

Mars® Protection steels

Mars® 600

Ultra-High-Hardness Armor with increased workability.

Mars® 600 is a multipurpose ultra-high-hard (typical 600 HBW) protection steel with an impressive ballistic behavior in terms of deformation capacity and resistance to multi-impacts together with an excellent toughness and a workability (mainly bending) close to a 500HB steel.

Its great properties suggest unlimited possibilities, as add-on armor but also as structural material.

Properties

Standards

Mars® 600 can be ordered according to the following standard: **NF A36-800 THD4**
MIL-DTL-32332 class1

Chemical composition - Ladle analysis - Max weight %

Thickness	C	S	P	Si	Mn	Ni	Cr	Mo	B	CE ¹⁾
≤ 20 mm	0.45	0.002	0.010	1.0	1.0	2.4	0.5	0.5	0.003	0.77
> 20 mm	0.55	0.002	0.010	1.0	0.7	4.5	0.4	0.5	0.003	

1) Carbon equivalence per ASTM A6/A6M, i.e. : $CE = C + [Mn/6] + [(Cr + Mo + V)/5] + [(Ni + Cu)/15]$

Mechanical properties (in both directions)

	Hardness	Yield Strength	UTS	Elongation	Charpy KV ²⁾ @-40°C standard 10 x 10 specimen ³⁾	
	HBW	MPa	Mpa	5d(%)	J	ft.lbs
Guarantees*	577 - 655	≥ 1300	≥ 2000	≥ 7	≥ 16	≥ 12
Typical values	601	1450	2150	10	23	17

* For thicknesses ≤ 20mm

2) Average of 3 tests. Single value min 70% of specified average.

3) For nominal thicknesses under 11mm, sub-size specimens are used. The specified minimum value is then proportional to the specimen cross section.

Brinell hardness test according to relevant standard (EN ISO 6506-1 / ASTM E10/E110), on each plate and in two places, one at each end of a diagonal, on a milled surface 0,5 to 1mm below plate surface.

Charpy Impact test according to relevant standard (EN ISO 148-1 / ASTM E23) on each heat and thickness from 6mm.

Tensile test according to EN ISO 6892-1, method B on each heat and thickness when specified in the standard or order.

Ultrasonic test is performed according to standard requirements or upon special agreement up to EN 10160 Class S₃/E₄.

In service conditions

Ballistic properties

Mars® 600 exceeds the ballistic performance requirements of MIL-DTL-32332A up to th.10mm (extension in progress)
See our table of recommended minimum thicknesses for common protection levels.

Ballistic test to be performed upon request.

Plate processing

Cutting

Mars® 600 can be cut either by abrasive waterjet, laser or plasma.

Bending

Mars® 600 offers ability to cold forming but as other protection steels must be used with caution. The elastic energy stored during forming may lead to rupture or shifting. It is essential to maintain a safety distance and not situate oneself in front of the plate while it is being formed. It is crucial to wear appropriate individual safety equipment and to equip machines with collective protection.

The capacity of the machine and tools must be suitable information on bending loads in relation to tools, plate thickness and steel strength.

The most important parameter when bending are the use of a correct punch radius.

Please contact us if you need assistance.

General recommendations :

- Minimal recommended temperature: 15°C
- Ensure that there are no obvious defects, especially on edges. Ideally, plate edges in the bending area should be ground smooth and rounded prior to operation.
- Die edges must remain clean, smooth, and ideally lubricated.
- Perform preliminary trials on prototypes and form the first pieces with low speed recommendation.
- Make sure that there is enough room in the die for the chosen punch together with the workpiece :
Die width > punch diameter + 3 x thickness

Grade	Thickness t mm (inch)	Mandrel Radius		Width of the die
		//	⊥	
Mars® 600	< 4 (0.16")	10t	8t	Die width > 2 x radius + 3 x thickness
	4 to 6 (0.16" to 0.24")	12t	10t	
	6 to 9 (0.24"-0.35")	14t	12t	
	> 9 (0.35")	Contact us		

Welding

Mars® 600 can be welded using common welding processes. Like the other protection steels, it can be sensitive to cold cracking in the heat affected zone of a weld. The best results can be obtained by :

- Make sure that the steel is at least at room temperature (≈20 °C). For thicknesses higher than 15mm, the steel must be preheated at a temperature maximum of 100°C (maximal temperature acceptable by plate to preserve mechanical properties).
- Clean the weld joint area, removing potential sources of hydrogen: rust, scale, moisture, grease, ...
- Using low hydrogen welding methods and consumables (filler material hydrogen content HD ≤ 5 ml/100 g).
- Preferably use MAG welding and a welding sequence that is designed to minimize residual stresses.
- Austenitic consumables must be used. The recommended stainless austenitic consumables are of type AWS 307.

Delivery conditions

Heat treatment

Mars® 600 is quenched and tempered at low temperature ($\leq 180^{\circ}\text{C}$)

Surface properties

MIL-DTL-32332 or EN 10163 class B – subclass 3

Shot blasting and weldable primer application can be performed upon request.

Sizes and tolerances

Mars® 600 can be supplied as quarto plates or cut-to-length sheets (from hot strip mill) in standard sizes or tailor made dimensions.

	Quarto plates			Cut-to-length sheets
Thicknesses	5.0 – 50.8 mm (.197" – 2") ⁴⁾			2.8 – 10.0 mm (.110" – .393")
Thickness tolerances	Th	For width ≤ 2000 mm	For width ≤ 2400 mm	
	≥ 5 to ≤ 12	0/+0.8	0/+0.8	$\geq 2.8 \leq$ to ≤ 8.5 : -0/+0.4
	> 12 to 20	0/+1.0	0/+1.2	> 8.5 to ≤ 10.0 : -0/+0.5
	> 20 to 35	0/+1.2	0/+1.4	
	> 35 to 50.8	0/+1.6	0/+1.8	
Width*	1500 – 2500 mm (39" – 98")			1500 – 2000 mm (39" – 78")
Length	1600 – 8100 mm (63" – 319")			1800 – 8100 mm (71" – 319")
Shape, length, and width tolerances as per MIL-DTL-32332 or EN 10029				

⁴⁾ Upon special agreement, thicknesses >50.8 mm (2") and up to 80 mm (3.15") can be produced.

* Depending on plate thickness.

Flatness

Maximum flatness deviation is 3 mm/m (when measured according to EN 10029).

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Technical data and information are to the best of our knowledge at the time of editing. However, they may be subject to some slight variations due to our ongoing research programme on steels. Therefore, we suggest that information be verified at time of enquiry or order. Furthermore, in service, real conditions are specific for each application. The data presented here are only for the purpose of description, and considered as guarantees when written formal approval has been delivered by our company. Further information may be obtained from the address opposite.