alform®

High-strength and ultra-high-strength thermomechanically rolled fine-grained steels

Technical terms of delivery for heavy plates

voestalpine Grobblech GmbH
www.voestalpine.com/grobblech

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ONE STEP AHEAD.

alform®

High-strength and ultra-high-strength thermomechanically rolled fine-grained steels

alform®

Steel grades

- High-strength: alform plate 620 M
  alform plate 700 M
- Ultra-high-strength: alform plate 900 M x-treme
  alform plate 960 M x-treme
  alform plate 1100 M x-treme

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 at www.voestalpine.com/grobblech

alform® x-treme

The high-strength steel grades alform plate 620 M, alform plate 700 M and the ultra-high-strength steel grades alform plate 900 M x-treme, alform plate 960 M x-treme and alform plate 1100 M x-treme are thermo-mechanically rolled fine-grain structural steels with excellent weldability and good bending properties.

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

The technical terms of delivery apply for plate thickness from

- 8 - 50 mm for alform plate 620 M
- 8 - 60 mm for alform plate 700 M
- 8 - 30 mm for alform plate 900 M x-treme
- 8 - 25 mm for alform plate 960 M x-treme
- 15 - 25 mm for alform plate 1100 M x-treme

Steel grades

Steel grades

Table 1: Steel grades

Steel grades
alform plate 620 M
alform plate 700 M
alform plate 900 M x-treme
alform plate 960 M x-treme
alform plate 1110 M x-treme

Production process

alform® steels are produced via the LD-route and are fully killed.

Chemical composition

Heat analysis

Guaranteed values

Table 2: Chemical composition

mass in %

Steel grades	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.
alform plate 620 M	0.12	0.50	2.00	0.020	0.008	0.020	1.50	0.50	2.00	0.12	0.06	0.05	0.0050
alform plate 700 M	0.12	0.60	2.10	0.020	0.008	0.020	1.50	0.50	2.00	0.12	0.06	0.05	0.0050
alform plate 900 M x-treme	0.12	0.60	1.70	0.020	0.008	0.020	1.50	0.70	2.00	0.12	0.06	0.05	0.0050
alform plate 960 M x-treme	0.12	0.60	1.70	0.020	0.008	0.020	1.50	0.70	2.00	0.12	0.06	0.05	0.0050
alform plate 1100 M x-treme	0.18	0.60	2.10	0.020	0.008	0.020	1.50	0.80	2.00	0.12	0.06	0.05	0.0050

[1] The total of Nb, V und Ti must not exceed 0.22%.

The chemical composition of alform plate 620 M is according to EN 10025-6 for steel grade S620QL.The chemical composition of alform plate 700 M is according to EN 10149-2 for steel grade S700MC. The chemical composition of alform plate 900 M x-treme is according to EN 10025-6 for steel grade S890QL. The chemical composition of alform plate 960 M x-treme is according to EN 10025-6 for steel grade S960QL.

Carbon equivalent

Standard values for carbon content and carbon equivalent

Table 3: Carbon content and equivalent

Steel grades	Plate thickness mm	C %	CEV[1] %	CET[2] %	PCM[3] %
alform plate 620 M	15	0.06	0.51	0.30	0.21
	40	0.06	0.52	0.31	0.21
alform plate 700 M	15	0.04	0.43	0.26	0.18
	40	0.06	0.47	0.26	0.19
alform plate 900 M x-treme	12	0.08	0.56	0.31	0.24
	20	0.08	0.60	0.33	0.25
alform plate 960 M x-treme	12	0.08	0.56	0.31	0.24
	20	0.08	0.60	0.33	0.25
alform plate 1100 M x-treme	20	0.13	0.70	0.40	0.31

[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

Plates of alform plate 620 M and alform plate 700 M are delivered in a thermomechanical rolled condition with accelerated cooling. Exceptionally conventional quenching and tempering is permitted. Plates of alform plate 900 M x-treme, alform plate 960 M x-treme and alform plate 1100 M x-treme are delivered in a thermomechanically rolled condition with accelerated cooling and tempering.

Mechanical properties

Mechanical properties in as-delivered condition

Table 4: Mechanical properties

Steel grades	Plate thickness range mm	Yield strength YS min. MPa	Tensile strength[1] Rm MPa	Fracture elongation[1] $L_0 = 5{,}65 \sqrt{S_0}$ min., %	Notch impact energy[2], min. J
alform plate 620 M	8 ≤ 50	620	700 - 890	15	40
alform plate 700 M	8 ≤ 15	700	770 - 1,050	10	40
	> 15 ≤ 50	680	770 - 1,050	12	40
	> 50 ≤ 60	650	770 - 1,050	12	30
alform plate 900 M x-treme	8 ≤ 30	900	940 - 1,100	11	30
alform plate 960 M x-treme	8 ≤ 25	960	980 - 1,150	10	30
alform plate 1100 M x-treme	15 ≤ 20	1,100	1,120 - 1,300	8	27
	> 20 ≤ 25	1,080	1,100 - 1,300	8	27

[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 or 10 x 5 mm are tested. The guaranteed value is reduced in proportion to the sample cross-section.

The mechanical properties of alform plate 620 M are according to EN 10025-6 for steel grade S620QL. The mechanical properties of alform plate 900 M x-treme are according to EN 10025-6 for steel grade S890QL. The mechanical properties of alform plate 960 M x-treme are according to EN 10025-6 for steel grade S960QL.

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. The notch impact bending test is carried out on longitudinal samples at –40 °C. A different sample position or testing temperature must be agreed 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. On request and surcharge we offer reduced flatness tolerances according to table 5 for alform plate 700 M.

Flatness tolerances

Measure in mm

Table 5: Flatness tolerances

	Normal, Class N				Reduced, Class S			
	alform plate 700 M		Steel group H acc. to EN10029		alform plate 700 M		Steel group H acc. to EN10029	
	Measuring length				Measuring length			
Plate thickness	1000	2000	1000	2000	1000	2000	1000	2000
≥ 8 < 15	10	14	10	14	7	12	7	12
≥ 15 < 25	10	13	10	13	7	11	7	11
≥ 25 < 40	9	12	9	12	7	11	7	11
≥ 40 < 60	8	12	8	12	6	10	6	10

Marking

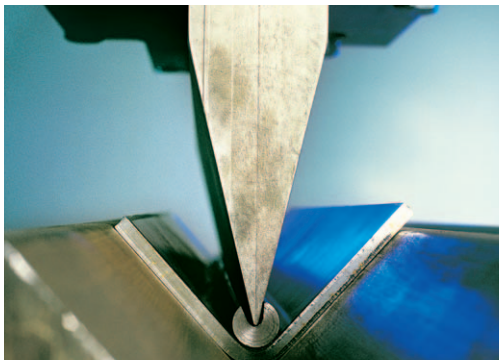
In general, marking consists of:

- 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® steels 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-radii according to table 6.

Recommended edging radii

Table 6: Recommended edging radii

Steel grades	Edging radii Ri min. at 90° edging (s = plate thickness) Position of the bending edge to the rolling direction		
	Longitudinal		Transverse
alform plate 620 M	4 s		3 s
alform plate 700 M	4 s		3 s
alform plate 900 M x-treme	5 s		4 s
alform plate 960 M x-treme	5 s		4 s
alform plate 1100 M x-treme	6 s		5 s

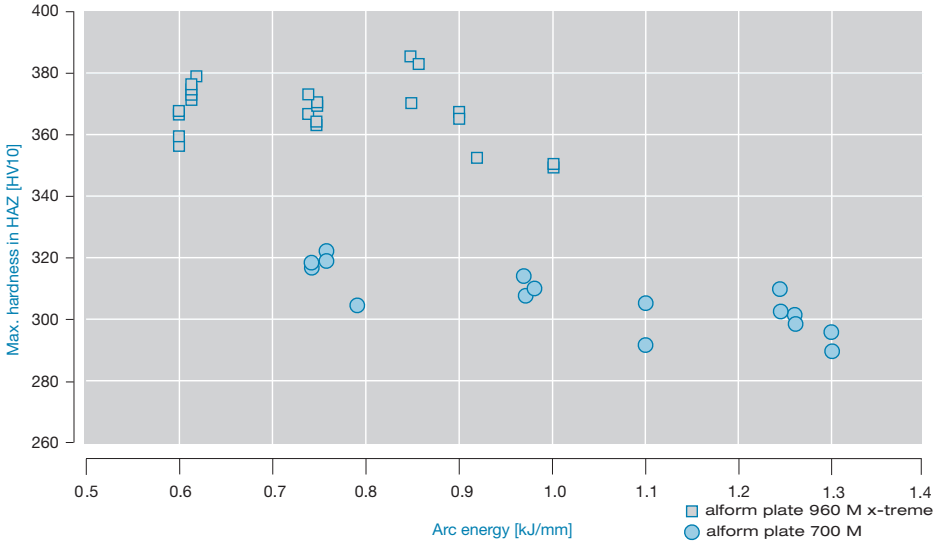
Hot forming and heat treatment

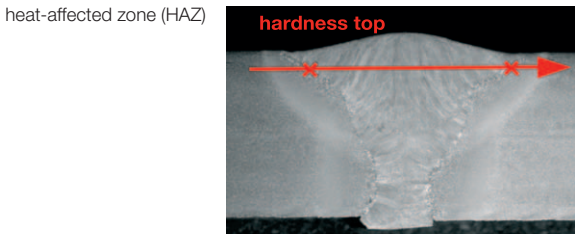
alform® steels are in thermomechanically rolled condition and are intended for cold forming. Hot forming and stress relief annealing are possible up to 580 °C. For optimum toughness properties of the weld we recommend stress relief annealing up to max. 520 °C. Tensile strength of alform plate 620 M and alform plate 700 M will decrease within the guaranteed values in table 4 compared to delivery condition due to heat input. Normalizing and quenching and tempering deteriorate the microstructure of TMCP-steels and therefore are not to be processed.

Welding

General information
alform® steels have excellent weldability, which results of a low carbon 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 (picture 1).

Hardening in heat-affected zone (HAZ)





Picture 1: Hardening in HAZ

However, despite this advantage, in view of the high yield point of the steel grade, 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 for plate thickness up to 20 mm 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 (GMAW, IGSW) 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.

For welding alform plate 700 M ER 110 S-G wires according to AWS A 5.28 are proven for inert gas shielded welding. Type E11018-G basic-coated stick electrodes according to AWS A 5.5 are suitable for shielded metal arc welding, and the wire-powder combination ~ F 10 A4-EM2-M2 according to AWS A 5.23-97 is suitable for submerged arc welding. Recommended welding consumables for high-strength and ultra-high-strength alform® steels are provided in table 7 and by alform® welding system at www.voestalpine.com/heavyplates/en/Brand-names/alform-R-welding-system.
alform® welding system is the world's first custom-matched system of steels and consumables for high-strength and ultra-high-strength welded structures.

Table 7: Recommended welding consumables

Base material	Welding process – consumable					
Material	Process	Filler metal	Shielding gas	Preheating [°C] [1) 2)]	Interpass-temperature [°C] [3)]	$t_{8/5}$-sector [s] [4)]
alform plate 620 M alform plate 700 M	GMAW	**Böhler alform 700-IG** ER 110 S-G wires (acc. to AWS A 5.28)	M21 (e.g. Corgon 18)	60 - 150	≤ 150	3 - 15
		e.g. Böhler X70-IG, Union X85 ER 110 S-G wires (acc. to AWS A 5.28)				
	SAW	**Böhler alform 700-UP** **Böhler alform BB 700** F10 A 4-EM4(mod.)-M4 (acc. to AWS 5.23) F69 A 4-EM4(mod.)-M4 (nach AWS 5.23)	---			
		e.g. Union S3 NiMoCr + UV 421 TT F11A8-EG-F6 (acc. to AWS A 5.23)				
	SMAW	**BÖHLER FOX alform 700, …** E 11018-GH4R electrodes (acc. to AWS A 5.5)				
		e.g. Phönix SHNi2K 100 … E 11018-G electrodes (acc. to AWS A 5.5)				
	GTAW	**e.g. Böhler NiCrMo2.5iG ...** ER 110S-G (acc. to AWS A5.28)	---			
alform plate 900 M x-treme alform plate 960 M x-treme	GMAW	**BÖHLER alform 960-IG** ER 120 S-G wires (acc. to AWS A 5.28)	M21 (e.g. Corgon 18)	60 - 150	≤ 150	3 - 12
		z. B. Union X96, Union X90-IG, … ER 120 S-G wires (acc. to AWS A 5.28)				
	SMAW	**e.g. Böhler FOX EV 100, …** E 12018-G electrodes (acc. to AWS A 5.5)	---			
		e.g. Phönix SHNi2K 130 … E 12018-G electrodes (acc. to AWS A 5.5)				

1) Preheating up to 60°C is recommended for drying fusing edge

2) In complex welded construction (e.g. out of position welding, accumulation of welds, …) preheating according EN 1011-2 is recommended

3) For specific requirements on strength and toughness of filler material and weld an interpass temperature below 150°C is recommended

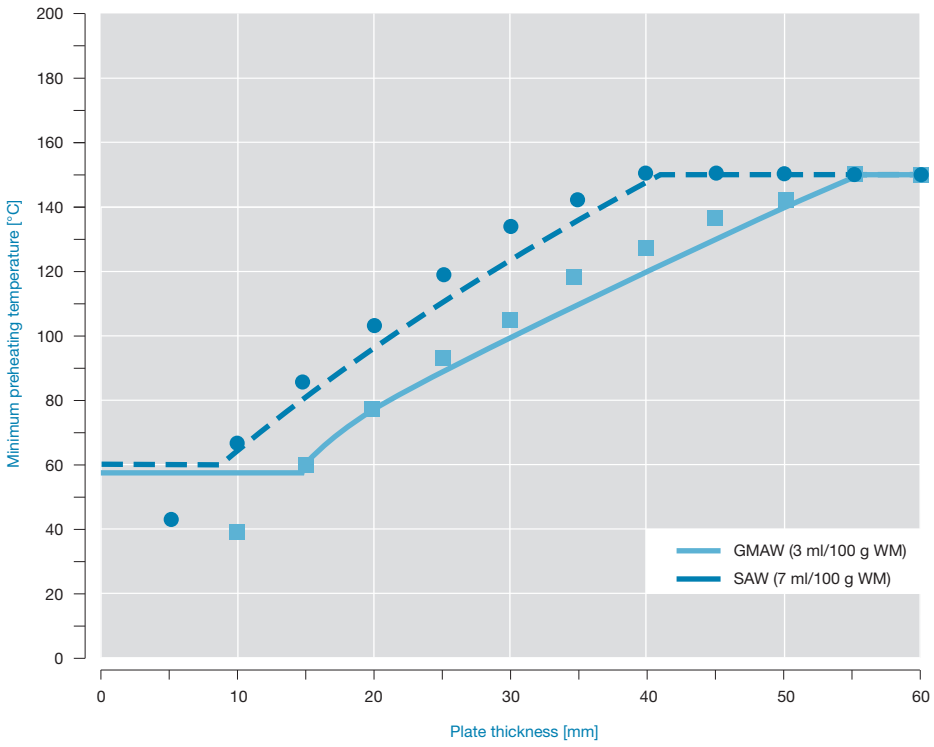
4) Cooling time $t_{8/5}$ (s), measured by thermocouple submerged into molten bath

You will find more information at www.voestalpine.com/welding
Experienced welding engineers are at your disposal.

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 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 2, even in case of unfavourable combinations between heat input and plate thickness.

Recommended preheating temperature

alform plate 620 M, alform plate 700 M, alform plate 900 M x-treme and alform plate 960 M x-treme



Picture 2: Recommended preheating temperature

To ensure the high strength and impact properties of the weld (base material, HAZ and filler metal) cooling times $t_{8/5}$ of 3 - 15 seconds and interpass temperatures of $\leq$150 °C are desirable. Cooling times $t_{8/5}$ above 15 seconds are permitted under special conditions (e.g. overmatching, ...) but are to be proven by the welder in every case.

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 plate 620 M

Thickness (mm)																										
60																										
55																										
50		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
45		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
40		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
35		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
30		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
25		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
20		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
15		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
10		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
8		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Width (mm)		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	3,100	3,200	3,300	3,400	3,500	3,600	3,700	3,800	

Maximum width: max. width of 3,750 mm for weight per piece > 15 mt

Maximum length: 18,700 mm

Different dimensions on request.

Dimensions

alform plate 700 M

Thickness (mm)	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	3,100	3,200	3,300	3,400	3,500	3,600	3,700	3,800
60	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
55	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
50	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
45	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
40	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
35	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
30	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
25	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
15	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
10	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
8	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								

Maximum width: max. width of 3,750 mm for weight per piece > 15 mt

Maximum length: 18,700 mm

Different dimensions on request.

Dimensions

alform plate 900 M x-treme

Thickness (mm)													
30													
25													
20													
15													
10													
8													
Width (mm)		1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	

Maximum length: 16,000 mm

Different dimensions on request.

Dimensions

alform plate 960 M x-treme

Thickness (mm)													
25													
20													
15													
10													
8													
Width (mm)		1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	

Maximum length: 16,000 mm

Different dimensions on request.

Dimensions

alform plate 1100 M x-treme

Thickness (mm)													
25													
20													
15													
Width (mm)		1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	

Maximum length: 16,000 mm

Different dimensions on request.

Technically more advanced. Successful together.

voestalpine Steel Division – the partner you can trust.

High-quality materials are the basis for our products. We strive to be the best partner for our customers and want to provide them with the best-possible solutions. We focus our expertise on two aspects:
The personal aspect, with dedicated and highly competent employees
The technical aspect, with high-quality methods, products and services

The companies in the voestalpine Steel Division and their employees understand partnership to be the following:

- Understanding for their customers' business
- Expertise and reliability
- Responsibility for satisfactory project completion
- Partnerships based on trust

Many years of successful partnerships with our customers prove our point.

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