High Performance Austenitic Stainless Steel

Steel grades

Outokumpu	EN	ASTM
904L	1.4539	N08904
254 SMO®	1.4547	S31254
4565	1.4565	S34565

Characteristic properties

- Austenitic structure
- Very good resistance to uniform corrosion
- Good to exceptionally good resistance to pitting and crevice corrosion
- Very good resistance to various types of stress corrosion cracking
- Good ductility
- Good weldability

Applications

- Process equipment in chemical industry
- Bleaching equipment in the pulp and paper industry
- Flue gas cleaning
- Desalination
- Seawater handling
- Heat exchangers

General characteristics

High performance austenitic stainless steels differ substantially from more conventional grades with regard to resistance to corrosion and, in some cases, also mechanical and physical properties. This is mainly due to the high contents of chromium, nickel, molybdenum and nitrogen.
From a fabrication viewpoint, i.e., with regard to manufacturing of components and equipment, they are to some extent similar to standard austenitic grades such as 1.4301 and 1.4401, but they still require special know-how with regard to welding and machining.

Outokumpu Stainless manufactures a numbers of steels of this type: 904L, 254 SMO and 4565. 4529 can also be delivered if specified. The properties of 4529 are in general terms very similar to those of 254 SMO.

In certain applications the grades 4439 (austenitic) and 2205 (duplex) may be used as an alternative to 904L, whilst SAF 2507 (duplex) may be used as an alternative to 254 SMO. More information concerning duplex options is available in the data sheet for duplex steels.

Chemical composition

The chemical composition of a steel grade may vary slightly between different national standards. Consequently, a specified standard should always be stated when ordering.

Chemical composition Table 1

Outokumpu steel name	International steel No		Chemical composition, % typical values						National steel designations, superseded by EN			
	EN	ASTM	C	N	Cr	Ni	Mo	Others	BS	DIN	NF	SS
2205	1.4462	S32205*	0.02	0.17	22	5.7	3.1	–	318S13	1.4462	Z3 CND 22-05 Az	2377
SAF 2507®	1.4410	S32750	0.02	0.27	25	7	4	–	–	–	Z3 CND 25-06 Az	2328
4436	1.4436	316	0.03	–	16.9	10.7	2.6	–	316S33	1.4436	Z7 CND 18-12-03	2343
4439	1.4439	S31726	0.02	0.14	17.8	12.7	4.1	–	–	1.4439	Z3 CND 18-14-05 Az	–
4529	1.4529	N08926	0.01	0.20	20	25	6.4	Cu	–	1.4529	–	–
904L	1.4539	N08904	0.01	–	20	25	4.3	1.5 Cu	904S13	1.4539	Z2 NCDU 25-20	2562
254 SMO®	1.4547	S31254	0.01	0.20	20	18	6.1	Cu	–	–	–	2378
4565	1.4565	S34565	0.02	0.45	24	18	4,5	6 Mn	–	1.4565	–	–

* Also available as S31803

Outokumpu Stainless

Microstructure

All these grades have an austenitic microstructure in the quench annealed condition. 254 SMO and 4565 can, however, contain traces of intermetallic phases (sigma phase) at the centre of the material. Normally, this does not affect the corrosion resistance or mechanical properties of the steel. Such precipitates can also occur if the material is exposed to temperatures in the range of 600-1000°C. Provided that the recommendations given for hot forming, welding and heat treatment are followed, such precipitates have negligable effect on usability.

Characteristic temperatures, °C Table 2

	904L	254 SMO	4565
Hot forming	1200 - 950	1200 - 1000	1200 - 900
Solution annealing	1080 - 1160	1150 - 1200*	1120 - 1170
Pressure vessel approval	(-60) - 400	(-60) - 400	(-196) - 400

* Quenching with water at a thickness above 2 mm, below 2 mm an annealing temperature of 1120-1150°C and cooling with air/water can be used.

Mechanical properties

The strength and elongation of 904L are similar to those for conventional austenitic stainless steels. However, the addition of nitrogen in 254 SMO and 4565 gives higher and considerably higher strength respectively, i.e., proof strength and tensile strength, see Tables 3 and 4.
Despite the greater strength of these steels, the possibilities for cold as well as hot forming are very good.

Minimum values at 20°C according to EN Table 3

			904L			254 SMO			4565
			P	H	C	P	H	C	P/H/C
Proof strength	$R_{p0.2}$	MPa	220	220	240	300	300	320	420
	$R_{p1.0}$	MPa	250	260	270	340	340	350	460
Tensile strength	R_m	MPa	500	530	530	650	650	650	800
Elongation	A_5	%	35	35	35	40	35	35	30
Hardness	HB	max.		180			210		240
Impact value	KV	J		60			60		90

P=hot rolled plate, H=hot rolled strip, C=cold rolled strip.

Tensile properties at elevated temperatures, minimum values according to EN, MPa Table 4

	904L			254 SMO			4565		
	$R_{p0.2}$	$R_{p1.0}$	R_m	$R_{p0.2}$	$R_{p1.0}$	R_m	$R_{p0.2}$	$R_{p1.0}$	R_m
100°C	205	235	500	230	270	615	350	400	750
200°C	175	205	460	190	225	560	270	310	640
300°C	145	175	440	170	200	525	240	270	640
400°C	125	155		160	190	510	210	240	610

Physical Properties

Typical values according to EN 10088 Table 5

		904L	254 SMO	4565
Density	kg/dm^3	8.0	8.0	8.0
Modulus of elasticity	GPa	195	195	190
Linear expansion at (20 → 100)°C	X10^{-6}/°C	15.8	16.5	14.5
Thermal conductivity	W/m°C	12	14	12
Thermal capacity	J/kg°C	450	500	450
Electric resistivity	µΩm	1.0	0.85	0.92

Corrosion resistance

Uniform corrosion

The high content of alloying elements gives the steels 904L, 254 SMO and 4565 exceptionally good resistance to uniform corrosion.

904L was originally developed to withstand environments involving dilute sulphuric acid and it is one of the few stainless steels that at temperatures of up to 35°C provides full resistance in such environments within the entire range of concentration, from 0 to 100%, Figure 1. It also offers good resistance to a number of other inorganic acids, e.g., phosphoric acid, as well as most organic acids.

Acids and acid solutions containing halide ions can, however, be very aggressive and the corrosion resistance of 904L may be insufficient. Examples of such acids are hydrochloric acid, hydrofluoric acid, chloride contaminated sulphuric acid, phosphoric acid produced according to the wet process (WPA) at higher temperatures, and also pickling acid based on nitric acid hydrofluoric acid solutions. In these cases 254 SMO and 4565 are preferable and in certain cases can be an alternative to other considerably more expensive alloys, Figures 2-5 and Tables 6-7.

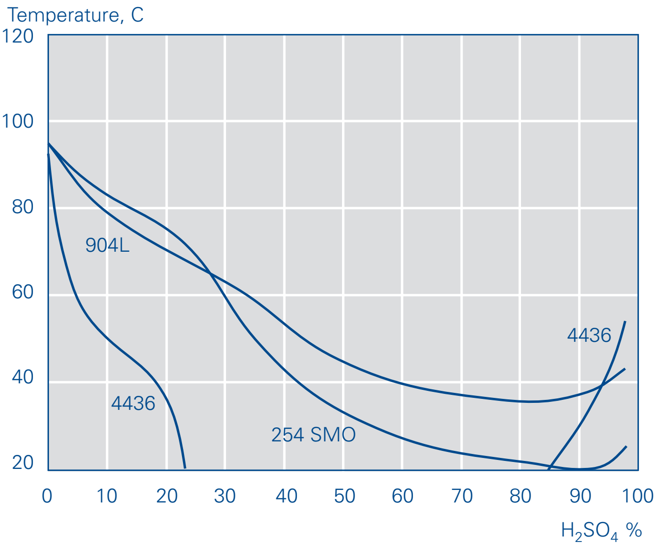


Fig. 1. Isocorrosion curves, 0.1 mm/y, in pure sulphuric acid.

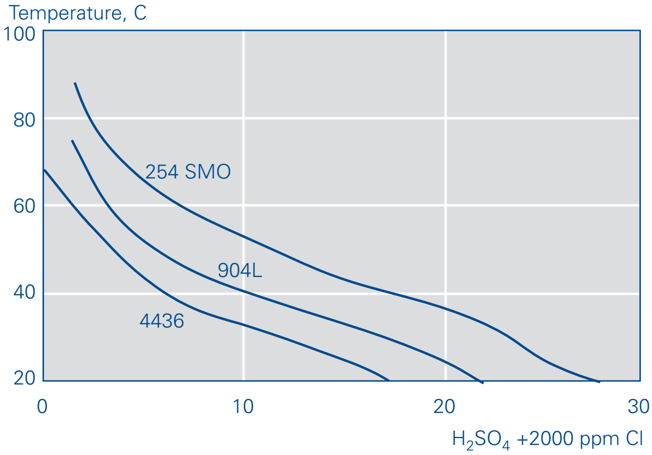


Fig. 2. Isocorrosion curves, 0.1 mm/y, in sulphuric acid containing 2000 ppm chloride.

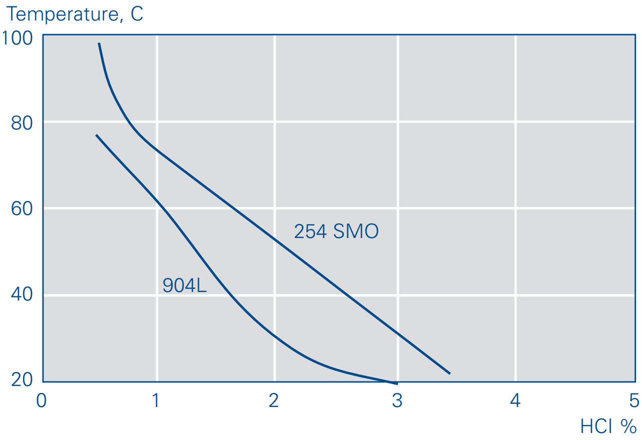


Fig. 3. Isocorrosion curves, 0.1 mm/y, in pure hydrochloric acid.

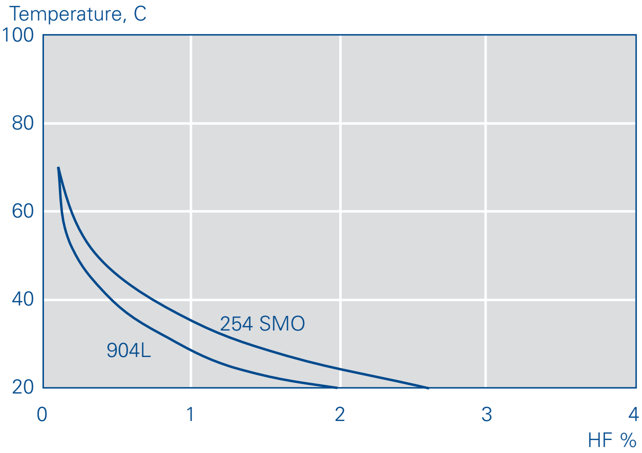


Fig. 4. Isocorrosion curves, 0.1 mm/y, in pure hydrofluoric acid.

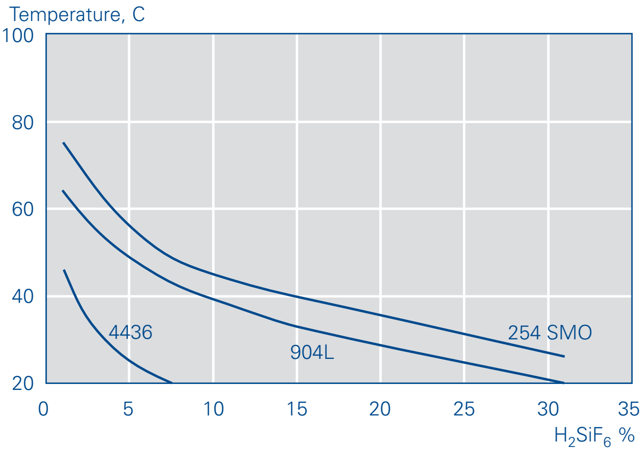


Fig. 5. Isocorrosion curves, 0.1 mm/y, in pure fluosilicic acid.

Uniform corrosion in wet process phosphoric acid at 60°C

Table 6

Steel grade	Corrosion rate, mm/year
4436	>5
904L	1.2
254 SMO	0.05

Composition in per cent: P_2O_5 54; HCl 0.06; HF 1.1; H_2SO_4 4.0; Fe_2O_3 0.27; Al_2O_3 0.17; SiO_2 0.10; CaO 0.20; MgO 0.70

Uniform corrosion in pickling acid at 25°C

Table 7

Steel grade	Corrosion rate, mm/year
4436	>5
904L	0.51
254 SMO	0.31

Composition: HNO_3 20%, HF 4%.

Better material may sometimes be needed for the fractional distillation of tall oil than the 1.4436 type standard steel, or even the more frequently used 1.4439. Table 8 presents the results of exposing test coupons at a Swedish plant with the object of determining suitable material for woven packings of stainless steel.

In this particular case woven packings produced from about 20,000 km of 0.16 mm diameter 254 SMO wire were used.

Corrosion rates in a fatty acid column for the distillation of tall oil at 260°C

Table 8

Steel grade	Corrosion rate, mm/year
4436	0.88
4439	0.29
904L	0.06
254 SMO	0.01

In hot concentrated caustic solutions the corrosion resistance is mainly determined by the nickel content of the material, and 904L in particular can be a good alternative to more conventional stainless steels.

For more detailed information concerning the corrosion resistance of the different steels in other environments, please refer to our Corrosion Handbook.

Pitting corrosion

Resistance to pitting corrosion (and also crevice corrosion) is determined mainly by the content of chromium, molybdenum and nitrogen in the material. This is often illustrated using the pitting resistance equivalent (PRE) for the material, which can be calculated using the formula:
PRE = %Cr + 3.3 x %Mo + 16 x %N

The PRE value can be used for rough comparisons of different materails. A much more reliable means, however, is to rank the steel according to the critical pitting temperature of the material (CPT).

There are several different methods available to measure the CPT. Figure 6 shows the CPT, as measured in the Avesta Cell (ASTM G 150), in a 1M NaCI solution (35,000 ppm or mg/l chloride ions) for some different stainless steels, in a ground (P320 mesh) condition. The actual value of mill finish surface may differ between product forms. The PRE value is also presented in Table 9 for comparison.

PRE values for different stainless steels

Table 9

Steel grade	PRE
4436	27
4439	33
2205	35
904L	36
SAF 2507	43
254 SMO	43
4565	46

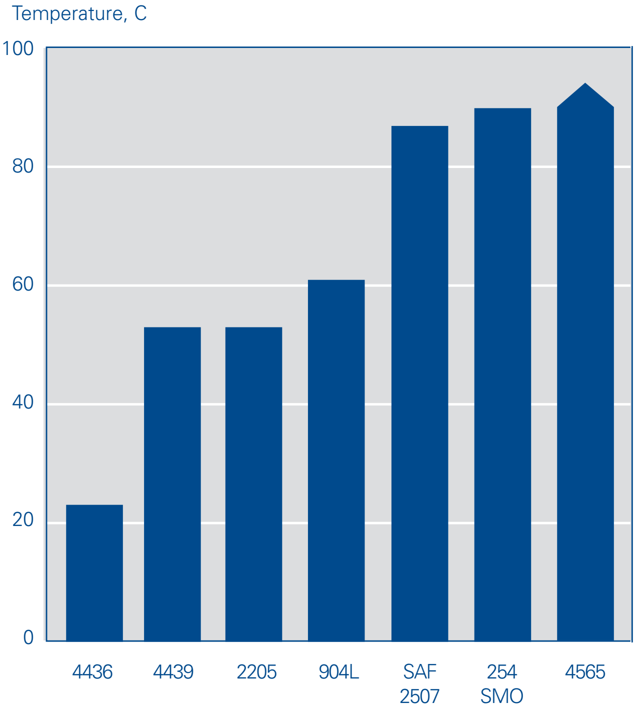


Fig. 6. Critical pitting corrosion temperature (CPT) for different stainless steels. (ASTM G 150)

Grade 4565 has such a good resistance to pitting that common test methods are not sufficiently aggressive to initiate any corrosion. A better measure of resistance is given by evaluating the results of various crevice corrosion tests.

Crevice corrosion

In narrow crevices the passive film may more easily be damaged and in unfavourable circumstances stainless steel can be subjected to crevice corrosion. Examples of such narrow crevices may be: under gaskets in flange fittings, under seals in certain types of plate heat exchangers, or under hard adherent deposits.

Crevice corrosion occurs in the same environments as pitting, and higher contents of chromium, molybdenum or nitrogen enhance the corrosion resistance of the steel, Figure 7.

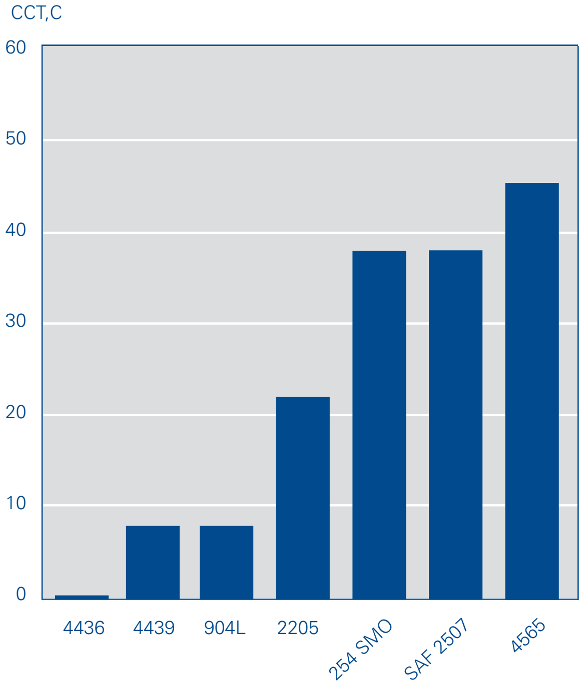


Fig. 7. Critical crevice corrosion temperatures (°C) for some stainless steels in 6% $FeCl_3$. Testing according to MTI-2.

Seawater

Natural seawater contains living organisms, which very quickly form a biofilm on stainless steel. This film increases the corrosion potential of the steel and thus, also the risk of pitting and crevice corrosion.

The activity of the biofilm is temperature-related, but since the different organisms are adapted to the natural temperature of the water, their activity varies between different seas around the world. This means that in cold seas the natural water is most aggressive at 25-30°C while the corresponding value in tropical seas is just above 30°C. The biological activity ceases at higher temperatures.

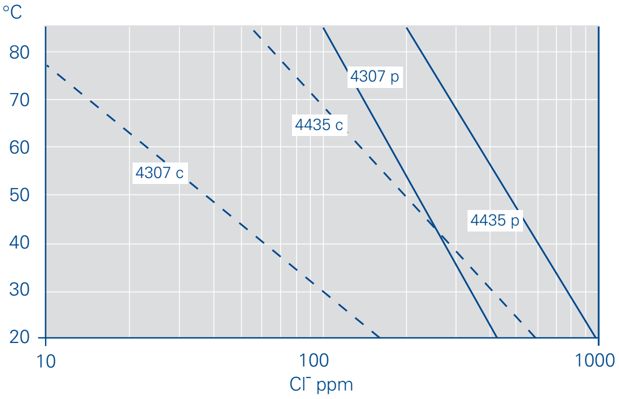
In many seawater systems the water is chlorinated with either chlorine or hypochlorite solutions to reduce the risk of fouling. Both chlorine and hypochlorite are strongly oxidising agents and they cause the corrosion potential of the steel surface to exceed what is normal in non-chlorinated seawater, which in turn means increased risk of corrosion. In chlorinated seawater the aggressiveness increases as the temperature rises.

Material selection for water treatment

Figures 8 and 9 show up to which approximate temperatures stainless steel can be used in oxygen-saturated solutions of varying chloride content. The diagrams are based on studies of literature, combined with practical experience, but it must be underlined that resistance of a material is also influenced by factors other than temperature and chloride content. Examples of such factors are weld defects, presence of oxide from welding or other heat treatment, contamination of the steel surface by particles of non-alloyed or low-alloyed steel, microbial activity, pH and chlorination of water.

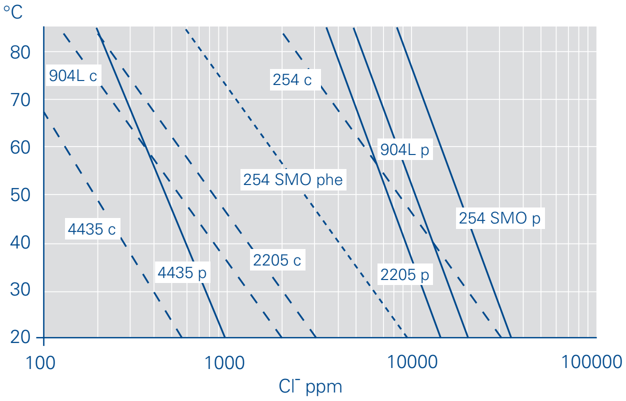
When selecting material for water that has such a low content of chloride that 1.4301 and 1.4401 can be considered, there is the additional risk of stress corrosion cracking at temperatures higher than about 60°C. The high alloy austenitics grades or the duplex are then more resistant.

The crevice geometry is normally more difficult in a plate heat exchanger than for flange joints, a deeper and more effective crevice due to the curved contact surface, thereof two boundary lines for crevice corrosion on 254 SMO. It should, however, be noted that the crevice geometry of a flange joint is dependent on the pressure that is obtained when tightening screws and bolts. The boundary line for crevice corrosion under “normal” conditions can in practice therefore be similar to that which applies to crevice corrosion for plate heat exchangers.



p=pitting, full line c=crevice corrosion, broken line

Fig. 8. Risk of pitting and crevice corrosion on conventional stainless steel in water of different chloride content or temperature.



p=pitting, full line c=crevice corrosion, broken line phe=plate heat exchanger

Fig. 9. Risk of pitting and crevice corrosion on high perfomance stainless steel in water of different chloride content or temperature.

In crevice-free, welded, constructions 254 SMO may normally be used in chlorinated seawater with a chlorine content of up to 1 ppm at temperatures up to about 45°C. Higher alloyed materials, e.g. a Ni-base alloy, should be used for flange joints, or the sealing surfaces should be overlay welded, e.g., using Avesta P16, if the temperature exceeds 30°C. Higher chlorine content can be permitted if chlorination is intermittent.

The risk of crevice corrosion in non-chlorinated seawater is considerably lower. 254 SMO has been used with great success in some thirty installations for desalination of seawater according to the reverse osmosis process. Various types of compression couplings that have relatively complicated crevice geometry between the stainless steel surface and the sealing gasket are used in such installations.

904L is not suitable for use in seawater.

Stress corrosion cracking

Conventional stainless steels of the 4301 and 4401 type are sensitive to stress corrosion cracking (SCC) under certain conditions, i.e., a special environment in combination with tensile stress in the material and often also an elevated temperature.

Resistance to SCC increases with the increased content of above all nickel and molybdenum. This implies that the high performance austenitic steels 904L, 254 SMO and 4565 have very good resistance to SCC.

There are different methods for ranking the resistance to SCC, among others the drop evaporation test (DET). In this test a dilute chloride solution (0.1 M NaCl) is allowed to drop onto a heated sample that is simultaneously subjected to tensile stress. The resistance is measured as the threshold stress, i.e. the maximum load related to proof strength at 200°C that does not cause rupture within 500 hours of testing.

The method is based on the fact that one common cause of SCC in practice is the evaporation of some type of water on a hot stainless steel component, e.g. piping or a process vessel.

High performance austenitic steels and duplex steels offer considerably better resistance than 1.4436 to SCC, Figure 10.

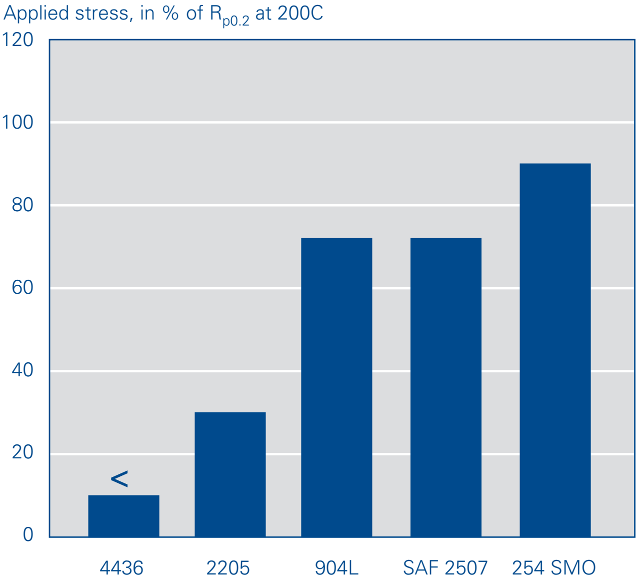


Fig. 10. SCC – threshold stresses determined using the DET method.

The resistance to alkaline SCC is more dependent on the nickel content of the material and also in this respect high performance austenitic steels are superior to conventional stainless steels. Nickel-based alloys are, however, to be preferred in the most demanding conditions.

Sulphide-induced stress corrosion

Hydrogen sulphide can sometimes cause embrittlement of ferritic steel and even of cold-worked duplex and austenitic steels. The sensitivity to cracking increases when the environment contains both hydrogen sulphide and chlorides. Such “sour” environments occur for example in the oil and gas industry.

The NACE standard MR0175-99 specifies certain requirements that must be fulfilled to define a material as suitable for use in sour environments for the extraction of oil and gas. For 254 SMO, approval has been granted for use in both an annealed condition and cold-worked condition up to a hardness of 35 HRC. For conventional grades such as 1.4301 and 1.4436 a maximum hardness of 22 HRC is permitted. The standard also states that these steels may not be cold-worked to increase the hardness.

Intercrystalline corrosion

High performance austenitic steels have such a low carbon content that the risk of conventional intercrystalline corrosion caused by chromium carbide precipitates in connection with welding is negligible.

On the other hand there is a risk of precipitation of intermetallic phases in the highest alloyed grades in the temperature range 600-1000°C, see also the section above on microstructure. However, such precipitates imply no risk of intercrystalline corrosion in the environments for which the steels were developed. This means that welding can be performed without risk of intercrystalline corrosion.

Erosion corrosion

Unlike copper alloys, stainless steel generally offers very good resistance to impingement attack and there are no motives for limiting the velocity of water, e.g. in piping systems that convey seawater. Further, stainless steel is not sensitive to seawater that has been contaminated by sulphur compounds or ammonia.

In systems subjected to particles causing hard wear, e.g., sand or salt crystals, the higher surface hardness of duplex steels can in some cases be an advantage.

Galvanic corrosion

The high performance austenitic steels 254 SMO and 4565 are not affected by galvanic corrosion if they are connected to titanium in systems used for conveying seawater. However, the rate of corrosion for copper alloys is increased if they come into contact with these steels (or with titanium). The intensity of corrosion is closely related to the surface area ratio between the stainless steel and the copper alloy, Figure 11. The tests presented have been carried out with 254 SMO but the relation is the same for other high performance steels.

The galvanic effect is reduced somewhat if the seawater is chlorinated.

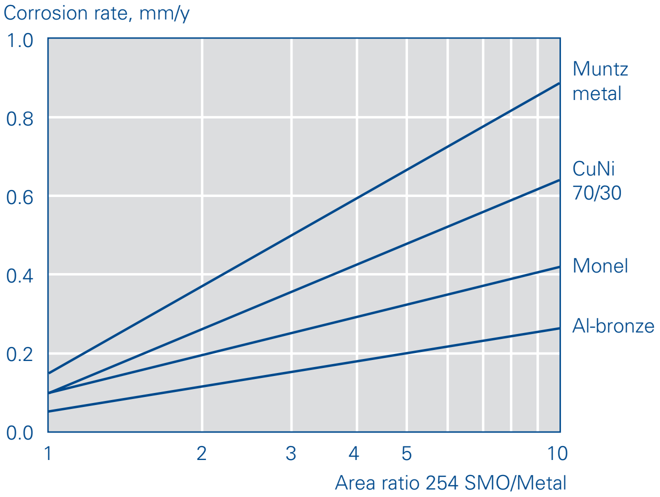


Fig. 11. Galvanic corrosion of copper alloys in slow moving seawater at ambient temperature.

Fabrication

Hot forming

Suitable temperatures for hot forming are shown in Table 2. Higher temperatures cause a deterioration in ductility and a sharp increase in the formation of oxides (scaling).

Normally hot working should be followed by solution allealing and quenching but, for 904L, if the hot forming is discontinued at a temperature above 1100°C and the material is quenched directly thereafter the material may be used without subsequent heat treatment. Here it is important that the entire workpiece has been quenched from b temperatures above 1100°C. In the case of partial heating or partial cooling below 1100°C or if the cooling has been to slow, hot working should always be followed by solution annealing and quenching.

Both 254 SMO and 4565 should be quenched at a temperature of at least 1150°C after hot working to avoid residual intermetallic phases. These phases can also rebuild if the subsequent cooling process is too slow, resulting in impaired corrosion resistance.

Cold forming

All these steels have good ductility. Bending, pressing and other forming operations can be performed without difficulty.

In this respect 904L behaves similarly to conventional austenitic grades, but it should be noted that 254 SMO, and especially 4565, cold-harden considerably faster. This, together with the initial high strength, makes it necessary to apply high forming forces.

The spring back for these grades is also greater than for conventional austenitic steels.

Typical proof strength values, $R_{p0.2}$, are noted in Table 10. About 90% of recorded values fall within the limits shown.

Spinning of e.g. dished ends can be done but it is essential that sufficiently high deformation forces are used to ensure thorough plastic deformation of the material at the very beginning of the operation. Otherwise there is a risk that deformation only occurs on the surface and after a few cycles of deformation it will be cold hardened to such a degree that the tensile strength and rupture elongation of the material are exceeded and it will crack.

In complicated cold-forming operations, intermediate annealing of the material may sometimes be necessary, especially if it includes welds.

The effect of work hardening, during and after cold-forming, is illustrated in Figures 12-13.

Typical proof strength Table 10

Steel grade	2 mm $R_{p0.2}$,MPa	5 mm $R_{p0.2}$,MPa	10 mm $R_{p0.2}$,MPa
904L	310 ± 30	290 ± 30	290 ± 20
254 SMO	390 ± 30	380 ± 30	
4565	440 ± 30	440 ± 30	440 ± 20

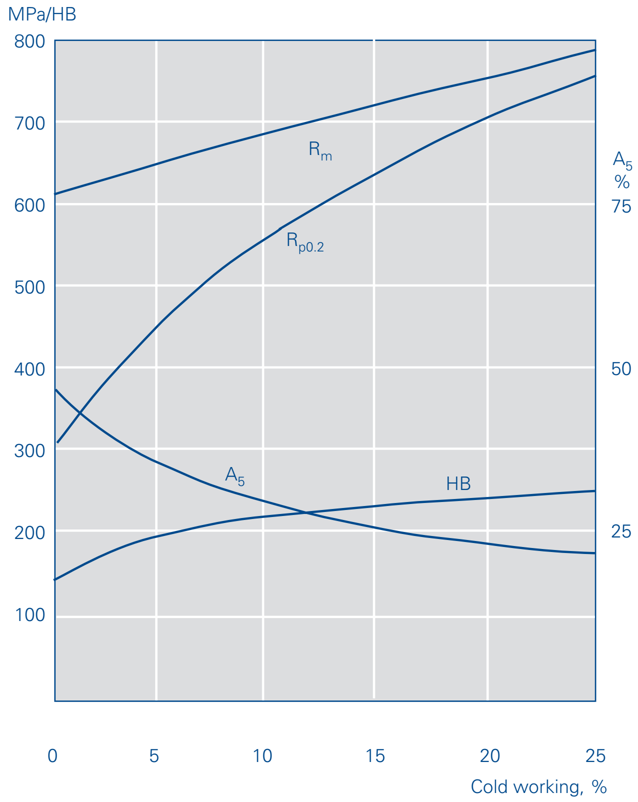


Fig. 12. 904L – influence of work hardening on the mechanical properties.

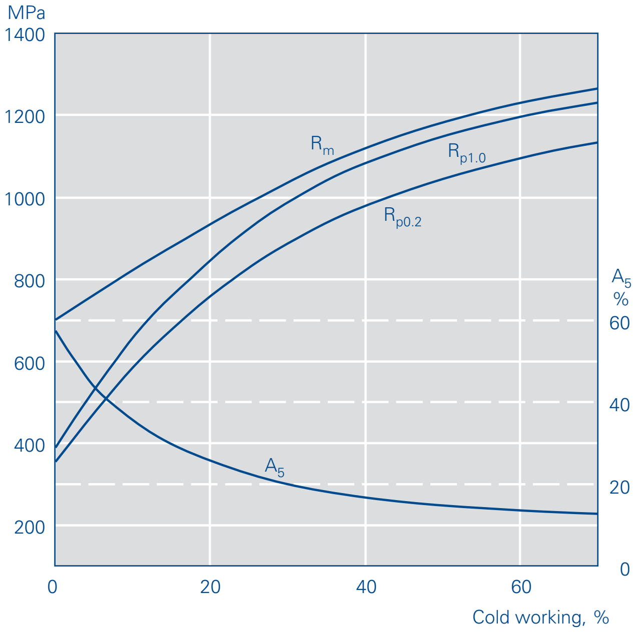


Fig. 13. 254 SMO – influence of work hardening on the mechanical properties.

Machining

Austenitic stainless steels work harden quickly and this, together with their toughness, means that they are often perceived as problematic from a machining perspective, e.g. in operations such as turning, milling and drilling. This applies to an even greater extent to most highly alloyed steels and especially those that have a high nitrogen content, i.e. 254 SMO and 4565.

With the right choice of tools, tool settings and cutting speeds, these materials can be machined. For further information contact Avesta Research Centre.

Welding

All these steels are well suited for welding and the methods used for welding conventional austenitic steels can also be used on 904L, 254 SMO and 4565. However, due to their stable austenitic structure, they are somewhat more sensitive to hot cracking in connection with welding and generally welding should be performed using the lowest heat input possible.

On delivery, sheet, plate and other processed products have a homogeneous austenitic structure with an even distribution of alloying elements in the material. A partial re-melting, e.g. by welding, causes redistribution of certain elements such as chromium, nickel and above all molybdenum, and when the material solidifies again this uneven distribution remains in the cast structureof the weld. These variations, segregation, can impair the material's corrosion resistance in certain environments.

Segregation tendency is less evident in 904L and this steel is normally welded using a filler of the same composition as the base material and it can even be welded without filler. For 254 SMO and 4565, however, the variation for molybdenum in particular is so great that it must be compensated for by using fillers, which have a higher content of molybdenum. Avesta P12 is normally used for welding 254 SMO and Avesta P16 is recomended for the welding of 4565.

The effect of segregation after welding can also be reduced by subsequent heat treatment, quench annealing, but such action is normally limited to geometrically very simple components, e.g., pipes, pipe fittings and end pieces.

In the case of multi-run welding, the workpiece should be allowed to cool to 100°C before welding the next run. This is the case for all three steels.

For other details regarding joint selection and preparation, welding techniques, heat input and post-weld cleaning, please refer to the series of publications entitled "How to weld", available on request from Avesta Welding AB.

Welding consumables Table 11

	Weld metal, typical composition, %						
	C	Si	Mn	Cr	Ni	Mo	Others
Avesta 904L							
Welding wire	0.01	0.35	1.7	20	25.5	4.5	1.5 Cu
Covered electrodes	0.03	0.8	1.2	20.5	25	4.5	1.5 Cu
PW-electrode	0.02	1.0	1.2	20	24.5	4.5	1.5 Cu
Avesta P12							
Welding wire**	0.01	0.1	0.1	22	65	9	3.6 Nb
Covered electrodes	0.02	0.4	0.4	21.5	66	9.5	2.2 Nb
Avesta P16							
Welding wire	0.01	0.1	0.2	25	60	15	–
Covered electrodes	0.02	0.2	0.3	25	59	15	–
Avesta P54*							
Welding wire	0.02	0.2	5.1	26	22	5.5	0.35 N

* For use in certain oxidising environments, e.g. chlorine dioxide stage in pulp bleaching plants, when welding 254 SMO or 4565.

** For submerged arc welding it is preferable to use a Nb-free version,P12-0$^{\text{Nb}}$.

Products

Outokumpu Stainless products

Table 12

Product	904L	254 SMO	4565
Hot rolled plate, sheet and strip	Dimension according to Outokumpu Stainless product program	Dimension according to Outokumpu Stainless product program	Plate according to Outokumpu Stainless product program
Cold rolled sheet and strip	Dimension according to Outokumpu Stainless product program	Dimension according to Outokumpu Stainless product program	-
Bars and forgins	Dimension according to Outokumpu Stainless product program	Dimension according to Outokumpu Stainless product program	-
Tube and Pipe	Welded tubes and pipes are supplied by Outokumpu Stainless Tubular Products	Welded tubes and pipes are supplied by Outokumpu Stainless Tubular Products	-
Pipe fittings	Outokumpu Stainless Tubular Products	Outokumpu Stainless Tubular Products	-
Wire rod and drawn wire	Fagersta Stainless	Fagersta Stainless	-
Welding consumables	Avesta Welding	Avesta Welding	Avesta Welding
Castings	Foundries	Licensed foundries	-

see also www.outokumpu.com/stainless

Material standards

Table 13

EN 10028-7	Flat products for pressure purposes – Stainless steels
EN 10088-2	Stainless steels – Corrosion resisting sheet/plate/strip for general and construction purposes
EN 10088-3	Stainless steels – Corrosion resisting semi-finished products/bars/rods/wire/sections for general and construction purposes
EN 10272	Stainless steel bars for pressure purposes
EN 10283	Corrosion resistant steel castings
ASTM A182 / ASME SA-182	Forged or rolled alloy-steel pipe flanges, forged fittings etc for high temperature service
ASTM A193 / ASME SA-193	Alloy and stainless steel bolts and nuts for high pressure and high temperature service
ASTM A240 / ASME SA-240	Heat-resisting Cr and Cr-Ni stainless steel plate/sheet/strip for pressure purposes
ASTM A249 / ASME SA-249	Welded austenitic steel boiler, superheater, heat exchanger and condenser tubes
ASTM A269	Seamless and welded austenitic stainless steel tubing for general service
ASTM A276	Stainless and heat-resisting steel bars/shapes
ASTM A312 / ASME SA-312	Seamless and welded austenitic stainless steel pipe
ASTM A351 / ASME SA-351	Steel castings, austenitic, duplex for pressure containing parts
ASTM A358 / ASME SA-358	Electric fusion-welded austenitic Cr-Ni alloy steel pipe for high temperature
ASME SA-403	Wrought austenitic stainless steel piping fitting
ASTM A409 / ASME SA-409	Welded large diameter austenitic pipe for corrosive or high-temperature service
ASTM A473	Stainless steel forgings for general use
ASTM A479 / ASME SA-479	Stainless steel bars for boilers and other pressure vessels
ASTM A743	Castings, Fe-Cr-Ni, corrosion resistant for general application
ASTM A744	Castings, Fe-Cr-Ni, corrosion resistant for severe service
NACE MR0175	Sulphide stress cracking resistant material for oil field equipment
ASTM B649 / ASME SB-649	Bar and wire
Norsok M-CR-630	Material data sheets for 6Mo stainless steel
VdTÜV WB 473	Austenitischer Walz- und Schmiedestahl. Blech, Band, Schmiedestück, Stabstahl für Druckbehälter
VdTÜV WB 537	Stickstofflegiertes austnitischen Stahl X2CrNiMnMoN 25-18-6-5 werkstoff-Nr. 1.4565/09-2000

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Outokumpu is a dynamic metals and technology group with a clear target to become the number one in stainless steel. Costumers in a wide range of industries use our metal products, technologies and services worldwide. We are dedicated to helping our costumers gain competitive advantage. We call this promise the Outokumpu factor.

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