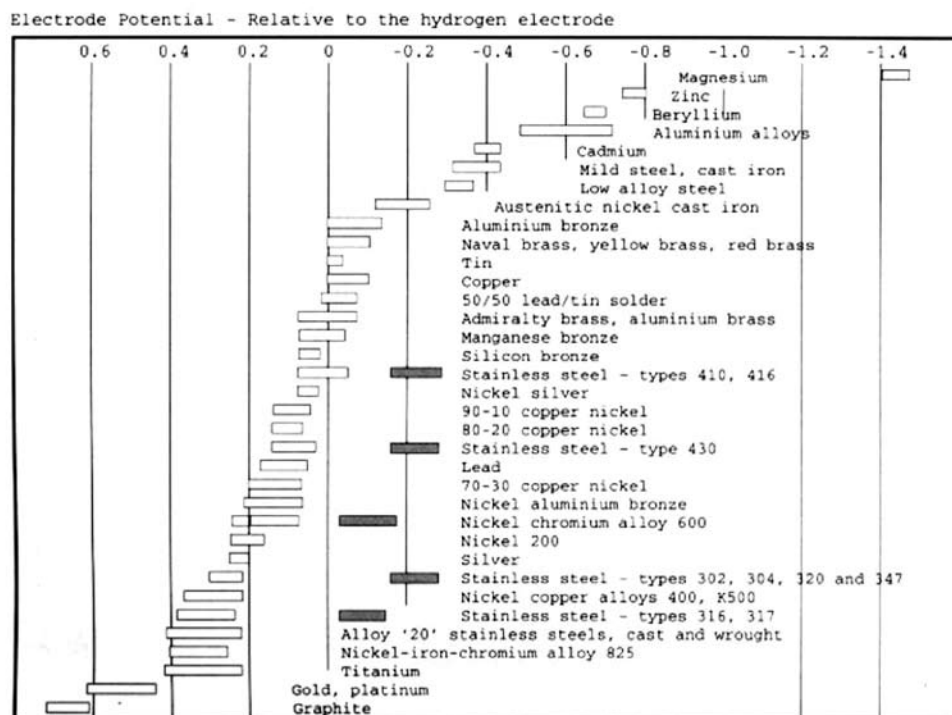
The mechanism of intergranular corrosion involves a difference in electric potential established between the grain boundaries and the interior of the grains. This can arise because of the presence of precipitate-free zones which can accompany intermetallic precipitate formation in the grain boundaries. Thus, austenitic stainless steel, e.g. Type 304, may **lose** some **chromium** near grain boundaries through formation of **chromium carbides** when **heated** between **550°C** and **850°C** (called "**sensitisation**"). The **chromium-depleted** zones become anodic relative to the remainder of the **passive** surface and chemical action in the presence of a corrodent can result in rapid attack along the grain boundaries.

An example of intergranular corrosion is "**weld decay**" which may occur in the **heat-affected** zone of a welded seam in sensitised austenitic stainless steel. This problem can be overcome by the **use** of very **low carbon** steels ("L" type), or **stabilised** grades containing **titanium** (Type 321) or niobium (Type 347). A solution **heat treatment** procedure will also **remove** the **chromium carbide** phase but this method is **rarely** used. **Excessive** heat input and **arc strikes** during welding can also lead to intergranular attack on or close to welds in stainless steels once the alloy is in use. Welding procedures which may be suitable for austenitics are not necessarily suitable for ferritic types.

DESIGN CONSIDERATIONS

continued

Galvanic Series of metals and alloys in sea water



Note: There are two ranges quoted for the stainless steels and nickel-chromium alloy 600. The more positive is the passive condition. The more negative when this film is not present, e.g. in chloride solutions.

Galvanic corrosion

Galvanic corrosion is the **oxidation** of the less **noble** (or more active) member of a pair of metals which are in contact and is also called **dissimilar metal corrosion**. The intensity of the attack (i.e. the rate of corrosion) on the more active metal depends on the following factors:

- The **reactivity** of the **dissimilar** metals is indicated by their relative positions in the Galvanic Series of metals. If two metals are coupled, the metal **nearer** the **active** end of the series will be **anodic** and suffer **increased** corrosion, whereas the metal **nearer** the **bottom** will be the **cathode**. Generally, the **further** apart the **two** metals are in the Galvanic Series, the **worse** will be the galvanic corrosion of the more **reactive** metal. If **dissimilar** metal contact is **inevitable**, then metals should be selected which are **very close** in the Galvanic Series.
- In practice, a **large cathode** coupled to a **small anode** will give very **intense corrosion** and can lead to **severe damage** of the **anodic** metal.
- **Insulation** of dissimilar metals will increase the **resistance** of any electrolyte between anode and cathode, thereby **reducing** the corrosive attack.

In **oxidising** solutions, stainless steels behave as **cathodes** and any other metal in contact may corrode. When the solution is **reducing**, the stainless steel may become **active** and metals such as copper and its alloys become **cathodic** and **accelerate** the corrosion of the stainless steel.

Under certain conditions when a stainless steel forms a **galvanic cell**, hydrogen ions (acid) may be formed, which can **alter** the surface of the stainless steel from **passive** to **active**, with a consequent **shift** in its **position** in the Galvanic Series. This can have a deleterious effect on the stainless alloy. For example, a **small** piece of **mild steel**, **copper**, **scale** or **other foreign matter** embedded into stainless steel may be sufficient to **destroy passivity** at the point of contact. The attack **starts** as a **microgalvanic cell** and pitting action can be initiated which, unless re-passivated, will lead to insidious attack. To avoid this problem, when stainless steel structures are **commissioned** into service they should be **free** from oil, scale, grinding dust or small particles of steel from tools, dies or rollers. On **no** account should **welding slag** or **other contamination** be removed from a stainless steel surface with a **mild steel wire brush**. Only a **stainless steel brush** should be used and even this may affect the passivity by increasing the surface roughness, creating microcrevices on the alloy surface.

DESIGN CONSIDERATIONS

continued

Stress corrosion cracking

If a metal is subjected to a tensile stress and is simultaneously subjected to a corrosive environment, then a rapid form of penetrating attack can occur called stress corrosion cracking (SCC). Stresses, whether static or fluctuating, weaken the passive oxide film on the metal and cause accelerated anodic attack at the highest stress points. Cracking may be intergranular or transgranular and occurs more frequently at high temperatures and in environments containing chlorides. The tensile stresses may result from manufacturing, bending or welding, or may be caused by operational factors. Heavily cold-worked parts are most susceptible to SCC in severe conditions.

To avoid SCC, attention should be given to the following points when an alloy type prone to cracking is to be used in a corrosive environment.

- Minimise residual stress levels in any stainless steel structure. Heat treatment procedures to relieve stress are available for stainless steels.
- When stress relieving is not feasible, a ferritic or a proprietary duplex alloy should be considered.
- Specify that perforated plates or steels be fully stress-relieved after forming if they are to be used as screens where the environment is known or suspected to contain a substance that induces SCC.
- Avoid cyclic bending, which repeatedly stresses stainless steels above their yield strength. This can build up internal stresses, so that even a mildly corrosive medium will cause SCC.
- Avoid joining metals of differing coefficients of expansion where a structure is to be heated and cooled in operation. Austenitic stainless steels expand about one and one-half times as much as ferritic or plain steels. Duplex alloys have similar expansion coefficients to those of the ferritic alloys.
- Avoid designs with cavities where water or liquors may collect and evaporate during cyclic operation and so build up salt concentrations in the cavity.
- Avoid build-up of corrosive salts from insulating materials, drips, condensation or corrosive sprays on the walls of vessels made of austenitic stainless steel.
- Ferritic and duplex grades of stainless steels are more SCC-resistant than are austenitics, but ferritics may suffer from pitting and present special problems when welded. Incorrect welding procedures on ferritic stainless steel (e.g. Type 444) can initiate intergranular corrosion of the weld metal, resulting in premature failure of the welding structure even in a mildly corrosive medium such as hot water of relatively low chloride content.

Corrosion fatigue and erosion

Stainless steels have higher corrosion fatigue limits than do plain carbon steels, but prior thermal treatment may have a marked influence on this form of damage. The former also show excellent resistance to cavitation, erosion and impingement attack, leading to wide usage for the manufacture of impellers and propellers for marine applications. Nevertheless, fretting corrosion, which results from friction or wear between two materials in contact (one or both of which are metals) and subject to vibration while in the presence of a corrodent, can result in damage to stainless steel. If the passive oxide film is broken down by such operating conditions, crevice corrosion and SCC may be initiated, leading to unexpected service failures.

The main causes, effects and cures of corrosion problems with stainless steels are well understood and documented. The failures that do occur could be avoided by the correct selection of the alloy type, good design and fabrication techniques and a maintenance schedule that includes regular inspection and cleaning of the structure.

Stainless Steels used in ordinary outdoor or indoor environments

Stainless steels are often specified because of their attractive appearance, even though their main attributes are long service life and low maintenance costs. But all materials - including stainless steels - may become stained in time by dirt, oil grease, paint, etc. which may impair the overall impression. Advice and suitable methods are described in this brochure, both for preventing discolouration and for cleaning stainless steel surfaces as well as for removing different types of stains.

WHAT IS STAINLESS STEEL?

Stainless steel is the collective name for a family of steel grades which, due to a content of at least 11% chromium, is inherently resistant to rust. This property is what engineers call corrosion resistance. The chromium in the steel reacts with the oxygen to which the steel surface is exposed, and forms an invisible film of chromium oxide which protects the steel against corrosion attack. This condition of the steel surface is described as being passive. If the oxide film is damaged, either mechanically or by chemical attack, the oxide film will form again spontaneously when the surface comes into contact with oxygen, even in concentrations as low as those occurring in ordinary water. The higher the chromium content, the better the corrosion resistance of the steel. This property is reinforced further if the steel is alloyed with molybdenum. Nickel is added to give the steel a structure (austenitic) which makes it easy to form and weld.

Conventional stainless steels have a chromium content of around 18% and a nickel content of 8- 9% and are known as 18-8 steels. These are generally used for kitchen equipment, domestic appliances and other indoor applications, and for parts used in moderately corrosive outdoor atmospheres. In coastal regions and in polluted urban and industrial atmospheres, molybdenum-alloyed stainless steels are usually necessary to ensure adequate corrosion resistance. This also applies to swimming baths, in which the combination of disinfectants containing chlorine and chlorine compounds, high ambient



humidity and elevated temperatures increases the risk of corrosion. See also the section on “Atmospheric corrosion” in the AvestaPolarit Corrosion Handbook.

The compositions of the most common stainless steel grades employed for normal indoor and outdoor applications are presented in the table below.

Suitable stainless steels for normal outdoor and indoor environments

EN	ASTM	Outokumpu steel name	Chemical composition typical values, %				National standard designations		
			C	Cr	Ni	Mo	SS	DIN	BS
1.4301	304	18-8	0.04	18.5	9	-	2333	1.4301	304S31
1.4401	316	17-10-2	0.04	17	11	2.2	2347	1.4401	316S31
1.4436	316	17-12-2.5	0.04	17	11	2.7	2343	1.4436	316S33

Preventive measures in project design, production and installation

All stainless steels are clean and passivated when they are delivered by the steel manufacturer. In other words, the material has a natural corrosion resistant film over its entire surface. The following instructions should be taken into account from the moment of project design, through to the production and installation stages, particularly for building components installed outdoors, in order to maintain as much as possible of the original appearance and corrosion resistance of the stainless material:

- **Specify the correct grade of steel**, taking into account the occurrence of deposits and air pollutants such as soot, sulphur dioxide, salt water or road salt in the immediate surroundings.
- **Select the correct design** that allows rain water to rinse away all deposits of dust and dirt from the entire surface.
- **Specify a grade of steel with a higher alloy content** for parts that are inaccessible to rain water or for parts installed in geographical locations where rainfall seldom occurs.
- **Use fasteners**, such as nails, screws and bolts, made of stainless steel during installation.
- **Avoid the risk of galvanic corrosion** between components of stainless steels and those of plain carbon steels in areas exposed to moisture and water (e.g. by providing electrical insulation).
- **Use clean tools** that are free from residues of plain carbon steel, such as swarf and iron particles from earlier work.



- ! Do **not** use steel brushes or steel wool made of plain carbon steel.
- ! Do **not** carry out shot blasting using ordinary steel shot or sand that has been used for shot blasting plain carbon steels.
- ! Do **not** use hydrochloric acid for removing residues of cement or mortar on stainless steel. Instead use water to wash off the mortar before it dries. Hydrochloric acid may not be used for cleaning stainless steels.

Preventive washing with water

Stainless steel building components installed outdoors, such as roofs and cladding, will usually be kept clean by normal rainfall. However, in dry geographical locations and on surfaces which are inaccessible to rainfall, it may be necessary to periodically wash the surface with water.



With components for which an attractive appearance is particularly important, such as office building cladding, shop entrances and signs, regular cleaning may be advisable in order to maintain the original sheen of the material. Washing also removes dirt and impurities that may cause corrosion attack and discolouration of the surface if they are left in place too long. The more polluted the environment, the more often such washing should be carried out. The intervals between washing can be determined from experience, but the following guidelines should be observed, depending on the grade of steel and the environment.

Environment	Washing intervals	
	(Type 304)	(Type 316)
Clean inland environment	3 - 6 months	6 - 12 months
Polluted urban environment or Industrial atmosphere	Unsuitable	6 - 12 months
Coastal atmosphere	Unsuitable	3 - 6 months



Washing is best carried out with soap or a mild detergent and warm water, followed by rinsing with clean cold water. The appearance of the surface can be improved further if the washed surface is wiped dry.

The above method of cleaning is also suitable for domestic appliances, kitchen equipment, sanitary installations and other products made of stainless steel and used in normal indoor applications.

CLEANING OF STAINLESS STEELS

How to maintain the original surface

A stainless steel may be discoloured by rust

- if it is exposed to a more aggressive environment than that for which that particular grade of steel is intended, e.g. highly polluted air, salt solutions or residues of cleaning agents containing chlorine
- if it has a rough surface finish that provides a foothold for corrosive substances and corrosion products from the surroundings
- if the design of the structure is inappropriate, with pockets and narrow gaps
- if the surface is contaminated by grinding swarf and other iron particles from tools used in the installation work
- if fasteners of ordinary steel are used for securing the material, or if the material comes into direct contact with adjacent components made of plain carbon steel in wet or humid conditions.

The risk of corrosion in the first three situations is highest for the lower-alloy stainless steel grades and can be reduced substantially right from the start by specifying molybdenum alloyed stainless grades (such as type 316). In the last two cases, the surface of the stainless steel will be discoloured by rust from the plain carbon steel.

If the stains or discolourations on the stainless steel surface are so serious that they cannot be removed by normal washing with water, the following cleaning methods are recommended.

Removal of stains and discolourations

Stain type	Cleaning agent and method
Fingerprints	Wash with soap, detergents or hydrocarbon solvents such as alcohol, thinner or acetone, rinse with clean cold water, and wipe dry.
Oil and grease	Wash with organic solvents, such as those mentioned above, then wash with soap or mild detergent and water, rinse with clean cold water, and wipe dry.
More stubborn stains and discolourations	Wash with a mild abrasive detergent, rub in the direction of the visible surface structure, rinse with clean cold water, and wipe dry. <i>Or:</i> Wash with a 10% phosphoric acid solution, rinse with ammonia solution, then with clean cold water, and wipe dry.
Temper colour and more serious stains	Wash with an abrasive detergent as described above. <i>Or:</i> Rub with Scotchbrite sponge in the direction of the visible structure, rinse with clean cold water and wipe dry.
Rust stains	Wet the surface with oxalic acid solution, leave it for 15-20 minutes, rinse with clean cold water, and wipe dry. If necessary, repeat the washing procedure with an abrasive detergent as described above.
Paint	Wash with paint solvent (use a soft nylon brush), and then rinse with clean cold water, and wipe dry.
Scratches on a ground or brushed surface	Polish with a polishing wheel (using an iron-free abrasive) in the direction of the structure, wash with soap or mild detergent and water, rinse with clean cold water, and wipe dry. N.B. The method must not be used for material with a 2B or 2D finish, or on patterned or decorated surfaces.

PROTECTIVE MEASURES

Use acids (acetic acid, citric acid, oxalic acid, phosphoric acid) only if other methods have proved inadequate. Wear rubber gloves and protective goggles, and follow your local safety regulations for such work. Ensure good ventilation when using solvents and note the risk of fire. Always follow your local safety regulations.



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