alform®

High-strength thermomechanically rolled steels

Technical terms of delivery

voestalpine Grobblech GmbH
www.voestalpine.com/grobblech

voestalpine
ONE STEP AHEAD.

alform®

High-strength thermomechanically rolled steels

alform® M

Steel grades

- alform 700 M
- alform 960 M

More information you will find in our technical terms of delivery for thermomechanically rolled steels.

Subject to change pursuant to further development.
The current version is available in internet: www.voestalpine.com/grobblech

alform 700 M

alform 700 M is a high-strength, thermomechanically rolled, weldable fine-grain structural steel with good cold forming properties.

The alloying concept provides very low carbon contents and low carbon equivalents, which aims in very good weldability. The high-strength grades provide special advantages in areas, where weight savings are of great importance, e.g. for mobile cranes, concrete pump cars and vehicles.

The technical terms of delivery apply for plate thickness from 8 - 25 mm.

Steel grades

Table 1: Steel grades

Steel grade
alform 700 M

Production process

alform 700 M is produced via the LD-route.

Chemical composition

Heat analysis

Guaranteed values

Table 2: Chemical composition

mass in %

C max.	Si max.	Mn max.	P max.	S max.	$Al_{tot.}$ min.	Cr max.	Mo max.	Ni max.	V[1] max.	Nb[1] max.	Ti[1] max.	B max.
0.12	0.60	2.10	0.020	0.008	0.020	1.50	0.50	2.00	0.20	0.09	0.22	0.005

[1] The total of Nb, V und Ti must not exceed 0,22 %.

Carbon equivalent

Standard values for carbon content and carbon equivalent

Table 3: Carbon content and equivalent

mass in %

C	CEV[1]	CET[2]	PCM[3]
0.04	0.42	0.26	0.17

[1] CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15, according to IIW

[2] CET = C + (Mn + Mo)/10 + (Cr + Cu)/20 + Ni/40, according to SEW 088

[3] PCM = C + Si/30 + (Mn + Cu + Cr)/20 + Ni/60 + Mo/15 + V/10 + 5*B, according to API 5L

As-delivered condition

The plates are delivered in a thermomechanical rolled condition with accelerated cooling. Exceptionally conventional quenching and tempering is permitted.

Mechanical properties

Mechanical properties in as-delivered condition

Table 4: Mechanical properties

Thickness range mm	Yield strength[1] YS min. N/mm²	Tensile strength[1] UTS N/mm²	Fracture elongation[1] $L_0 = 5{,}65 \sqrt{S_0}$ min. %	Notch impact energy[2] J, min.	Bending test[3]
8 ≤ 15	700	750 - 1,050	10	40	2 s
>15 ≤ 25	680	750 - 1,050	12	40	2 s

[1] Tensile test in accordance with EN 10002 on transverse samples.

[2] Notch impact bending test in accordance with EN 10045 on Charpy-V longitudinal samples at –40 °C.
The mean value from 3 individual samples must reach the specified requirements. No individual value may be below 70 % of the guaranteed mean value. For thicknesses < 10 mm, samples similar to Charpy-V with dimensions of 10 x 7.5 mm are tested. The guaranteed value is reduced in proportion to the sample cross-section. The notch impact bending test can be agreed upon ordering.

[3] Bending angle 180°, mandrel diameters = sample thickness, transverse sample position.

Quality test

Test unit

Unless otherwise agreed upon ordering, 40 t of a heat or a smaller portion is used as test unit for the mechanical properties. The test unit must consist of plates with the same steel grade and the same thickness range for the yield strength according to table 4.

Scope of testing

Quality testing includes the tensile test. On customer request, the notch impact bending test is carried out on longitudinal samples at –40 °C. A different sample position or testing temperature must be agreed upon on request.
Bending test is applied on request.
The heat analysis is provided as proof of the chemical composition.

Tolerances and surface finish

Unless otherwise agreed, tolerances pursuant to EN 10029 (thickness tolerance according to class A, flatness tolerance according to class N), and surface finish according to EN 10163-A1 are valid.

Marking

In general, marking consists of:

- voestalpine symbol
- Steel grade designation
- Heat number
- Plate number

Material testing certificate

Type of certificate accordig to EN 10204 must be agreed upon ordering.

Processing guidelines

Cold forming

alform 700 M steel plates provide good cold forming properties.
On condition that cut edges have been ground very smooth and that the bending process is done skillfully a minimum inner bending radius of 2,5 x plate thickness without cracks for 90°-bending is guaranteed at the component. In general, the resulting bending radius on the plate is smaller than the die-radius. The proper die-radius is to be chosen by the processor; we recommend a minimum die-radius of 3 x plate thickness.

Hot forming

Heavy plates of alform 700 M are in thermomechanically rolled condition and are intended for cold forming. In case of hot forming necessary, reheating for short time up to maximum 580 °C is possible.

Welding

General information
Thermomechanically rolled, high-strength alform 700 M steel has excellent weldability, which results of a lowcarbon equivalent (CEV), and in particular, a low carbon-content (C). The low CEV and C values provide reduced hardening in the heat-affected zone (HAZ) of welds. This leads to greater resistance to cold cracking. However, despite this advantage, in view of the high yield point of the steelgrade, it is advisable to take extra care during welding. The generally valid and accepted rules for the welding of low-alloyed, higher-strength fine-grain structural steels according to EN 1011-2 and STAHL-EISEN Werkstoffblatt (SEW) 088 must be observed.

Weld preparation, thermal cutting
Weld preparation can take the form by machining or thermal cutting. In the case of the latter, preheating is not required at a workpiece temperature above +5 °C.
Prior to welding the weld edges must be dry and clean.

Welding process
All standard automatic and manual welding processes can be employed. Inert gas shielded welding (MAG, MIG) with solid wire has the advantage of providing very low hydrogen content in the weld material and is also especially suitable with regard to cold cracking resistance.

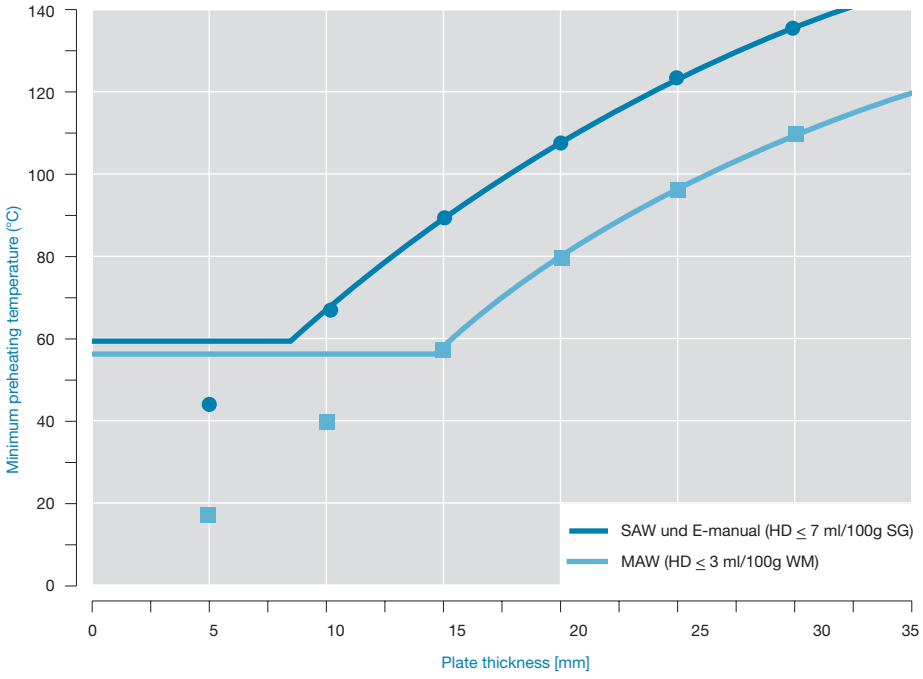
Filler materials and welding conditions
(preheating, welding parameters)

The selection of the filler materials should result in a weld that matches the chemical composition and the mechanical-technological properties of the base material.
ER 110 S-G wires according to AWS A 5.28 (e.g. Thyssen Union X85) are proven for inert gas shielded welding. Type E11018-G basic-coated stick electrodes according to AWS A 5.5 (e.g. Böhler FOX EV 85) are suitable for shielded metal arc welding, and the wire-powder combination ~ F 10 A4-EM2-M2 according to AWS A 5.23-97 (e.g. Böhler 3NiCrMo 2,5 UP/BB 24) is suitable for submerged arc welding.

As a result of their high strength, such welded joints show a higher tendency to cold cracking, which can be minimised by the selection of suitable welding conditions. The tendency to crack formation in the HAZ, in general, is distinctly lower than in the weld metal due to the lower hardening characteristics of the base metal. For reasons of cold cracking prevention, the hydrogen content in the weld material should be very low (HD ≤ 3 ml/100g WM). This is guaranteed by inert gas shielded welding with solid wire. Basic electrodes and welding powder for submerged arc welding must be subjected to secondary drying. The instructions of the manufacturer concerning drying and the method of use to obtain the required hydrogen criterion must be adhered to. The risk of cold cracking can be minimised by moderate preheating in accordance with picture 1, even in case of unfavourable combinations between heat input and platethickness.

Recommended preheating temperature, alform 700 M

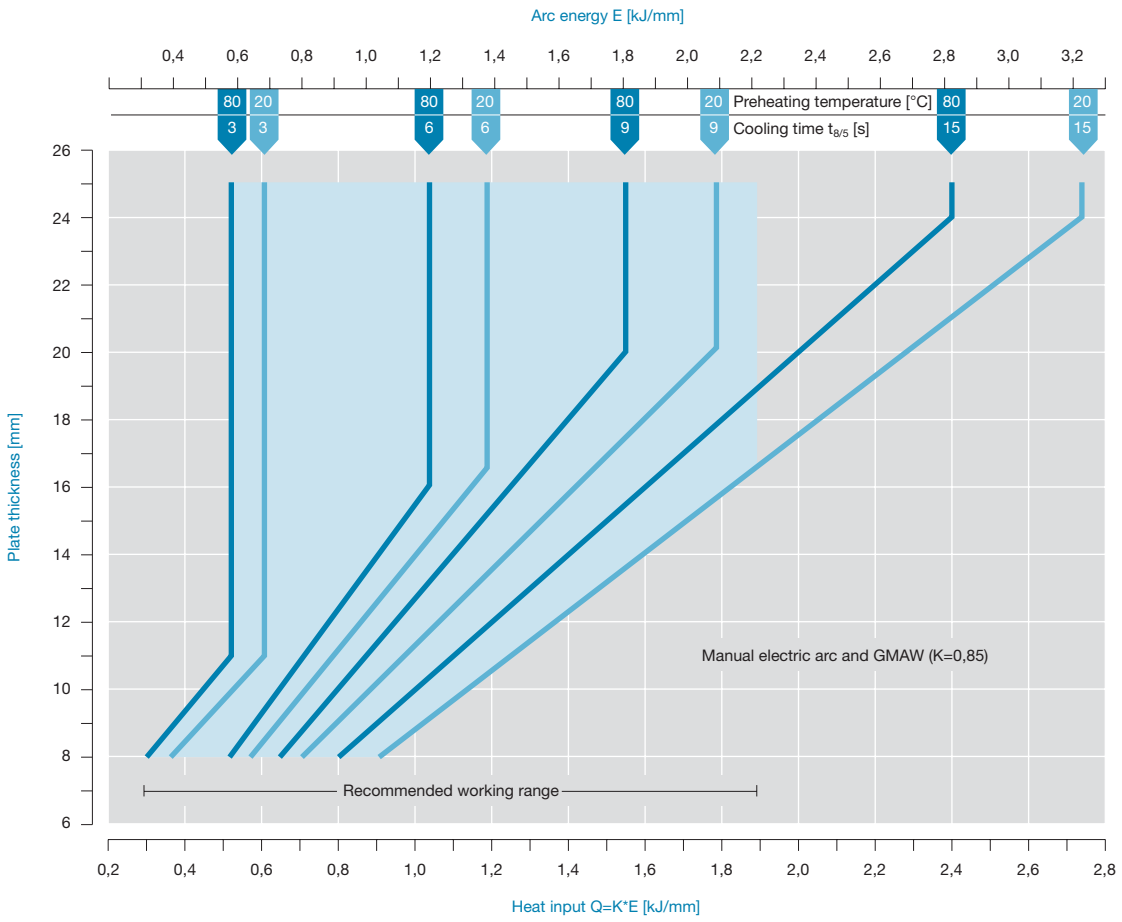
Picture 1: Recommended preheating temperature



To ensure the high strength and impact properties of the base metal in the weld metal, cooling times $t_{8/5}$ of 3 - 15 seconds and interpass temperatures of $\leq$ 150 °C are desirable.
Standard values for the arc energies to maintain the given cooling times are contained inpicture 2.

Standard value for cooling time $t_{8/5}$ acc. to EN 1011-2 annex B, alform 700 M

Picture 2: Standard value cooling time



Precondition for high notch impact energy in the welded joint is multi-layer welding, in which the number of weld layers is calculated on the basis of the following approximation:

$$\text{Minimum number of weld layers} \sim \frac{\text{Plate thickness (mm)}}{3}$$

Following appropriate checking (e.g. using process tests according to EN 15614-1), other welding conditions can be selected, if the properties of the welded joint correspond with the requirements made on the component.

Dimensions

alform 700 M

Thickness (mm)																			
25		■	■	■	■	■	■	■	■	■	■	■							
24		■	■	■	■	■	■	■	■	■	■	■							
23		■	■	■	■	■	■	■	■	■	■	■							
22		■	■	■	■	■	■	■	■	■	■	■							
21		■	■	■	■	■	■	■	■	■	■	■							
20		■	■	■	■	■	■	■	■	■	■	■							
19		■	■	■	■	■	■	■	■	■	■	■							
18		■	■	■	■	■	■	■	■	■	■	■							
17		■	■	■	■	■	■	■	■	■	■	■							
16		■	■	■	■	■	■	■	■	■	■	■							
15		■	■	■	■	■	■	■	■	■	■	■							
14		■	■	■	■	■	■	■	■	■	■	■							
13		■	■	■	■	■	■	■	■	■	■	■							
12		■	■	■	■	■	■	■	■	■	■	■							
11		■	■	■	■	■	■	■	■	■	■	■							
10		■	■	■	■	■	■	■	■	■	■	■							
9		■	■	■	■	■	■	■	■	■	■	■							
8		■	■	■	■	■	■	■	■	■	■	■							
		1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	2,600	2,700	2,800	2,900	3,000		Width (mm)

Maximum length: 12,000 mm

Different dimensions on request.

alform 960 M

alform 960 M is a high-strength, thermomechanically rolled, weldable fine-grain structural steel with good cold forming properties.

The alloying concept provides very low carbon contents, which aims in very good weldability. The high-strength grades provide special advantages in areas, where weight savings are of great importance, e.g. for mobile cranes, concrete pump cars and vehicles.

The technical terms of delivery apply for plate thickness from 10 - 15 mm.

Steel grades

Table 1: Steel grades

Steel grade
alform 960 M

Production process

alform 960 M is produced via the LD-route.

Chemical composition

Heat analysis

Guaranteed values

Table 2: Chemical composition

mass in %

C max.	Si max.	Mn max.	P max.	S max.	$Al_{tot.}$ min.	Cr max.	Mo max.	Ni max.	V max.	Nb max.	Ti max.	B max.
0.20	0.80	1.70	0.020	0.008	0.020	1.50	0.70	2.00	0.12	0.06	0.05	0.0050

The heat analysis is according to EN 10025-6 for steel grade S960.

Carbon equivalent

Standard values for carbon content and carbon equivalent

Table 3: Carbon content and equivalent

mass in %

C	CEV[1)]	CET[2)]	PCM[3)]
0.08	0.55	0.31	0.28

1) CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15, according to IIW

2) CET = C + (Mn + Mo)/10 + (Cr + Cu)/20 + Ni/40, according to SEW 088

3) PCM = C + Si/30 + (Mn + Cu + Cr)/20 + Ni/60 + Mo/15 + V/10 + 5*B, according to API 5L

As-delivered condition

The plates are delivered in a thermomechanical rolled condition with accelerated cooling and tempering.

Mechanical properties

Mechanical properties in as-delivered condition

Table 4: Mechanical properties

Thickness range mm	Yield strength[1)] YS min. N/mm²	Tensile strength[1)] UTS N/mm²	Fracture elongation[1)] $L_0 = 5{,}65 \sqrt{S_0}$ min. %	Notch impact energy[2)] J, min.
10 ≤ 15	960	980 - 1,150	10	30

1) Tensile test in accordance with EN 10002 on transverse samples.

2) Notch impact bending test in accordance with EN 10045 on Charpy-V longitudinal samples at –40 °C.
The mean value from 3 individual samples must reach the specified requirements. No individual value may be below 70 % of the guaranteed mean value. For thicknesses < 10 mm, samples similar to Charpy-V with dimensions of 10 x 7.5 mm are tested. The guaranteed value is reduced in proportion to the sample cross-section. The notch impact bending test can be agreed upon ordering.

The mechanical properties are according to EN 10025-6 for steel grade S960.

Quality test

Test unit

Unless otherwise agreed upon ordering, 40 t of a heat or a smaller portion is used as test unit for the mechanical properties.

Scope of testing

Quality testing includes the tensile test. On customer request, the notch impact bending test is carried out on longitudinal samples at –40 °C. A different sample position or testing temperature must be agreed upon ordering.
The heat analysis is provided as proof of the chemical composition.

Tolerances and surface finish

Unless otherwise agreed, tolerances pursuant to EN 10029 (thickness tolerance according to class A, flatness tolerance according to class N), and surface finish according to EN 10163-A1 are valid.

Marking

In general, marking consists of:

- voestalpine symbol
- Steel grade designation
- Heat number
- Plate number

Material testing certificate

Type of certificate accordig to EN 10204 must be agreed upon ordering.

Processing guidelines

Cold forming

alform 960 M steel plates provide good cold forming properties.
On condition that cut edges have been ground very smooth and that the bending process is done skillfully 90°-bending without cracks is guaranteed for die-radius of minimum 4 x plate thickness.

Hot forming

Heavy plates of alform 960 M are in thermomechanically rolled condition and are intended for cold forming. In case of hot forming necessary, reheating for short time up to maximum 580 °C is possible.

Dimensions

alform 960 M

Thickness (mm)																			
25																			
24																			
23																			
22																			
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9																			
8																			
		1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	2,600	2,700	2,800	2,900	3,000		Width (mm)

Maximum length: 12,000 mm

Different dimensions on request.

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