

Mars[®] Protection steels

Mars[®] 440 Medium Hardness Armor.

Mars[®] 440 is a protection steel intended to be used as vehicle structures for protection against mines and IED. It offers optimal compromise in terms of hardness (typical 440 HBW), toughness, and ductility for resistance against blast loads and fragments, while keeping an excellent workability, especially bending and welding, for building specific vehicle profiles used for blast protection (example: V-shaped floor).

Properties

Standards

Mars[®] 440 can be ordered according to the following standard: **NF A36-800 THD1**
MIL-DTL-12560 class 4a & 4b

Or upon specific agreement according to **TL2350-0000 grade O**

Chemical composition - Ladle analysis - Max weight %

Version	Available Th range	C	S	P	Si	Mn	Ni	Cr	Mo	B	CE ¹⁾
Liquid quenched (4a)	4 to 50 mm	0.22	0.002	0.015	0.5	1.5	2	1	0.6	0.003	0.70
Air hardened (4b)	20 to 70 mm	0.24	0.002	0.015	0.5	1.5	5	2	0.6	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)

Version		Hardness	Yield Strength	UTS	Elongation	Charpy KV ²⁾ @-40°C standard 10 x 10 specimen ³⁾	
			MPa		5d(%)	J	ft.lbs
Liquid quenched (4a)	Guarantees	420-470	≥ 1100	≥ 1250	≥ 10	≥ 27	≥ 20
Liquid quenched (4a)	Typical values	440	1150	1450	13	48	35
Air hardened (4b)	Guarantees	≥ 390	≥ 800	≥ 1200	≥ 10	≥ 20	≥ 15
Air hardened (4b)	Typical values	400	900	1300	-	-	-

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[®] 440 exceeds the ballistic performance requirements of MIL-DTL-12560 for class 4 material. Ballistic test to be performed upon request.

Plate processing

Cutting

Mars[®] 440 can be cut either by abrasive waterjet, laser or plasma.

Bending

Mars[®] 440 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 [®] 440	< 8 (0.315")	6t	6t	Die width > 2 x radius + 3 x thickness
	8 to 16 (0.315" to 0.63")	6t	5t	
	> 16 (0.63")	Contact us		

Welding

Mars[®] 440 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).
- 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

In his liquid quenched version, **Mars® 440** is quenched and tempered at low temperature ($\leq 200^{\circ}\text{C}/390^{\circ}\text{F}$). Air hardened version is auto-tempering which is specially adapted to hot forming.

Surface properties

According to MIL-DTL-12560 or EN 10163 class B - subclass 3

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

Sizes and tolerances

Mars® 440 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	4.0 – 70 mm (.157" – 2.75")			4.0 – 10.0 mm (.174" – .393")
Thickness tolerances	Th	For width $\leq 2000\text{mm}$	For width $\leq 2400\text{mm}$	
	≥ 4 to ≤ 12	0/+0.8	0/+0.8	$4 \leq \text{to} \leq 7.8$: -0/+0.4
	> 12 to 20	0/+1.0	0/+1.2	> 7.8 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	
	> 35 to 70	0/+2.2	0/+2.4	
Width*	1500 – 2500 mm (39" – 98")			1500 – 2000 mm (39" – 78")
Lenght	1600 – 8100 mm (63" – 319")			1800 – 8100 mm (71" – 319")
Shape, length, and width tolerances as per MIL-DTL-12560 or EN 10029				

* Depending on plate thickness.

Flatness

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

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