A22 - Amstrong® Ultra - Ultra High Strength Steels

Using these steel grades makes it possible to build longer/higher booms for cranes and aerial platforms.

A22

Properties

These low alloy steel grades complete the Amstrong® range (see data sheet A20) and offer exceptionally high yield strength values. They have a fine grain structure, low carbon content for improved weldability, and controlled internal purity.

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Advantages

Weight reduction

The grades in this data sheet combine outstanding mechanical properties (very high strength, fatigue resistance and toughness) with good formability and weldability. Their guaranteed high yield strength makes it possible to achieve substantial weight reduction through downgauging, whilst maintaining overall performance and safety. These steel grades are therefore frequently used to replace conventional structural steel grades when weight reduction is required.

Thickness reduction brings additional savings when processing the material, since it is easier to weld, and reduces transport costs. Further savings are also achieved in service, in the form of lower energy consumption, improved mechanical performance, safety etc.

Abrasion/wear resistance

In some applications (conveying devices, earth-moving or transportation vehicles etc), the steel surface can be subject to wear. Wear is a complex physical phenomenon that depends not only on the presence of abrasive materials but also on the conditions under which it occurs (pressure, temperature, impact, corrosion etc).

Compared with standard structural steel grades, Ultra High Strength Steel grades allow a significant improvement in wear resistance. In many cases, they can be more economical and easier to process than steel grades specifically designed for wear resistance.

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Applications

Their very high yield strength contributes to a solution that increases the payload capacity and gives higher strength structures.

Typical applications include telescopic cranes, aerial platforms, concrete pumps, telescopic handlers, tippers and truck trailers, where the emphasis is on strength and weight reduction potential.

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Recommendations for use

Thermal cutting

These grades are suitable for oxygen, plasma and laser cutting.

Estimation of the possible thickness reduction

When switching from grade 1 (with low yield strength) to grade 2 (proposed in this data sheet), an estimation of the thickness reduction that can be achieved is given by the following formula:

$t_2 = t_1 \, (R_{e1}/R_{e2})^{½}$

where t = thickness R_e = yield strength

Please note that other issues, such as fatigue resistance, need to be checked before reducing thickness.

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Surface quality

These grades are available in "A - Unexposed" finish only.

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Weldability

Weldability and cold crack susceptibility of these grades are more accurately assessed using the PCM formula (parameter crack measurement), which was developed for low carbon steels (< 0.11%).

Due to their typical low carbon equivalent value (PCM < 0.25), these ArcelorMittal grades do not need to be pre- or post-heated when welding. They are not prone to excessive hardening due to their low carbon and low alloy content, are totally insensitive to cold cracking and are suitable for all types of arc welding.

	Thickness range	CEV typical	PCM typical
Amstrong® Ultra 650MC	≤ 12 mm	0.42	0.18
	> 12 mm	0.45	
Amstrong® Ultra 700MC	< 6 mm	0.37	0.16
	6 < 10 mm	0.43	0.18
	≥ 10 mm	0.45	

$$CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

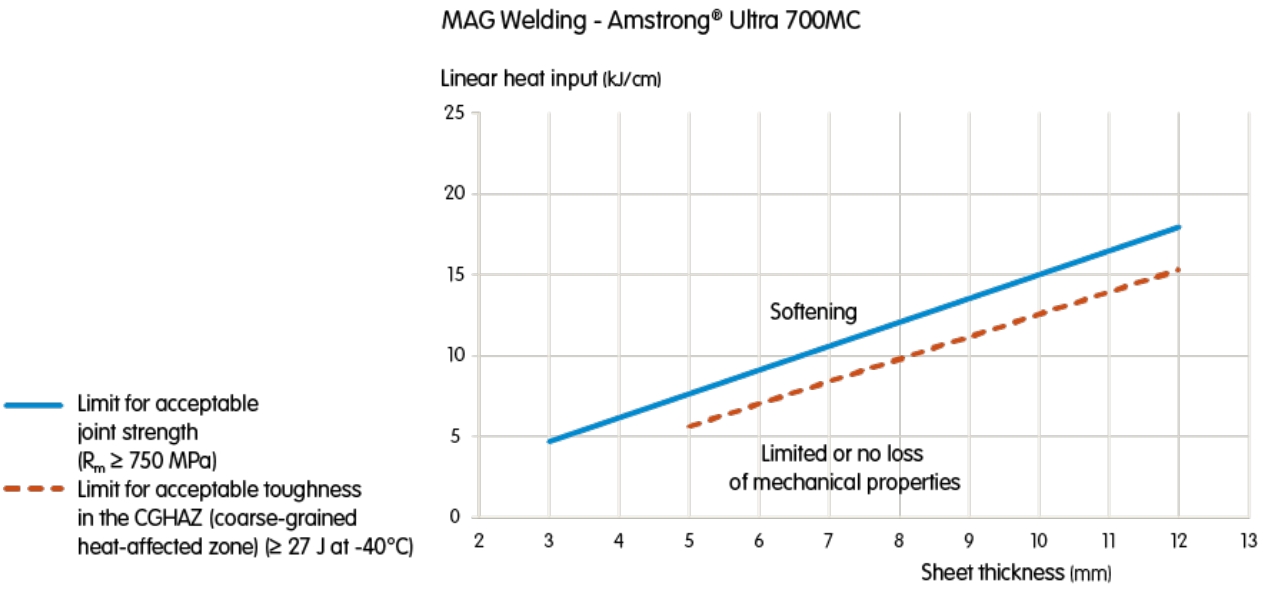
$$PCM = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

Heat-affected zone softening - welding recommendations

If special care is not taken, softening may occur in the heat-affected zone (HAZ), particularly in the intercritical heat-affected zone (ICHAZ), which is typical behaviour of thermomechanically rolled steel grades with yield strength above 500 MPa. The extent of softening and the width of the softened zone increases with heat input applied during welding.

In order to preserve the high mechanical properties of the base material after welding, the recommendation is to limit the welding energy to about 1.5 kJ/cm per millimetre of thickness, as shown in the figure below, which corresponds to the following maximum cooling times (between 800°C and 500°C):

- When only the joint strength is a priority, we recommend using heat inputs that make it possible to reach $t_{800-500}$ ≤ 20 s
- When both the joint strength and the toughness of the HAZ (at -40°C) are priorities, we recommend using lower heat inputs that make it possible to reach $t_{800-500}$ ≤ 13 s



Recommendations for selecting the suitable heat input for MAG welding of Amstrong® Ultra 700MC grade.

Interpass temperature & heat treatment

Amstrong® Ultra 650MC and Amstrong® Ultra 700MC do not need to be pre- or post-heated when welding. In multi-pass welding, the interpass temperature acts as preheating for the subsequent pass and increases cooling time. The interpass temperature should therefore be limited to minimise any loss in mechanical properties. The maximum recommended interpass temperature is 100°C.

Similarly, post-weld heat treatment may cause loss in mechanical properties. We therefore strongly recommend that you contact ArcelorMittal prior to performing any heat treatment, to define the suitable settings.

Filler wire selection

We recommend using filler wires that at least match or overmatch the strength of the base material. Recommended wires/fluxes for Amstrong® Ultra 700MC are listed in the table below.

Supplier	SMAW	GMAW	FCAW	SAW	
Esab	OK 75.75	OK Autrod 13.29, OK Aristorod 13.31	OK Tubrod 14.03	OK Autrod 13.43	OK Flux 10.62
Filarc	Filarc 118		Filarc PZ 6148		
Lincoln	Conarc 80	LNM MoNiVa	Outershield 690-H	LNS 168	P230
	Conarc 85		Outershield MC-100	LA 100	Lincolnweld 8500
Oerlikon	Tenacito 80 CL	Carbofil NiMoCr	Fluxofil 42	OE-S3 NiMoCr	OP 121TT
	Tenax 118M	Carbofil MnNiMo	Citoflux M07	Fluxocord 42	
S.A.F. Air Liquide	Safer ND 80	Nertalic 88	Steelcored 42		
			Safdual 270		
Thyssen	SHNK 100	Union NiMoCr		Union S3 NiMoCr	UV 421TT

Mechanical properties after welding

When welded within the recommended heat input range, the tensile strength and the impact toughness of the welded area of Amstrong® Ultra 650MC and Amstrong® Ultra 700MC steel grades are superior to the minimum requirements of European standards EN 288 and EN 10149 relating to the base metal.

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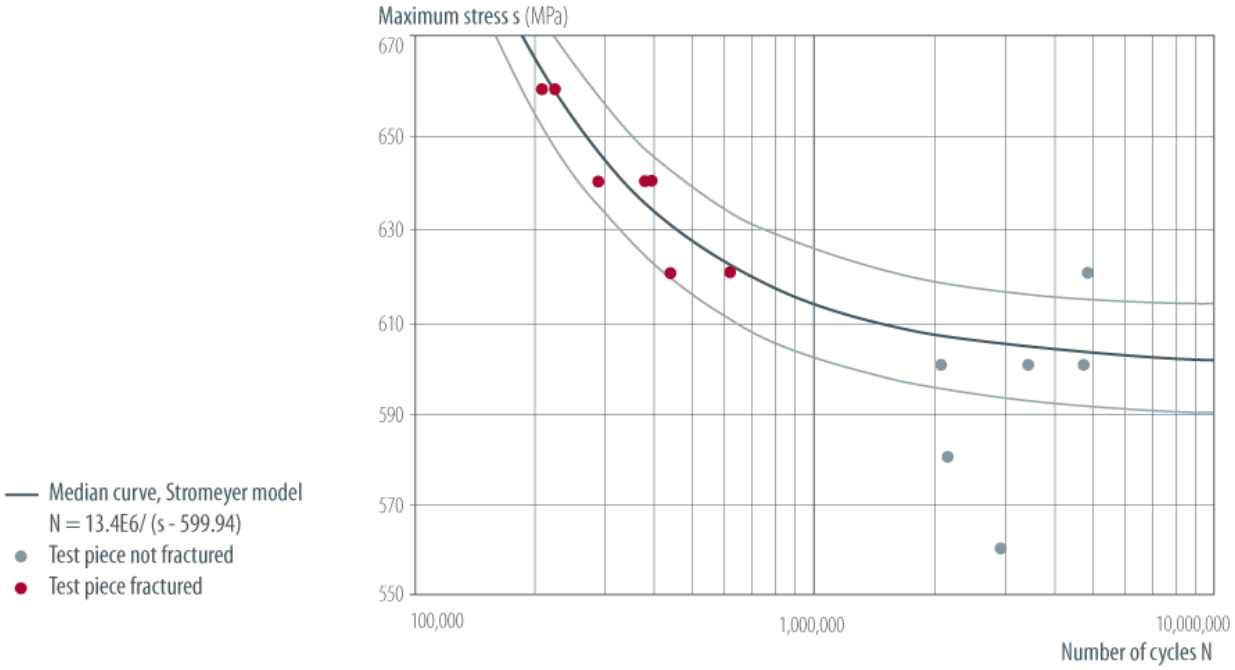
Fatigue resistance

The fine grain size and low sulphur content improve the fatigue resistance of the steel. Fatigue performance is measured by uniaxial tests at different stress levels. These values are used to plot the Wöhler curve and determine the endurance limit of the steel grade.



Typical Wöhler curves of Amstrong® Ultra 700MC show an endurance limit above 560 MPa (with R = 0.1).

However, it should be noted that it is advisable - as with most materials - to keep welded joints away from highly stressed zones, particularly in the case of dynamic loading, since they may adversely affect fatigue endurance.

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Brand correspondence

	EN 10149-2:2013	NF A 36-203:1992	BS 1449/1	SEW 92*	USA ASTM
S650MC EN 10149-2	S650MC			(QstE 690TM)	
Amstrong® Ultra 650MC					
S700MC EN 10149-2	S700MC	(E690D)			
Amstrong® Ultra 700MC	S700MC	(E690D)	75F70		A514

() Closest grade as no fully equivalent grade exists.

* The values for the tensile test of these steel grades apply to transverse test pieces.

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Dimensions

Mill finish

Thickness (mm)	Min width	S650MC EN 10149-2, Amstrong® Ultra 650MC	S700MC EN 10149-2, Amstrong® Ultra 700MC
		Max width	Max width
2.00 ≤ th < 3.00	800	-	1250
3.00 ≤ th < 4.00		1520	1520
4.00 ≤ th < 5.00		1620	1620
5.00 ≤ th < 6.00		1720	1720
6.00 ≤ th < 7.00		1780	1780
7.00 ≤ th < 8.00		1850	1850
8.00 ≤ th < 10.00		2020	2020
10.00 ≤ th < 11.00		2040	2040
11.00 ≤ th < 12.00		2050	2050
12.00 ≤ th < 15.00		*	-

** Please contact us.*

Pickled

Available on request. Please contact us.

A22

Mechanical properties

Toughness

The fine grain size and low sulphur and carbon content of these Amstrong® Ultra grades improve steel toughness.

For this reason, the option proposed by EN 10149:2013 for this characteristic is included in our Amstrong® Ultra range.

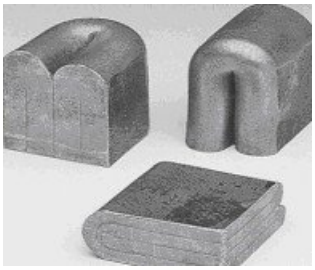
Two versions of Amstrong® Ultra 650MC and Amstrong® Ultra 700MC are available:

- Standard version with a toughness guarantee of 40J/-20°C.
- Tough version with a toughness guarantee of 27J/-40°C.

Bending

The minimum 180° bending radius of Amstrong® Ultra 650MC and Amstrong® Ultra 700MC can vary according to the edge quality of the sheet:

- On milled edges and good-quality plasma or laser cut edges, bending can be performed with a minimum mandrel diameter of 1.8 times the sheet thickness
- For cut edges (sheared or slit), depending on the care exercised in shearing/cutting, a bend with a mandrel diameter of 1.8 times the thickness can be achieved, but fracture of the outside surface of the bend edge may occur



	Notes	Direction	Thickness (mm)	R_e **(MPa)**	R_m **(MPa)**	A_{80} **(%)**	Min. mandrel diameter for 180° bending	KV -20°C **(J)**	KV -40°C **(J)**	A 5.65$\sqrt{S_o}$ **(%)**
S650MC EN 10149-2	1	L	2 - 3	≥ 650	700 - 880	≥ 10	-	-	-	-
			3 - 8			-				≥ 12
			8 - 10	≥ 630						
		T	2 - 10	-	-	-	≥ 2 x t	-	-	-
Amstrong® Ultra 650MC	2+1	L	2 - 3	≥ 650	700 - **850**	≥ 10	-	-	-	-
			3 - 6			-				**≥ 14**
			6 - 8					**≥ 40**	**≥ 27**	
			8 - 12	≥ 630						
		T	2 - 3	**≥ 670**	**710 - 880**	**≥ 10**	**≥ 1.8 x t**	-	-	-
			3 - 8			-				**≥ 12**
			8 - 15	**≥ 650**						
S700MC EN 10149-2	1	L	2 - 3	≥ 700	750 - 950	≥ 10	-	-	-	-
			3 - 8			-				≥ 12
			8 - 10	≥ 680						
		T	2 - 10	-	-	-	≥ 2 x t	-	-	-
Amstrong® Ultra 700MC	2+1	L	2 - 3	≥ 700	750 - **930**	≥ 10	-	-	-	-
			3 - 6			-				**≥ 14**
			6 - 8					**≥ 40**	**≥ 27**	
			8 - 13	≥ 680						
		T	2 - 3	**≥ 720**	**760 - 950**	**≥ 10**	**≥ 1.8 x t**	-	-	-
			3 - 8			-				**≥ 12**
			8 - 10	**≥ 700**						
			10 - 13				-			

Values in bold: tighter than the standard

1. Minimum specified mandrel diameter for bending angles up to 180° according to EN 10149-2:2013
t = nominal thickness

2. Tough version with a toughness guarantee of 27J/-40°C, symbolised in the steel grade name by the T - Amstrong® Ultra 650MCT and Amstrong® Ultra 700MCT.

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Chemical composition

	C (%)	Mn (%)	P (%)	S (%)	Si (%)	Al (%)	Nb (%)	Ti (%)	Mo (%)	B (%)	V (%)	Galvanisation
S650MC EN 10149-2	≤ 0.120	≤ 2.00	≤ 0.025	≤ 0.015	≤ 0.60	≥ 0.015	≤ 0.090	≤ 0.220	≤ 0.50	≤ 0.0050	≤ 0.200	No
Amstrong® Ultra 650MC	≤ **0.100**	≤ 2.00	≤ 0.025	≤ **0.005**	≤ **0.25**	≥ 0.015	≤ 0.090	≤ **0.150**	≤ 0.50	≤ 0.0050	≤ 0.200	-
S700MC EN 10149-2	≤ 0.120	≤ 2.10	≤ 0.025	≤ 0.015	≤ 0.60	≥ 0.015	≤ 0.090	≤ 0.220	≤ 0.50	≤ 0.0050	≤ 0.200	No
Amstrong® Ultra 700MC	≤ **0.100**	≤ 2.10	≤ 0.025	≤ **0.005**	≤ **0.25**	≥ 0.015	≤ 0.090	≤ **0.150**	≤ 0.50	≤ 0.0050	≤ 0.200	-

Values in bold: tighter than the standard

The above chemical properties are based on cast analysis data.
The total Nb, V and Ti content should not exceed 0.22%.

Galvanisability is defined as per the requirements of EN ISO 14713-2 Table 1.

Amstrong® Ultra 650MC and Amstrong® Ultra 700MC: Cat. A possible on request for thicknesses ≤ 8 mm and Cat. B available for higher thicknesses.

Any questions?
Ask them via our contact form on https://industry.arcelormittal.com/getintouch