

Mars® Protection steels

Perforated Mars® 650 Ultra-High-Hardness Armor perforated armor

Mars® 650 is a ultra-high-hard (typical 650 HBW) protection steel offering uncompromising ballistic resistance performance, for use as add-on armor.

In the perforated version, holes are evenly distributed within the surface to interact with the diameter of the incoming threat. The use of specific perforation process leads to very good flatness, absence of HAZ and low residual stress.

Properties

Chemical composition - Ladle analysis - Max weight %

C	S	P	Si	Mn	Ni	Cr	Mo	B	CE ¹⁾
0.55	0.002	0.010	1.0	0.7	2.4	0.4	0.5	0.003	0.83

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

Mechanical Properties

	Hardness
	HBW
Guarantees	≥ 577
Typical values	650

In service conditions

Ballistic properties

Perforated Mars® 650 is intended to be used as add-on armor at some stand-off distance from platform base armour.

Incoming AP projectiles tends to fracture due to bending stress induced by impacts on holes edges or into the ultra-high hard material in-between. If they are not fractured, projectiles are at least diverted from their incident trajectory which thus drastically reduce their residual penetration capability into base armor.

The holes reduce the areal density of armor plate and also limit possible cracks propagation conferring to Perforated Mars® 650 an exceptional multi-hits capability.

It results to a mass efficiency close the one of ceramic/composites solutions, with a much more better multi-hit capability and easier integration.

See our table of recommended minimum thicknesses for multi-layers configuration examples.

Plate processing

Perforated Mars® 650 is not intended for forming or welding.

For information concerning machining and cutting, see our userguide for Mars® protection steels.

Delivery conditions

Heat treatment

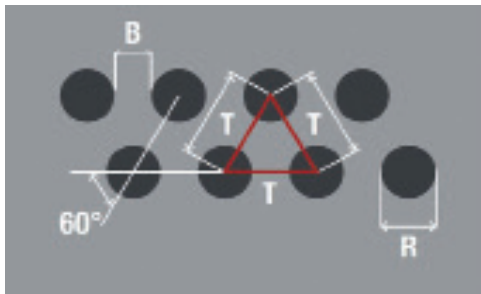
Perforated Mars® 650 is quenched and tempered at high temperature ($\leq 180^{\circ}\text{C}$).

Sizes and tolerances

Perforated Mars® 650 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 – 16 mm (.157" – .630")			2.8 – 10.0 mm (.098" – .393")
Thickness	Th	For width ≤ 2000 mm	For width ≤ 2400 mm	
	≥ 4 to ≤ 12 > 12 to 16	0/+0.8 0/+1.0	0/+0.8 0/+1.0	≥ 2.5 to ≤ 8.5 : -0/+0.4 > 8.5 to ≤ 10.0 : -0/+0.5
Width	1500 – 2000 mm (39" – 98")			1500 – 2000 mm (39" – 78")
Length	1600 – 4000 mm (63" – 157")			1800 – 4000 mm (71" – 157")
Shape, length, and width tolerances as per MIL-DTL-32332 or EN 10029 Tolerances on perforation according to DIN 24041				

Usual perforation configurations



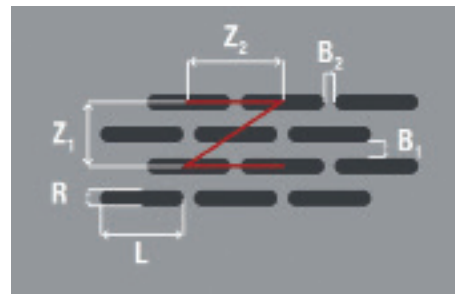
$$\text{Open area (OA\%)} = \frac{R^2 \times 90.69}{T^2}$$

Recommended configurations: $R \geq th$ & $T \geq R \times 1,5$
Example of perforations usually realized (OA > 30%): 4 mm R4 T7, 6 mm R6 T10, 8 mm R8 T12 ...

Perforated plates are delivered with an ≤ 50 mm blank margin (distance from the plate's edge to the first line of holes) all over the plate.

Flatness

Maximum flatness deviation according to EN 10029 class N, steel type H.



$$\text{Open area (OA\%)} = \frac{(L \times R - 0.2146R^2) \times 100}{0.5 \times Z1 \times Z2}$$

Example of perforations usually realized: 4 mm LR 4x20 Z 16x24 (OA \approx 40%)

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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.