

# Ultra 4565

EN 1.4565, ASTM UNS S34565

## General characteristics

4.5% Mo, very high N alloyed austenitic grade with excellent corrosion resistance and high mechanical strength. Typically used in e.g. flue gas desulphurization applications.

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 austenitic stainless steels have good weldability and excellent formability. Outokumpu manufactures a number of steels of this type and 4565 is one of them.

## Typical applications

- Process equipment in chemical industry
- Bleaching equipment in the pulp and paper industry
- Flue gas desulphurization applications
- Desalination
- Seawater handling
- Hydrometallurgy
- Food and beverage
- Pharmaceuticals
- Heat exchangers

## Products & dimensions

### Cold rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
2E	Cold rolled, heat treated, mech. desc. pickled	0.50-4.00	36-1300	0.50-4.00	400-1300
2H	Work hardened	0.40-3.00	1250-1300		
2R	Cold rolled, bright annealed	0.05-1.50	3-649		

### Quarto plate products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1D	Hot rolled, heat treated, pickled			7.00-40.00	400-2700

## Chemical composition

The typical Outokumpu composition as well as the demands in some standards are given below

The chemical composition is given as % by weight.

	C	Mn	Cr	Ni	Mo	N	Other
<b>Typical</b>	<b>0.02</b>	<b>5.5</b>	<b>24.0</b>	<b>17.0</b>	<b>4.5</b>	<b>0.45</b>	
ASME II A SA-240	≤0.030	5.0-7.0	23.0-25.0	16.0-18.0	4.0-5.0	0.40-0.60	
ASTM A240	≤0.030	5.0-7.0	23.0-25.0	16.0-18.0	4.0-5.0	0.40-0.60	
EN 10088-2	≤0.030	5.0-7.0	24.0-26.0	16.0-19.0	4.0-5.0	0.30-0.60	
EN 10088-3	≤0.030	5.0-7.0	24.0-26.0	16.0-19.0	4.0-5.0	0.30-0.60	
EN 10088-4	≤0.030	5.0-7.0	24.0-26.0	16.0-19.0	4.0-5.0	0.30-0.60	

## 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%. 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.

### 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:  $PRE = \%Cr + 3.3 \times \%Mo + 16 \times \%N$ . 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 and ASTM G 150 is one method that uses the Avesta Cell with a 1M NaCl solution (35,000 ppm or mg/l chloride ions). CPT-values are shown in the table below. Grades 4565 and 654 SMO® have 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. Typical critical crevice corrosion temperature (CCT) according to ASTM G48 Method F are shown in the table below. (Test surfaces dry ground to 120 mesh.) CCT varies with product form and surface finish. The actual value of mill finish surface may differ between product forms.

### 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®, 654 SMO® and 4565 have very good resistance to SCC.

Pitting corrosion resistance		Crevice corrosion resistance
PRE	CPT	CCT
46	>90	40

PRE Pitting Resistant Equivalent calculated using the formula:  $PRE = \%Cr + 3.3 \times \%Mo + 16 \times \%N$

CPT Corrosion Pitting Temperature as measured in the Avesta Cell (ASTM G 150), in a 1M NaCl solution (35,000 ppm or mg/l chloride ions).

## Mechanical properties

The strength and elongation of 904L are similar to those for conventional austenitic stainless steels. The addition of nitrogen in 254 SMO<sup>®</sup>, 654 SMO<sup>®</sup> and 4565 gives higher proof strength and tensile strength. Despite the greater strength of these steels, the possibilities for cold as well as hot forming are very good.

Cold rolled coil and sheet	R <sub>p0.2</sub> MPa	R <sub>p1.0</sub> MPa	R <sub>m</sub> MPa	Elongation <sup>1)</sup> %	Impact strength J	Rockwell	HB	HV
<b>Typical (thickness 1 mm)</b>								
ASME II A SA-240	≥ 415		≥ 795				≤ 241	
ASTM A240	≥ 415		≥ 795			≤ 100HRB	≤ 241	
EN 10088-2	≥ 420	≥ 460	800 - 950	≥ 30				
EN 10088-4	≥ 420	≥ 460	800 - 950	≥ 30				

Hot rolled coil and sheet	R <sub>p0.2</sub> MPa	R <sub>p1.0</sub> MPa	R <sub>m</sub> MPa	Elongation <sup>1)</sup> %	Impact strength J	Rockwell	HB	HV
<b>Typical (thickness 4 mm)</b>								
ASME II A SA-240	≥ 415		≥ 795				≤ 241	
ASTM A240	≥ 415		≥ 795				≤ 241	
EN 10088-2	≥ 420	≥ 460	850 - 950	≥ 30				

Hot rolled quarto plate	R <sub>p0.2</sub> MPa	R <sub>p1.0</sub> MPa	R <sub>m</sub> MPa	Elongation <sup>1)</sup> %	Impact strength J	Rockwell	HB	HV
<b>Typical (thickness 15 mm)</b>	<b>440</b>	<b>480</b>	<b>825</b>	<b>55</b>			<b>200</b>	
ASME II A SA-240	≥ 415		≥ 795			≤ 100HRB	≤ 241	
ASTM A240	≥ 415		≥ 795			≤ 100HRB	≤ 241	
EN 10088-2	≥ 420	≥ 460	800 - 950	≥ 30				
EN 10088-4	≥ 420	≥ 460	800 - 950	≥ 30				

<sup>1)</sup>Elongation according to EN standard:

A<sub>80</sub> for thickness below 3 mm.

A for thickness = 3 mm.

Elongation according to ASTM standard A<sub>2</sub> or A<sub>50</sub>.

## Physical properties

The typical values of some physical properties are given in the table below.

Density	Modulus of elasticity	Thermal exp. at 100 °C	Thermal conductivity	Thermal capacity	Electrical resistance	Magnetizable
kg/dm <sup>3</sup>	GPa	10 <sup>-6</sup> /°C	W/m°C	J/kg°C	μΩm	No
8.0	190	14,5	12	450	0.92	No

## Fabrication

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

## 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®, 4565 and 654 SMO®. However, with the right choice of tools, tool settings and cutting speeds, these materials can be successfully 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.

# More information

A number of publications regarding this steel grade are available for downloading from our publications system. The downloads can be found under Products/Useful Tools Online/Publications. Below are a few publications that might be of interest.

High Performance Austenitic Stainless Steel - 904L. 254 SMO. 4529. 4565. 654 SMO  
Material data sheet presenting the properties for Outokumpu Stainless most corrosion resistant alloys.

Acom 2010 Ed:4

Acom chronicle 1980-2010

J. Gunnarsson

Superaustenitic stainless steels in demanding environments

M. Liljas. C. Canderyd. R. Pettersson. M. Willför

Lean duplex - the first decade of service experience

E. Alfonsson

80 years with duplex steels - a historic review and prospects for the future

M. Liljas

30 years with acom (index) - in order

30 years with acom (index) - by subject

# Standards & approvals

Some standards are given in the table below.

Standard	Designation
ASME SA-240M Code Sect. II. Part A	UNS S34565
ASTM A240/A240M	UNS S34565
EN 10088-2	1.4565
EN 10088-3	1.4565

# Contacts & Enquiries

Contact your nearest sales office

[www.outokumpu.com/contacts](http://www.outokumpu.com/contacts)

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