High Alloyed Austenitic Stainless Steel   904L, 254 SMO®, 654 SMO®

STEEL GRADES

AvestaPolarit	EN	ASTM
904L	1.4539	N08904
254 SMO®	1.4547	S31254
654 SMO®	1.4652	S32654

CHARACTERISTIC PROPERTIES

- Austenitic structure
- Good to 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 and 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-alloyed austenitic stainless steels have such high contents of chromium, nickel, molybdenum and nitrogen that they differ substantially from more conventional grades with regard to resistance to corrosion and, in some cases, also mechanical and physical properties.

From a workshop practice 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.

AvestaPolarit manufactures four steels of this type: 904L, 254 SMO® and 654 SMO®, 20-25-6 can also be delivered if specified.

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.

Table 1. Chemical composition

AvestaPolarit steel name	International steel No		Typical composition, %						National steel designations, superseded by EN			
	EN	ASTM	C	N	Cr	Ni	Mo	Others	BS	DIN	NF	SS
4436	1.4436	316	0.02	0.05	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	–
20-25-6	1.4529	N08926	0.01	0.20	20	25	6.4	Cu	–	1.4529	–	–
904L	**1.4539**	**N08904**	**0.01**	**0.06**	**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**
654 SMO®	**1.4652**	**S32654**	**0.01**	**0.50**	**24**	**22**	**7.3**	**3,5 Mn, Cu**	**–**	**–**	**–**	**–**
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
Ni-alloys**			Cmax									
Alloy 625	–	N06625	0.10	–	21	60	9	Nb		2.4856		
Alloy C-276	–	N10276	0.02	–	15	60	16	W		2.4819		

SAF 2507® is made on licence from AB Sandvik Steel.

* *Also available as S31803*

** *These alloys are not produced within AvestaPolarit*

MICROSTRUCTURE

All three grades have an austenitic microstructure in the quench annealed condition.

Both 254 SMO® and 654 SMO® can, however, contain traces of intermetallic phases (chi and sigma phase) at the centre of the material. Normally, this does not affect the resistance to corrosion 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 no negative effect in usability.

Table 2. Characteristic temperatures, °C

	904L	254 SMO®	654 SMO®
Hot forming	1200 - 950	1200 - 1000	1200 - 1100
Quench annealing	1080 - 1160	1150 - 1200*	1150 - 1200*
Pressure vessel approval	(-60) - 400	(-60) - 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 654 SMO® 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. Data according to EN.

Table 3. Minimum values at 20°C

			904L	254 SMO®	654 SMO®
Proof strength	$R_{p0.2}$	MPa	220	300	430
	$R_{p1.0}$	MPa	260	340	470
Tensile strength	R_m	MPa	520	650	750
Elongation	A_5	%	35	35	40
Hardness	HB	max.	180	210	250
Impact value	KV	J	60	60	60

Table 4. Tensile Properties at elevated temperatures, minimum values, MPa

	904L			254 SMO®			654 SMO®		
	$R_{p0.2}$	$R_{p1.0}$	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	390	680
200°C	175	205	460	190	225	560	315	355	620
300°C	145	175	440	170	205	525	300	335	585
400°C	125	155		160	190	510	295	330	560

PHYSICAL PROPERTIES

Table 5. Typical values according to EN 10088

		904L	254 SMO®	654 SMO®
Density	kg/dm^3	8.0	8.0	8.0
Modulus of elasticity	GPa	195	195	190
Linear expansion at (20 → 100)°C	$X10^{-6}/°C$	16	16.5	15
Thermal conductivity	W/m°C	12	14	11
Thermal capacity	J/kg°C	450	500	500
Electric resistivity	μΩm	1.0	0.85	0.78

CORROSION RESISTANCE

Uniform corrosion

The high content of alloying materials gives the steels 904L, 254 SMO® and 654 SMO® 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 corrosion resistance in such environments within the entire range of concentration, from 0 to 100%, see 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 is in many cases insufficient. Examples of such acids are hydrochloric acid, hydrofluoric acid, chloride contaminated sulphuric acid, phosphoric acid produced according to the wet process (WPA), and also pickling acid based on nitric acid hydrofluoric acid solutions. In these cases 254 SMO® and 654 SMO® are preferable and in certain cases can be an alternative to other considerably more expensive alloys, see Figures 2-5 and Tables 6-7.

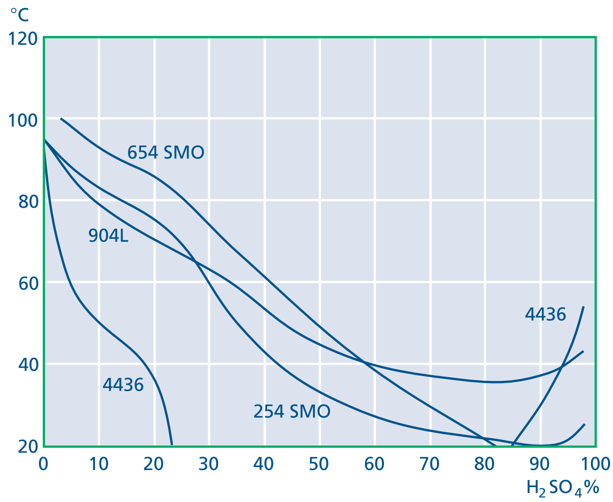

Fig. 1. Isocorrosion curves, 0.1 mm/y, in pure sulphuric acid.

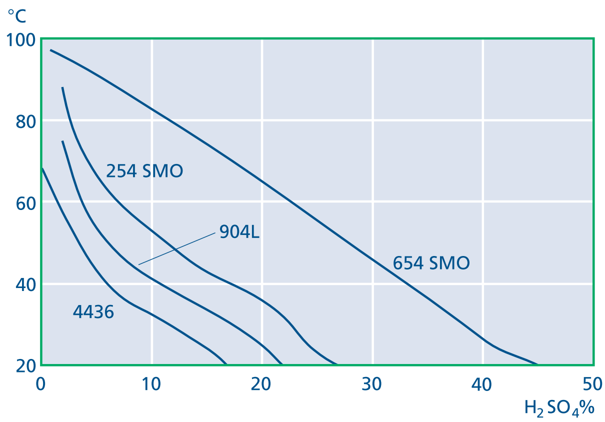

Fig. 2. Isocorrosion curves, 0.1 mm/y, in sulphuric acid containing 2000 ppm chloride.

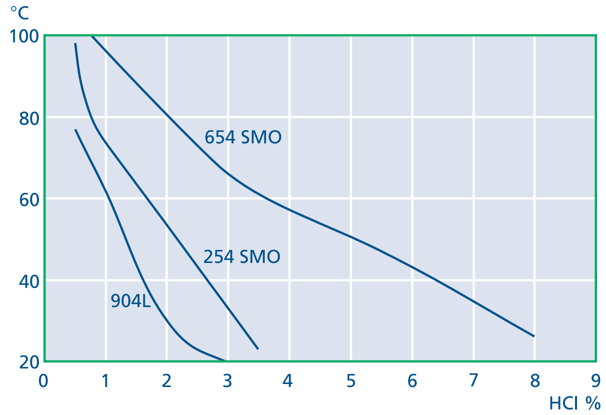

Fig. 3. Isocorrosion curves, 0.1 mm/y, in pure hydrochloric acid.

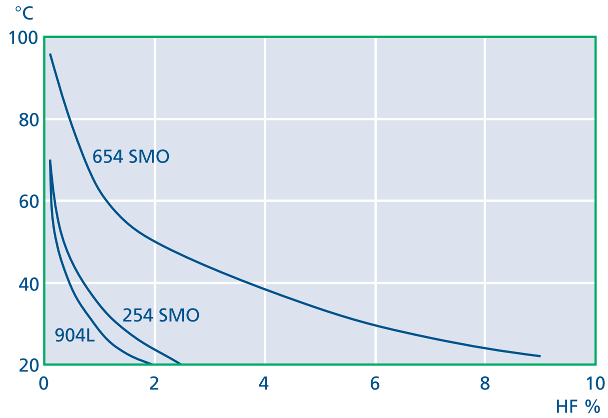

Fig. 4. Isocorrosion curves, 0.1 mm/y, in pure hydrofluoric acid.

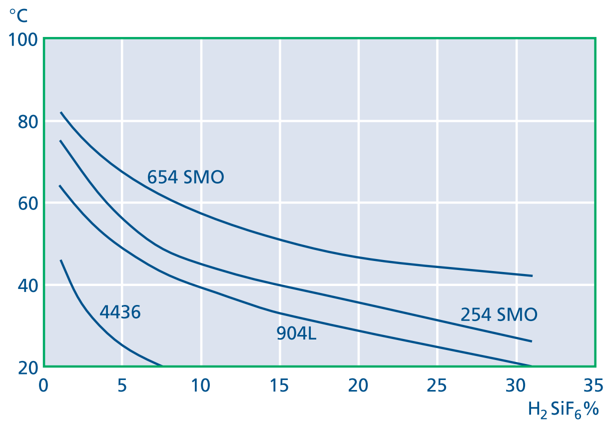

Fig. 5. Isocorrosion curves, 0.1 mm/y, in pure fluosilicic acid.

Table 6.
Uniform corrosion in wet process phosphoric acid at 60°C

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

Table 7. Uniform corrosion in pickling acid at 25°C

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

Composition in per cent: 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 installation 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.

Table 8. Corrosion rates of stainless steels in a fatty acid column for the distillation of tall oil at 260°C

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 AvestaPolarit Corrosion Handbook on Stainless Steels.

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 materials. A much more reliable means, however, is to measure the critical pitting temperature of the material (CPT).

Figure 6 shows the critical pitting temperatures in a 1M sodium chloride solution (35,000 ppm or mg/l chloride ions) for some different stainless steels. The PRE value is also presented in Table 9 for comparison.

Table 9. PRE values for different stainless steels

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

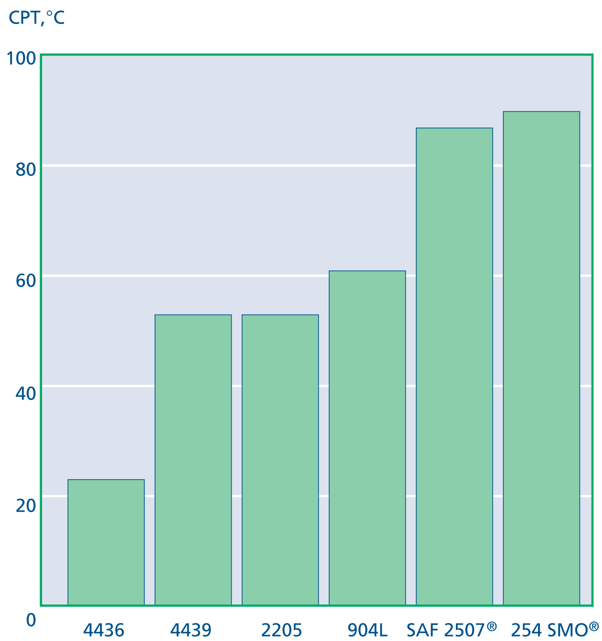

Fig. 6. Critical pitting corrosion temperature (CPT) for different stainless steels. Measured in 1 M NaCl according to ASTM G150, using the Avesta Cell.

654 SMO® has such 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 (e.g. under gaskets in flange fittings, under seals in certain types of plate heat exchangers, or under hard adherent deposits) the passive film may more easily be damaged and in unfavourable circumstances stainless steel can be subjected to crevice corrosion.

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

654 SMO® is superior to any other stainless steel in terms of its resistance to crevice corrosion, as shown by Figure 7.

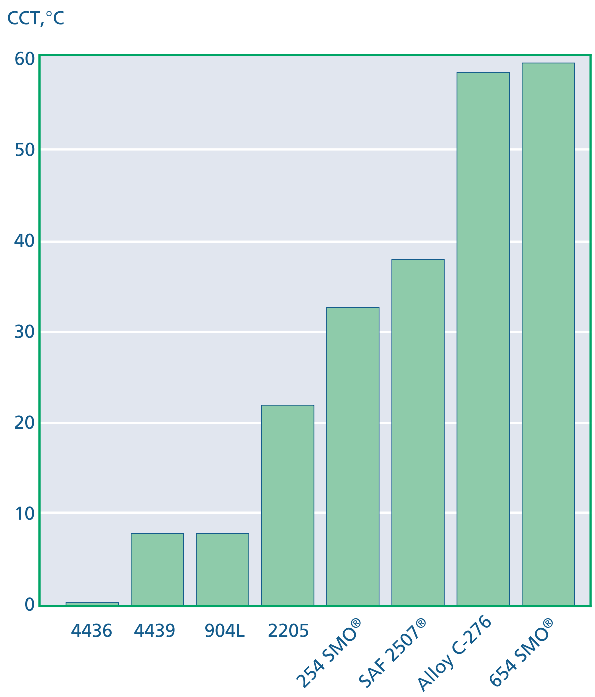

Fig. 7. Critical crevice corrosion temperatures (°C) for some stainless steels in 6% $FeCl_3$. Testing according to MTI-2.

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 strong 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 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 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.

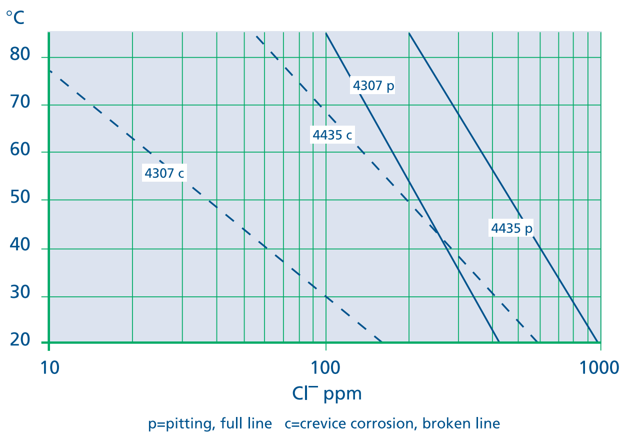

Fig. 8. Risk of pitting and crevice corrosion on conventional stainless steel in water of different chloride content or temperature.

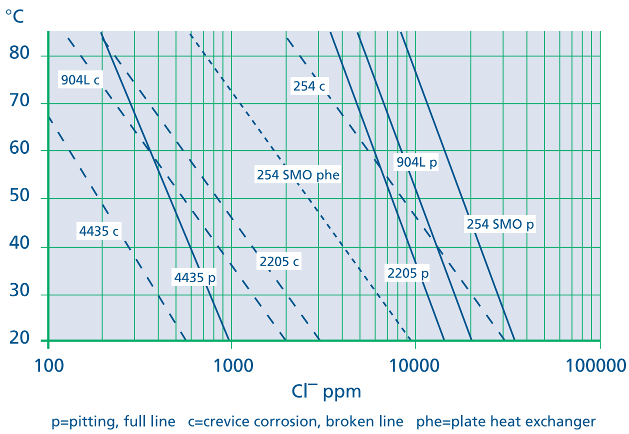

Fig. 9. Risk of pitting and crevice corrosion on high alloyed stainless steel in water of different chloride content or temperature.

In crevice-free, welded, constructions 254 SMO® can normally be used in chlorinated seawater with a chlorine content of up to 1 ppm at temperatures up to about 45°C. 654 SMO® 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.

Ongoing tests indicate that 654 SMO® can be used in plate heat exchangers with chlorinated seawater as a cooling medium at temperatures up to at least 60°C.

654 SMO® is resistant to pitting in natural boiling seawater.

The 904L grade should not be used in seawater.

Stress corrosion cracking

Conventional stainless steels of the 1.4301 and 1.4401 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-alloyed austenitic steels 904L, 254 SMO® and 654 SMO® 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 threshold stress, i.e. the maximum load related to proof strength 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.

As shown in Figure 10, high-alloyed austenitic steels and duplex steels offer considerably better resistance than 1.4436 to SCC.

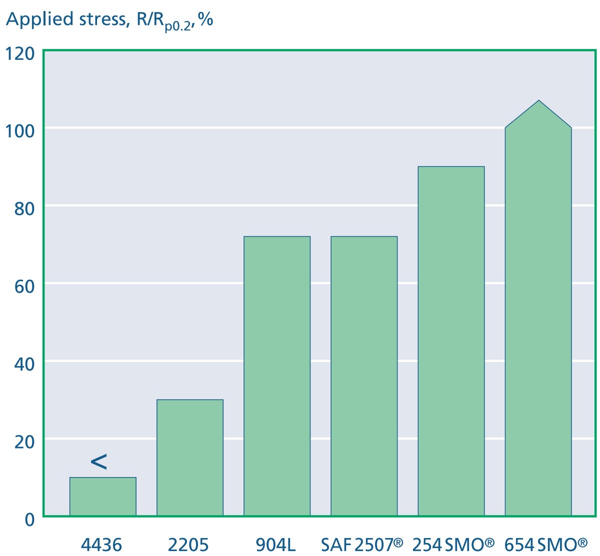

Fig. 10. SCC – threshold stresses determined using the DET method.

The resistance to alkaline SCC is more dependent on the nickel content of the material and also in this respect high-alloyed 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-alloyed 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-alloyed austenitic steels 254 SMO® and 654 SMO® 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, as shown by Figure 11. The tests presented have been carried out with 254 SMO® but the picture is also the same for 654 SMO® and other high-alloyed steels.

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

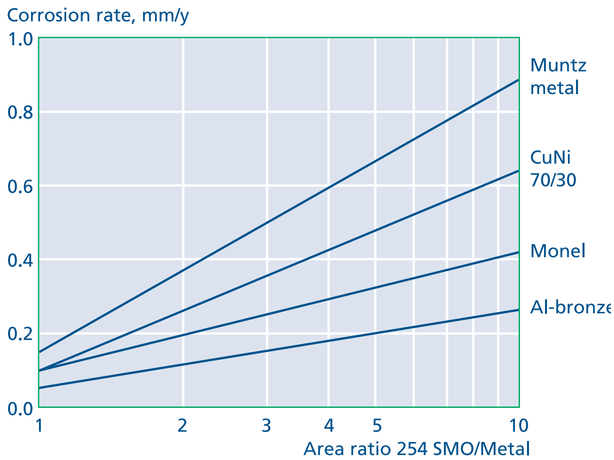

Fig. 11. Galvanic corrosion of copper alloys in slow moving seawater at ambient temperature.

FABRICATION

Hot forming

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

With 904L, if hot forming is discontinued at a temperature above 1100°C the material can be quenched and used without subsequent heat treatment. It is, however, important that the entire workpiece has been exposed to a sufficiently high temperature. In the case of partial heating, or cooling that is too slow, hot working should be followed by quench annealing.

Both 254 SMO® and 654 SMO® should be quenched at a temperature of at least 1150°C after hot working to avoid residual intermetallic phases from the working. These phases can also rebuild if the subsequent cooling process is too slow, resulting in impaired corrosion resistance.

Cold forming

All three 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 654 SMO®, 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, it may sometimes be necessary for intermediate annealing of the material, especially if it includes welds.

The effect of cold hardening, during and after cold-forming, on 254 SMO® and 654 SMO® is illustrated in Figures 12 and 13 respectively.

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	
654 SMO®	560		

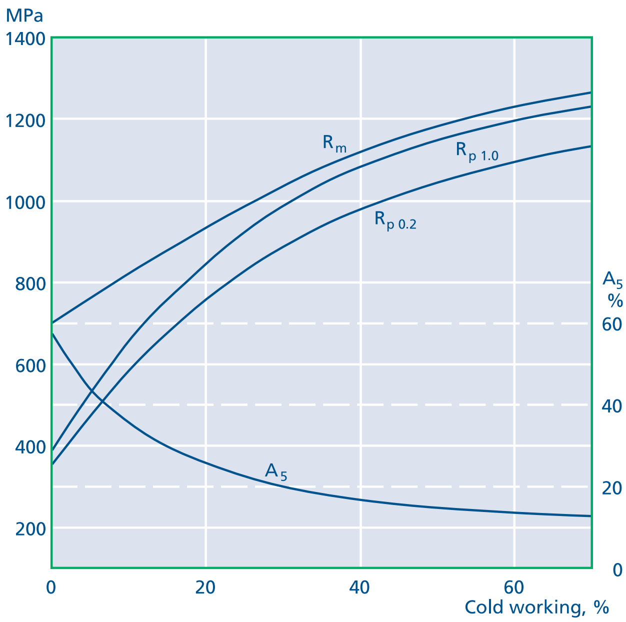

Fig. 12. 254 SMO® – influence of work hardening on strength properties.

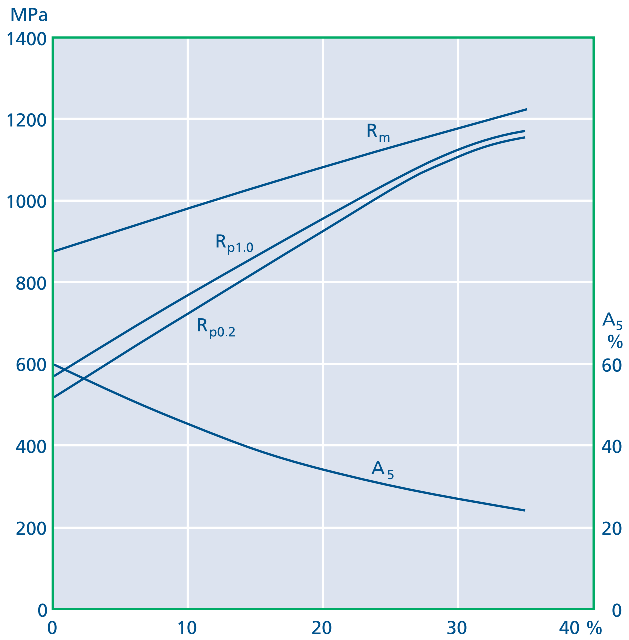

Fig. 13. 654 SMO® – influence of work hardening on strength properties.

Machining

Austenitic stainless steels cold 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 for steels that have a high nitrogen content, i.e. 254 SMO® and 654 SMO®.

With the right choice of tools, tool settings and cutting speeds, these materials can be machined. However, if experience is lacking, consultation with the department for technical market support at AvestaPolarit R&D Centre in Avesta is recommended.

Welding

All the three steels are well suited for welding and the methods used for welding conventional austenitic steels can also be used on 904L, 254 SMO® and 654 SMO®. 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 structure. 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 654 SMO®, 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 and P16 respectively.

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.

Table 11. Welding consumables

	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 654 SMO®.*

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

PRODUCTS

Table 12.

Product	904L	254 SMO®	654 SMO®
Hot rolled plate, sheet and strip	Dimensions according to AvestaPolarit product program	Dimensions according to AvestaPolarit product program	Dimensions according to agreement
Cold rolled sheet and strip	Dimensions according to AvestaPolarit product program	Dimensions according to AvestaPolarit product program	Dimensions according to agreement
Bars and forgins	AvestaPolarit Valbruna	AvestaPolarit Valbruna	–
Tube and Pipe	Welded tubes and pipes are supplied by Avesta Sandvik Tube AB www.asttube.com	Welded tubes and pipes are supplied by Avesta Sandvik Tube AB www.asttube.com	Welded tubes and pipes are supplied by Avesta Sandvik Tube AB www.asttube.com
Pipe fittings	Calamo Nords, ABE	Calamo Nords, ABE	–
Wire rod and drawn wire	Fagersta Stainless	Fagersta Stainless	–
Welding consumables	AvestaPolarit Welding	AvestaPolarit Welding	AvestaPolarit Welding
Castings	Foundries	Licensed foundries	Licensed foundries

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

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