

Quenched and tempered fine-grain steels

Technical terms of delivery

aldur®

Quenched and tempered fine-grain steels



aldur® Q

Steel grades

- aldur 500 Q, QL, QL1
- aldur 700 Q, QL, QL1

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

aldur[®] Q

The grades of the aldur[®] Q series are water-quenched and tempered, high-strength, weldable fine-grain structural steels. Main applications are welded structures subjected to extreme loads, e.g. in crane and vehicle manufacturing, for steel construction, in pressure vessel and pressure piping systems.



The steel grades are supplied in three groups:

- **Basic series aldur[®] ... Q**
with guaranteed notch impact toughness at -20 °C
- **Low temperature series aldur[®] ...QL**
with guaranteed notch impact toughness at -40 °C
- **Special low-temperature series aldur[®] ...QL1**
with guaranteed notch impact toughness at -60 °C

The technical terms of delivery apply for plate thicknesses from 12 - 100 mm.

Steel grades

Steel grades

Steel grades	Designation according EN 10025-6	Material number
aldur 500 Q	S500Q	1.8924
aldur 500 QL	S500QL	1.8909
aldur 500 QL1	S500QL1	1.8984
aldur 700 Q	S690Q	1.8931
aldur 700 QL	S690QL	1.8928
aldur 700 QL1	S690QL1	1.8988

Table 1:
Steel grades

Production process

aldur[®] Q steels are produced via the LD-route.

Chemical composition

Heat analysis

Guaranteed values

Steel grades	mass in %															
	C	Si	Mn	P	S	Al _{tot.}	N	Cr	Ni	Mo	Cu	V	Nb	Ti	B	Zr
	max.	max.	max.	max.	max.	min.	max.	max.	max.	max.	max.	max.	max.	max.	max.	max.
aldur 500 Q, QL, QL1	0.20	0.80	1.70	0.020	0.010	0.018	0.015	1.50	2.00	0.70	0.50	0.12	0.06	0.05	0.0050	0.15
aldur 700 Q, QL, QL1	0.20	0.80	1.70	0.020	0.010	0.018	0.015	1.50	2.00	0.70	0.50	0.12	0.06	0.05	0.0050	0.15

Table 2:
Chemical
composition

Carbon equivalent

Depending on the analyses employed, the following carbon equivalents result for varying plate thicknesses.

Standard values

Steel grades		Carbon equivalent mass in % plate thickness in mm		
		≤ 25	> 25 ≤ 50	> 50 ≤ 100
aldur 500 Q, QL, QL1	CEV ¹⁾ max. acc. EN 10025-6	0.47	0.47	0.70
	CEV ¹⁾ standard value	0.40	0.46	0.46
	CET ²⁾ standard value	0.25	0.29	0.29

Table 3:
carbon
equivalent

Steel grades		Carbon equivalent mass in % plate thickness in mm			
		≤ 30	> 30 ≤ 50	> 50 ≤ 70	> 70 ≤ 100
aldur 700 Q, QL, QL1	CEV ¹⁾ max. acc. EN 10025-6	0.65	0.65	0.77	0.77
	CEV ¹⁾ standard value	0.46	0.52	0.52	0.54
	CET ²⁾ standard value	0.29	0.32	0.32	0.35

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

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

As-delivered condition

The plates are delivered in water-quenched and tempered condition. Direct hardening after hot rolling is permitted.

Mechanical properties

Mechanical properties at ambient temperature

Steel grades	Material number	Yield strength YS ¹⁾ MPa, min. plate thickness in mm		Tensile strength UTS MPa plate thickness in mm		Fracture elongation $L_0 = 5,65 \sqrt{S_0}$ min. %
		≤ 50	> 50 ≤ 100	≤ 50	> 50 ≤ 100	
aldur 500 Q	1.8924					
aldur 500 QL	1.8909	500	480	590 - 770	590 - 770	17
aldur 500 QL1	1.8984					
aldur 700 Q	1.8931					
aldur 700 QL	1.8928	700	650	770 - 940	760 - 930	14
aldur 700 QL1	1.8988					

**Table 4:
Mechanical
properties**

¹⁾ Where there is no distinct yield strength, the 0,2 %-proof stress (Rp 0,2) is established.

Notch impact energy (valid for Charpy V-notch samples)

Steel grades	Sample direction	Notch impact energy AV ¹⁾ J, min. testing temperature in °C			
		-60	-40	-20	± 0
aldur 500 Q	longitudinal	-	-	30	40
aldur 700 Q	transversal	-	-	27	30
aldur 500 QL	longitudinal	-	30	40	50
aldur 700 QL	transversal	-	27	30	35
aldur 500 QL1	longitudinal	30	40	50	60
aldur 700 QL1	transversal	27	30	35	40

**Table 5:
Notch impact
energy**

¹⁾ Notch impact test according to EN 10045 at longitudinal samples. Mean value from 3 individual samples must reach the specified requirements. No individual value may be below 70 % of the guaranteed mean value. Testing temperature is -20 °C for the basic series aldur Q, -40 °C for the low-temperature series aldur QL and -60 °C for the special low-temperature series aldur QL1.

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. The thickness of the plate in the test unit may not differ more than 5 mm from the thickness of the sample.

Position of test samples

The sample position in the rolled plate is at one end and at a quarter of the width.

Scope of testing

The following tests are carried out on the test samples:

- Tensile test at ambient temperature on transverse samples
- Notch impact test on longitudinal samples

The heat analysis is provided as proof of the chemical composition.

A transverse sample has to be taken for the tensile test at ambient temperature. Usually flat samples are used for thicknesses up to 42 mm (aldur 500) resp. up to 20 mm (aldur 700); at least one rolled surface shall remain on the sample. Round samples are permitted. For product thicknesses higher than mentioned above round samples are used in any case.

Unless otherwise agreed, 3 longitudinal samples are taken from each position for the notch impact tests. For product thicknesses of up to 40 mm, one side of the sample must be as near as possible to the rolled surface. In the case of product thicknesses above 40 mm, the samples are taken in such a manner that their longitudinal axes are at a distance of a quarter of the product thickness from the surface, or as near as possible to this point. The notch must be vertical to the product surface.

Tolerances and surface finish

Unless otherwise agreed, tolerances according 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 according to EN 10204 must be agreed upon ordering.

Processing guidelines

Cold forming

aldur® Q plates are well-suited for the standard cold forming processes in general steel construction work.

Recommended minimum bending radii

Bending line	transverse	parallel	to the rolling direction
Bending radius	≥ 3	≥ 4	x plate thickness

**Table 6:
Minimum
bending radii**

The recommended minimum bending radius is only valid on condition that cut edges have been removed and that the bending process is done professional.

Hot forming

Hot forming at temperatures above the permissible maximum stress-relief temperature (560 °C) can influence the original tempered condition. In that case water-quenching and tempering must be repeated after hot forming.

Welding

General information

A prerequisite for high-quality welding is adherence to 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.

Weld preparation, thermal cutting

Weld preparation can be done by machining or flame cutting. In the case of the latter, aldur 500 Q does not require preheating for workpiece temperatures above +5 °C. aldur 700 Q in plate thicknesses above 50 mm should be preheated to 100 °C.

Welding process

All standard automatic and manual welding processes can be employed, particularly shielded metal arc, inert gas shielded and submerged arc welding.

Filler materials and welding conditions (preheating, welding parameters)

The filler materials should be selected in that way, that the weld material matches the mechanical-technological properties of the base material. The filler materials listed in tables 7 and 8 are used in daily practice.

For preventing of cold cracking, care should be taken to ensure a low hydrogen content of $HD < 5 \text{ ml/100 g WM}$. This is generally guaranteed by inert gas shielded welding with solid wire. Basic electrodes and welding powder must be subjected to secondary drying in accordance with manufacturers instructions.

In order to prevent excessive hardening of the micro structure in the heat affected zone (HAZ) and to achieve better resistance to hydrogen-induced cold cracking, apart from the control of the hydrogen content, preheating is recommended in accordance with the information given in tables 7 and 8.



Preheating has the effect of reducing the hardening of the microstructure in the HAZ through an extension of the cooling time $t_{8/5}$ and has a dominating influence on the time available in the temperature range below 300 °C for hydrogen effusion out of the weld region. In order to prevent cracks in the weld material, low-hydrogen annealing (postheating) in accordance with the conditions shown in tables 7 and 8 is recommended for plate thicknesses above 50 mm. In order to attain also in the weld material the high-strength and excellent toughness properties of the base material, heat input should be limited to max. 25 kJ/cm for aldur 500 Q and max. 20 kJ/cm for aldur 700 Q and multi-layer welding is to be employed as temper bead technique. Welding conditions, which lead to cooling times $t_{8/5}$ of 10 - 20 seconds, have proved effective. Following appropriate checks, welding can take place with other cooling times if the requirements on the component are fulfilled.

Recommended fillers and heat control during welding

aldur 500 Q, QL, QL1

Welding process	Filler material		Pre-heating °C	Interpass temp. °C	Post-heating °C - hrs
	Standard AWS-ASME II/C	Designation			
Shielded metal arc	A 5.5-SFA 5.5	E 8018-G	80 s ≥ 30 mm	max. 200	250 - 3 s ≥ 50 mm
Inert gas shielded	A 5.28-SFA 5.28	ER 90 S-G			
Submerged arc	A 5.23-SFA 5.23	F9A8-EF1-F1			

Table 7:
Fillers and heat control aldur 500 Q

aldur 700 Q, QL, QL1

Welding process	Filler material		Pre-heating °C	Interpass temp. °C	Post-heating °C - hrs
	Standard AWS-ASME II/C	Designation			
Shielded metal arc	A 5.5-SFA 5.5	E 11018-G	100 s ≥ 12 mm	max. 170	250 - 3 s ≥ 50 mm
Inert gas shielded	A 5.28-SFA 5.28	ER 110 S-G			
Submerged arc	A 5.23-97	F10-A4-EM4-M2			

Table 8:
Fillers and heat control aldur 700 Q

Recommended welding consumables

Base material			Welding process – consumable				
voestalpine	EN 10025-6	Material-number	SMAW	GTAW	GMAW	SAW	
						wire	flux
aldur 500 Q	S500Q	1.8924	FOX EV 65 Phoenix SH Ni 2 K90	NiMo1-IG Union NiMo	NiMo1-IG Union MoNi	3 NiMo1-UP Union S 3 NiMo	BB 24 UV 421 TT
aldur 500 QL	S500QL	1.8909					
aldur 500 QL1	S500QL1	1.8984					
aldur 700 Q	S690Q	1.8931	FOX EV 85 Phoenix SH Ni 2 K100	NiCrMo 2,5-IG –	NiCrMo 2,5-IG Union NiMoCr/ Union X85	3 NiCrMo 2,5-UP Union S 3 NiMoCr	BB 24 UV 421 TT
aldur 700 QL	S690QL	1.8928					
aldur 700 QL1	S690QL1	1.8988					

Table 9:
Recommended welding consumables

You will find more information at www.boehler-welding.com and www.t-put.com. Experienced welding engineers are at your disposal.

Stress-relieving

Where stress-relief annealing is required due to the structure and/or processing conditions, temperatures ≤ 560 °C must be used.

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