# 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

- 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
- Hydrometallurgy
- Food and beverage
- Pharmaceuticals
- 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. High performance austentic stainless steels have good weldability and excellent formability.

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

## Chemical composition

The typical chemical composition of Outokumpu grades are shown in table 1. The chemical composition of a specific steel grade may vary slightly between different national standards. The required standard will be fully met as specified on the order.

**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steel name | International steel No | | Chemical composition, % typical values | | | | | | National steel designations, superseded by EN | | | |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 |
| Austenitic | 4404 | 1.4404 | 316L | 0.02 | – | 17 | 10 | 2.1 | – | 316S11 | 1.4404 | Z3 CND 17-11-07 | 2348 |
| | 4439 | 1.4439 | S31726 | 0.02 | 0.14 | 18 | 13 | 4.1 | – | – | 1.4439 | Z3 CND 18-14-05 Az | – |
| | 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 |
| | 4529 | 1.4529 | N08926 | 0.01 | 0.20 | 20 | 25 | 6.5 | Cu | – | 1.4529 | – | – |
| | 4565 | 1.4565 | S34565 | 0.02 | 0.45 | 24 | 17 | 4.5 | 5.5 Mn | – | 1.4565 | – | – |
| Duplex | 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 | 7.0 | 4.0 | – | – | – | Z3 CND 25-06 Az | 2328 |

* Also available as S31803

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## Microstructure

The high performance austenitic stainless steels have a fully austenitic microstructure in the quench annealed condition. They 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. Provided that the recommendations given for hot forming, welding and heat treatment are followed, such precipitates have negligible effect on usability.

## Mechanical properties

The strength and elongation of 904L are similar to those for conventional austenitic stainless steels. The addition of nitrogen in 254 SMO and 4565 gives higher proof strength and tensile strength, see tables 2 and 3.
Despite the greater strength of these steels, the possibilities for cold as well as hot forming are very good.

**Mechanical properties at 20˚C** Table 2

| | | | Minimum values, according to EN 10088 | | | Typical values |
|---|---|---|---|---|---|---|
| | | | P | H | C | P (15mm) |
| **904L** | | | | | | |
| Proof strength | $R_{p0.2}$ | MPa | 220 | 220 | 240 | 260 |
| Proof strength | $R_{p1.0}$ | MPa | 260 | 260 | 270 | 300 |
| Tensile strength | $R_m$ | MPa | 520 | 530 | 530 | 600 |
| Elongation | $A_5$ | % | 35 | 35 | 35 | 50 |
| Hardness | HB | | | | | 155 |
| **254 SMO®** | | | | | | |
| Proof strength | $R_{p0.2}$ | MPa | 300 | 300 | 320 | 340 |
| Proof strength | $R_{p1.0}$ | MPa | 340 | 340 | 350 | 380 |
| Tensile strength | $R_m$ | MPa | 650 | 650 | 650 | 680 |
| Elongation | $A_5$ | % | 40 | 35 | 35 | 50 |
| Hardness | HB | | | | | 160 |
| **4565** | | | | | | |
| Proof strength | $R_{p0.2}$ | MPa | 420 | 420 | 420 | 440 |
| Proof strength | $R_{p1.0}$ | MPa | 460 | 460 | 460 | 480 |
| Tensile strength | $R_m$ | MPa | 800 | 800 | 800 | 825 |
| Elongation | $A_5$ | % | 30 | 30 | 30 | 55 |
| Hardness | HB | | | | | 200 |

P = hot rolled plate. H = hot rolled strip. C = cold rolled coil and strip.

**Tensile properties at elevated temperatures, minimum values according to EN, MPa** Table 3

| | 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

In table 4 typical values of some physical properties are given for 904L, 254 SMO and the grade 4565.

**Typical values according to EN 10088** Table 4

| | | 904L | 254 SMO | 4565 |
|---|---|---|---|---|
| Density | g/cm$^3$ | 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%, fig 1. 904L 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 elevated temperatures, and also pickling acid based on nitric acid and hydrofluoric acid mixtures. In these cases 254 SMO and 4565 are preferable and in certain cases they can be an alternative to other considerably more expensive alloys, Figures 2-5 and tables 5 and 6.

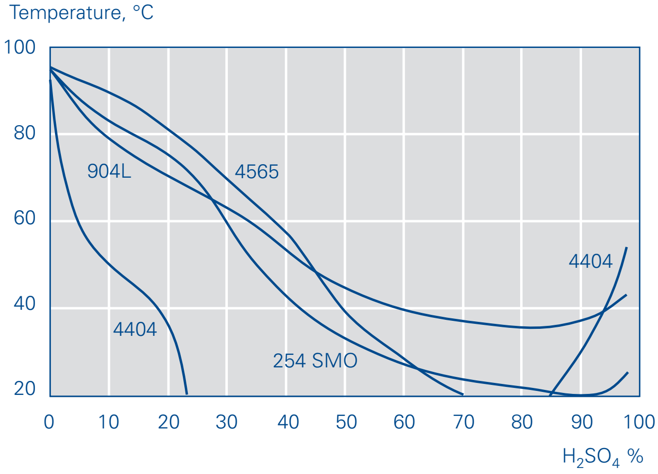


**Fig. 1.** Isocorrosion curves, 0.1 mm/year, in pure sulphuric acid.

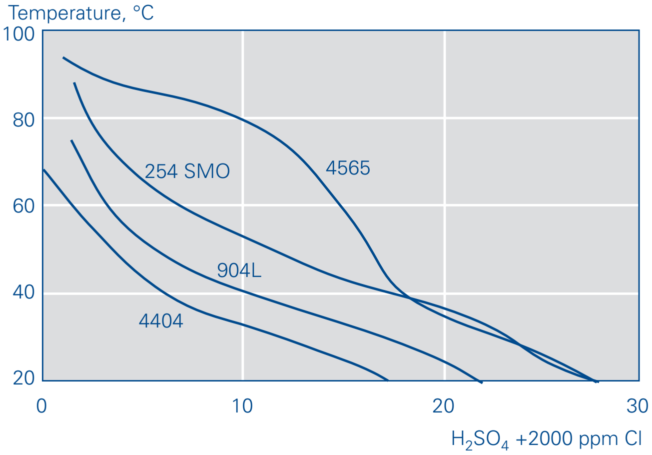


**Fig. 2.** Isocorrosion curves, 0.1 mm/year, in sulphuric acid containing 2000 ppm chloride.

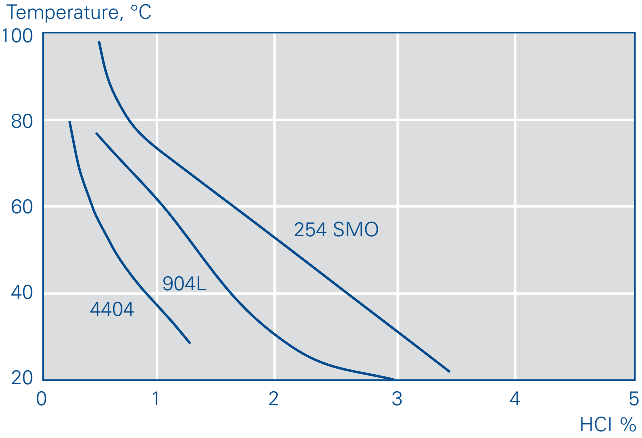


**Fig. 3.** Isocorrosion curves, 0.1 mm/year, in pure hydrochloric acid.

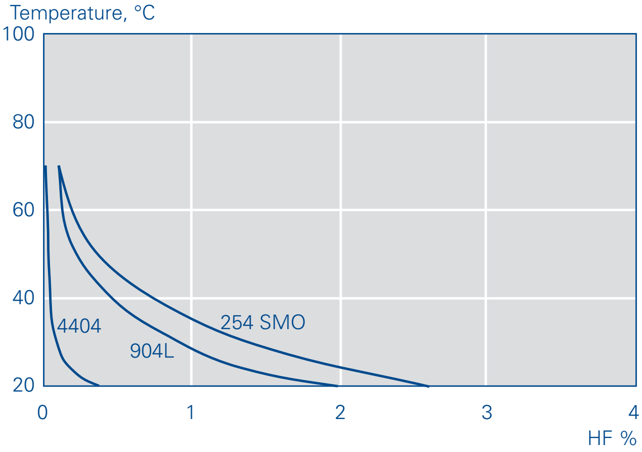


**Fig. 4.** Isocorrosion curves, 0.1 mm/year, in pure hydrofluoric acid.

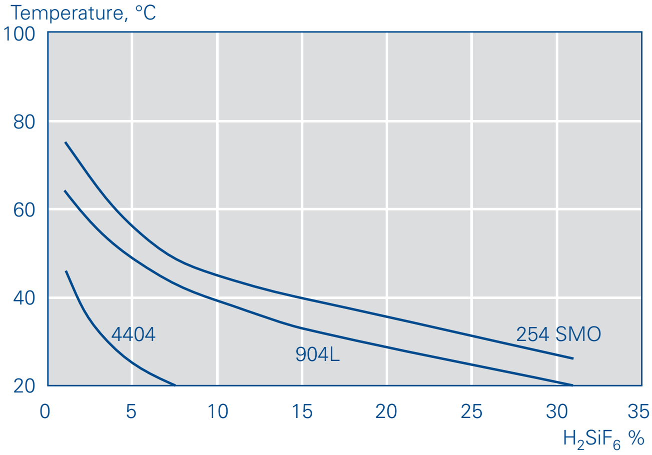


**Fig. 5.** Isocorrosion curves, 0.1 mm/year, in pure fluosilicic acid.

### Uniform corrosion in wet process phosphoric acid at 60°C

Table 5

| Steel grade | Corrosion rate, mm/year |
|---|---|
| 4404 | >5 |
| 904L | 1.2 |
| 254 SMO | 0.05 |

Composition: 54% $P_2O_5$, 0.06% HCl, 1.1% HF, 4.0% $H_2SO_4$, 0.27% $Fe_2O_3$, 0.17% $Al_2O_3$, 0.10% $SiO_2$, 0.20% CaO and 0.70% MgO

### Uniform corrosion in pickling acid at 25°C

Table 6

| Steel grade | Corrosion rate, mm/year |
|---|---|
| 4404 | >5 |
| 904L | 0.51 |
| 254 SMO | 0.31 |

Composition: 20% $HNO_3$, 4% HF.

Better material may sometimes be needed for the fractional distillation of tall oil than the 4404, or even the more frequently used 4439. Table 7 presents the results of exposing test coupons at a Swedish tall oil plant with the object of determining suitable material for woven packings of stainless steel.

In this particular case, 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 7

| Steel grade | Corrosion rate, mm/year |
|---|---|
| 4404 | 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, see our Corrosion Handbook.

### Pitting and Crevice 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. PRE values are presented in table 8.

### PRE values for different stainless steels

Table 8

| Steel grade | PRE |
|---|---|
| 4404 | 25 |
| 4439 | 33 |
| 2205 | 35 |
| 904L | 35 |
| SAF 2507 | 43 |
| 254 SMO | 43 |
| 4565 | 46 |

The PRE value can be used for rough comparisons of different materials. 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 NaCl solution (35,000 ppm or mg/l chloride ions). The actual value of mill finish surface may differ between product forms.

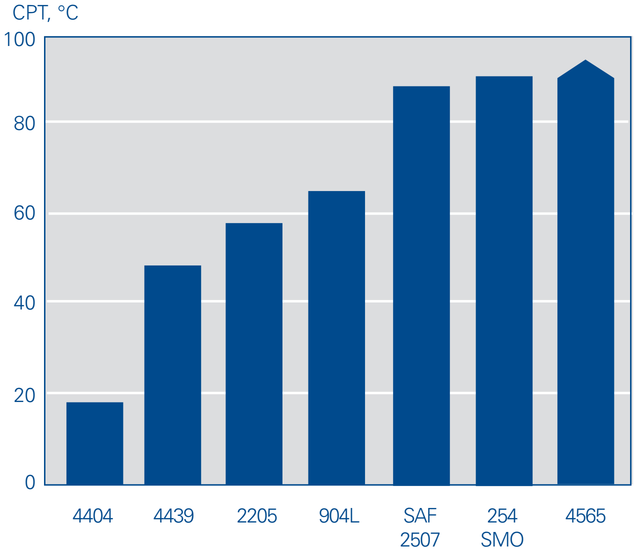


**Fig. 6.** Typical critical pitting corrosion temperatures (CPT) in 1M NaCl measured according to ASTM G150 using the Avesta Cell. Test Surfaces wet ground to 320 mesh. CPT varies with product form and surface finish.

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.

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. Higher contents of chromium, molybdenum or nitrogen enhance the corrosion resistance of the steel, see fig 7.

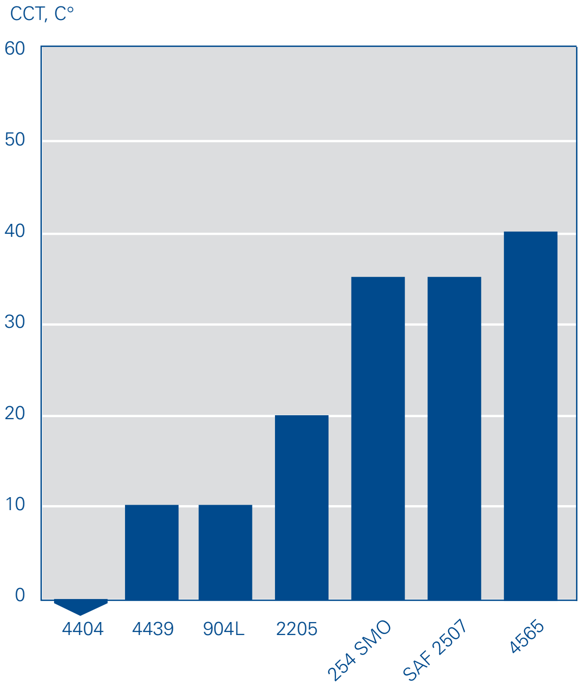


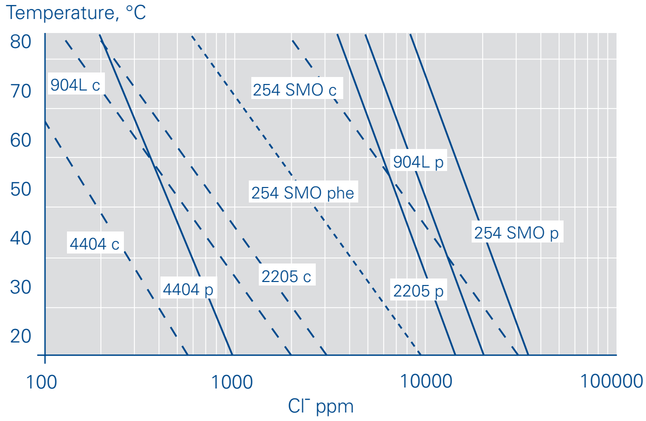
**Fig. 7.** Typical critical crevice corrosion temperature (CCT) according to ASTM G48 Method F. Test surfaces dry ground to 120 mesh. CCT varies with product form and surface finish.

### Guide to Material Selection

Fig 8 illustrates to which approximate temperatures stainless steel can be used in oxygen saturated waters of varying chloride content. It should be underlined that the 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, contamination of the steel surface by particles of non-alloyed or low-alloyed steel, microbial activity, pH and chlorination of water.

A deeper and more severe crevice is formed between the gasket and the plate in plate heat exchangers due to the curved contact surface. Thereof the two boundary lines for crevice corrosion on 254 SMO in fig. 8.

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. Also threads contain equally severe crevices, which should be considered when designing joints in highly alloyed stainless steels.



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

**Fig. 8.** Engineering diagram illustrating the risk of pitting and crevice corrosion on high performance stainless steel in water of different chloride content or temperature.

### 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. The different organisms are adapted to the natural water temperature of their habitat. Their activity therefore varies between the 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.

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 an ISO NiCr25Mo16 type filler, 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 sucessfully been used in some fifty installations for desalination of seawater according to reverse osmosis process.

### Stress corrosion cracking

Conventional stainless steels such as 4307 and 4404 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.

Different methods are used to rank stainless steel grades with regard to their resistance to SCC. The results can vary depending on the method and testing environment. The resistance to stress corrosion cracking in a chloride solution under evaporative conditions can be determined according to the drop evaporation method. This means that a salt solution is allowed to slowly drip onto a heated specimen, while it is being subjected to tensile stress.

By this method the threshold value is determined for the maximum relative stress not resulting in rupture after 500 hours testing. The threshold value is usually expressed as a percentage of the proof strength of the steel at 200°C. Fig. 9 shows the results of such a test.

High performance austenitic steels and duplex steels offer considerably better resistance than 4404 to SCC, fig. 9.

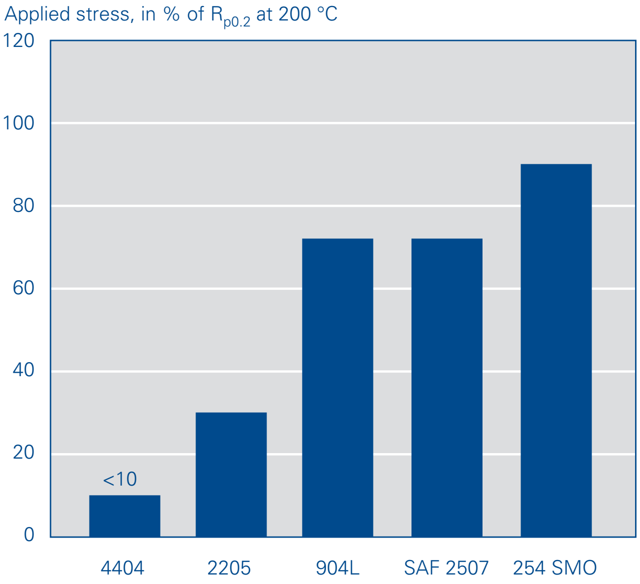


**Fig. 9.** Typical threshold stresses determined using the drop evaporation test.

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 cracking

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.

254 SMO is approved according to NACE MR0175 ”Standard Material Requirements - Metals for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments”

### 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.

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 most stainless steels (or with titanium). The intensity of corrosion is closely related to the surface area ratio between the stainless steel and the copper alloy, fig 10. 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.

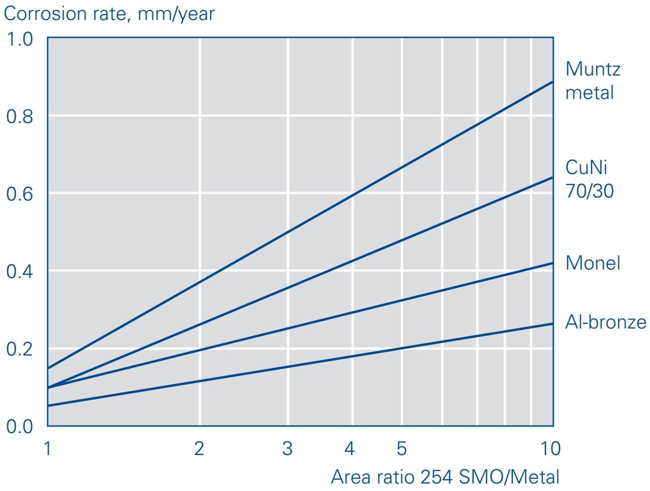


**Fig. 10.** Galvanic corrosion of copper alloys in slow moving seawater at ambient temperature.

# Fabrication

## Hot forming

Suitable temperatures for hot forming are shown in Table 9. Higher temperatures cause a deterioration in ductility and an increase in the formation of oxides (scaling) Normally hot working should be followed by solution annealing 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. It is important that the entire workpiece has been quenched from temperatures above 1100°C. In the case of partial heating or partial cooling below 1100°C or if the cooling has been too 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.

The high performance austenitic stainless steels, especially 254 SMO and 4565, cold-harden considerably faster than conventional austenitic grades. This, together with the initial high strength, makes it necessary to apply high forming forces. The spring back for grades 254 SMO and 4565 is also greater than for conventional austenitic steels.

Typical proof strength values, $R_{p0.2}$, are given 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 with subsequent cracking.

**Characteristic temperatures, °C** Table 9

| | 904L | 254 SMO | 4565 |
|---|---|---|---|
| Hot forming | 1200 - 950 | 1200 - 1000 | 1200 - 1000 |
| 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.

In complicated cold-forming operations, intermediate annealing of the material may sometimes be necessary, especially if the workpiece is welded.

The effect of work hardening, during and after cold-forming, is illustrated in fig. 11 and 12.

**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 |

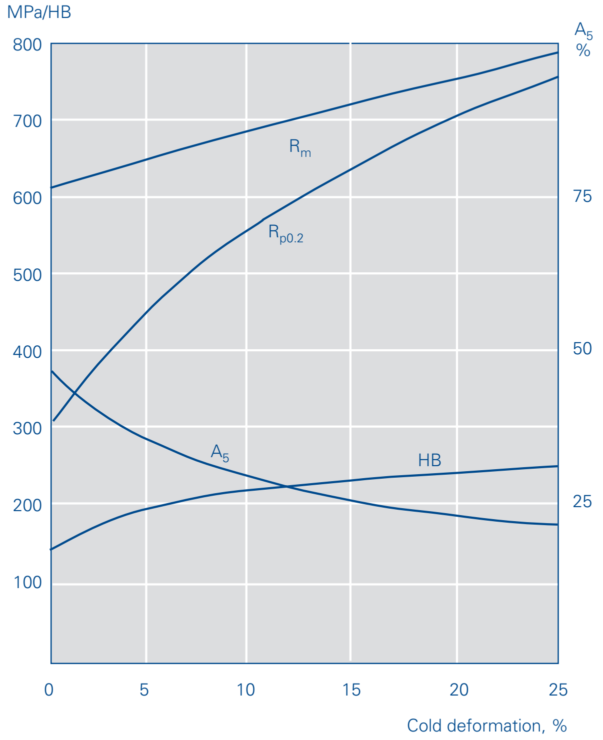


**Fig. 11.** 904L – influence of cold deformation on the mechanical properties.

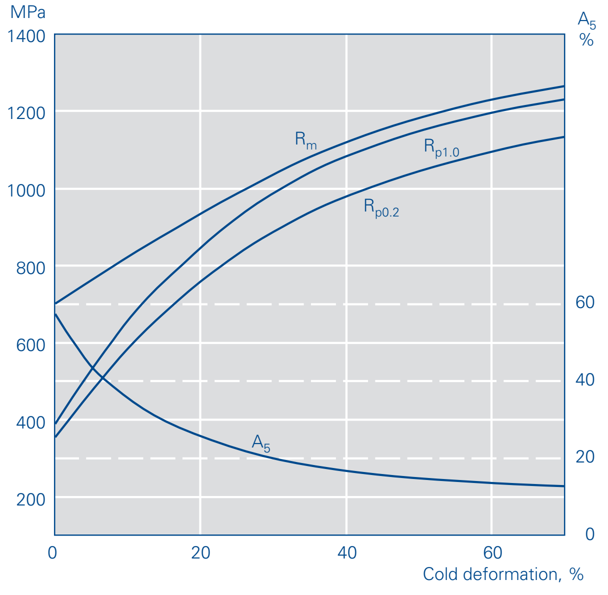


**Fig. 12.** 254 SMO – influence of cold deformation on the mechanical properties.

### 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.

However, with the right choice of tools, tool settings and cutting speeds, these materials can be sucessfully machined. For further information contact Outokumpu.

### 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 a low heat input.

On delivery, sheet, plate and other processed products have a homogeneous austenitic structure with an even distribution of alloying elements in the material. Solidification after partial remelting, e.g. by welding, causes redistribution of certain elements such as molybdenum, chromium and nickel. These variations, segregation, remain in the cast structure of the weld and 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. EN ISO NiCr21MoFeNb type filler is normally used for welding 254 SMO and ISO NiCr25Mo16 type filler is recommended 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 uncomplicated geometries, 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 further information regarding joint selection and preparation, welding techniques, heat input and post-weld cleaning, please contact Outokumpu.

### Post Fabrication treatment

In order to restore the stainless steel surface and achieve good corrosion resistance after fabrication, it is often necessary to perform a post fabrication treatment.
There are different methods available, both mechanical methods such as brushing, blasting and grinding and chemical methods, e.g. pickling. Which method to apply depend on what consequences the fabrication caused, i.e. what type of imperfections to be removed, but also on requirements with regard to corrosion resistance, hygienic demands and aesthetic appearance.

For more information, contact Outokumpu.

**Welding consumables**

Table 11

| Product form | Designation | Typical composition, % | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | C | Si | Mn | Cr | Ni | Mo | Others |
| **Welding of 904L** | | | | | | | | |
| Welding wire | ISO 20 25 5 Cu L | 0.01 | 0.35 | 1.7 | 20 | 25.5 | 4.5 | 1.5 Cu |
| Covered electrode | ISO 20 25 5 Cu N L | 0.03 | 0.8 | 1.2 | 20.5 | 25 | 4.5 | 1.5 Cu |
| **Welding of 254 SMO®** | | | | | | | | |
| Welding wire** | EN ISO NiCr22Mo9Nb | 0.01 | 0.1 | 0.1 | 22 | 65 | 9 | 3.6 Nb |
| Covered electrodes | EN ISO NiCr21MoFeNb | 0.02 | 0.4 | 0.4 | 21.5 | 66 | 9.5 | 2.2 Nb |
| **Welding of 4565** | | | | | | | | |
| Welding wire | ISO NiCr25Mo16 | 0.01 | 0.1 | 0.2 | 25 | 60 | 15 | – |
| Covered electrodes | EN ISO NiCr23Mo16 | 0.02 | 0.2 | 0.3 | 25 | 59 | 15 | – |
| **Welding of 254 SMO* or 4565*** | | | | | | | | |
| Welding wire | Avesta Welding P54* | 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, EN ISO NiCr22Mo9 or NiCr25Mo16.

## Products

**Outokumpu products** Table 12

| Product | 904L | 254 SMO | 4565 |
|---|---|---|---|
| Hot rolled plate, sheet and strip | Dimension according to Outokumpu product program | Dimension according to Outokumpu product program | Plate according to Outokumpu product program |
| Cold rolled sheet and strip | Dimension according to Outokumpu product program | Dimension according to Outokumpu product program | - |
| Bars and forgins | Dimension according to Outokumpu product program | Dimension according to Outokumpu product program | - |
| Tube and Pipe | Dimension according to Outokumpu product program | Dimension according to Outokumpu product program | - |
| Pipe fittings | Dimension according to Outokumpu product program | Dimension according to Outokumpu product program | - |
| Wire rod and drawn wire | Fagersta Stainless | Fagersta Stainless | - |
| Castings | Foundries | Licensed foundries | - |

see also www.outokumpu.com

## 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 |

1044EN-GB:4. Centrum Tryck AB, Avesta, Sweden. July 2007.

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

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

www.outokumpu.com