# Hot rolled Steel Plates, Sheets and Coils

## Armour steel

Ramor

Customers are seeking extreme protection and safety performance for their end-products. Ramor plate has excellent ballistic properties in combination with high hardness and strength. Ramor is developed for applications, where blast protection or high ballistic resistance is required.

**Applications**

- Doors, window frames, walls
- Bank counters and vaults
- Money exchange offices
- Cars, security vans
- Secured containers
- Shooting gallery devices
- Military vehicles and equipment

Ruukki is a metal expert you can rely on all the way, whenever you need metal based materials, components, systems or total solutions. We constantly develop our product range and operating models to match your needs.

- **Description of the steel grades**
  Ramor armour steels are manufactured with a novel direct quenching process. With this method not only a good blast and ballistic protection is achieved, but also good flatness, surface quality and dimensional accuracy are obtained.

  Ramor 400 steel is designed to give protection against high pressures caused by explosions and blasts.

  Ramor 500 is the most suitable choice, when protection is needed against kinetic energy projectiles i.e. ballistic performance.

  The number of the designation indicates the average Brinell hardness value 400 and 500 HBW, respectively.

- **Product forms**
  Heavy plates and cut lengths (=sheets).

- **Delivery condition**
  Quenched.

- **Dimensions**
  Heavy plates 6,0 – 60 mm.
  Cut lengths with mill edges 3,0 – 6,5 mm.

- **Tolerances**
  **Heavy plates**
  Thickness EN 10029 Class C.
  Width and length EN 10029.
  Flatness EN 10029 class N, steel type H.

  **Cut lengths**
  Thickness, width and length EN 10051.
  Flatness EN 10029 class N, steel type H.

- **Surface condition**
  According to EN 10 163-2 Class B Subclass 3.
  Repair welding of plates is not permitted in plate production of Ramor steels.

- **General technical delivery condition**
  According to EN 10 021. Unless otherwise agreed, inspection document EN 10 204-2.2 is issued in English.

- **Chemical composition**
  The chemical composition is stated in Table 1.

- **Mechanical properties**
  Typical mechanical properties are presented in Table 2.

- **Materials testing**
  Materials testing procedure is presented in Table 3. Recommended minimum plate thickness for different protection classes is presented in Table 4.

- **Heat treatment**
  Heat treatment is not recommended. If tempering process is needed, please, contact technical customer service for further assistance.

- **Welding**
  Ramor steels can be welded with common welding methods. Austenitic steel welding consumables are recommended. Ferritic welding consumables can be used also, if the strength of the joint is important. If ferritic consumables are used, the need for elevated working temperature has to be studied in order to achieve faultless weld joint.

- **Bending**
  When cold forming Ramor 500 steels by bending, the bending radius of the upper tool has to be 12 times the thickness of the material. Special care has to be taken to the working safety, when these steels are cold formed. Mechanical cutting is not suitable as an edge preparation process for bended parts.

- **Cutting**
  Ramor steels are well suitable for laser and plasma cutting. Mechanical cutting can also be used, if the cutting shears/blades are hard enough and the equipment used is rigid. However, water jet cutting is preferred, because with this method the ballistic properties of the cut edge can be obtained.

- **Machining**
  Ramor steels can be machined using rigid hard metal tools and rigid equipment. Sufficient lubrication has to be provided and special attention has to be paid to clamping of work piece. The cutting parameters should be chosen in the way that the vibration of the cutting tool and the work piece can be avoided, because vibration decreases the lifetime of the cutting tool considerably.

- **Occupational safety**
  Special care must be taken in all stages of handling of hardened steels. Flanging is challenging due to the high strength and high flexural stresses of the plate. If the bending radius, for example, is too small and a crack is created in the bending point, the plate may fly from the bending tool in the direction of the bend. Those bending the plate must take appropriate precautions to protect themselves and no outsiders must be allowed in the

area. The safest location is usually by the bending machine. The handling instructions of the steel supplier and safety instructions of the workshop must be adhered to in detail. New employees must receive appropriate training before they are allowed to process hardened steels.

## Further information

Further information can be found in the following data sheets: Welding, Welding consumables, Thermal cutting and flame straightening, Flanging and forming, Mechanical cutting and machining.

## Chemical composition

*Table 1*

| | Content %, maximum (cast analysis) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C | Si | Mn | P | S | Cr | Ni | Mo | B |
| Ramor 400 | 0.24 | 0.70 | 1.50 | 0.020 | 0.015 | 1.00 | 1.00 | 0.70 | 0.005 |
| Ramor 500 | 0.32 | 0.70 | 1.50 | 0.020 | 0.015 | 1.00 | 2.00 | 0.70 | 0.005 |

*The steel is grain-refined.*

## Mechanical properties, typical

*Table 2*

| | Yield strength $R_{p\,0.2}$ MPa | Tensile strength $R_m$ MPa | Elongation $A_5$ % | Hardness HB | Impact strength longitudinally t °C | Charpy V J |
|---|---|---|---|---|---|---|
| Ramor 400 | 1100 | 1300 | 8 | 360 – 450 | -40 | 30 |
| Ramor 500 | 1450 | 1650 | 7 | 480 – 560 | -30 | 20 |

## Testing

*Table 3*

| Test | According to standard | Test frequency |
|---|---|---|
| Tensile test | EN 10002-1 | Typical values or according to agreement. |
| Brinell hardness test | EN ISO 6506-1 | Each heat treatment individually. |
| Charpy impact test | EN 10045-1 | Typical values or according to agreement. |
| Ballistic protection | PM2000/EN 1522<br>Stanag 4569 | Typical values according to approval tests. |

## Recommended minimum plate thickness for different protection classes

*Table 4*

| Standard / Norm | Protection level | Threat | Weight of the bullet Grams | Distance Meters | Obliquity Degrees | Striking velocity m/s | Recommended minimun thickness mm |
|---|---|---|---|---|---|---|---|
| PM 2000/EN 1522 | PM3 | .357 Magnum | 10.20 | 5 | 0 | 430±10 | 3.00 |
| PM 2000/EN 1522 | PM4 | .357 Magnum | 10.20 | 5 | 0 | 430±10 | 3.00 |
| | | .44 Magnum | 15.60 | 5 | 0 | 440±10 | |
| PM 2000/EN 1522 | | 7.62 x 39 mm AK-47 (M43) | 8.00 | 10 | 0 | 720±10 | 4.25 |
| PM 2000/EN 1522 | PM6 | 5.56 x 45 mm SS109 (M855) | 4.00 | 10 | 0 | 950±10 | 6.50 |
| | | 7.62 x 51 mm Nato Ball | 9.55 | 10 | 0 | 830±10 | |
| PM 2000/EN 1522 | PM7 | 7.62 x 51 mm P80 Nato AP | 9.45 | 10 | 0 | 820±10 | 14.20 |
| Stanag 4569 | Level 1 | 7.62 x 51 mm Nato Ball | 9.55 | 30 | 0 | 833±20 | 9.20 |
| | | 5.56 x 45 mm SS109 (M855) | 4.00 | 30 | 0 | 900±20 | |
| | | 5.56 x 45 mm M 193 | 3.56 | 30 | 0 | 937±20 | |
| Stanag 4569 | Level 2 | 7.62 x 39 mm AK-47 API BZ | 7.77 | 30 | 0 | 695±20 | 12.20 |
| Stanag 4569 | Level 3 | 7.62 x 51 mm AP (WC) | 8.40 | 30 | 0 | 930±20 | 25.10 |
| | | 7.65x 54R mm B32 API | 10.30 | 30 | 0 | 945±20 | |

All statements as to the properties and utilisation of materials and products mentioned in this data sheet are for the purpose of description only.

Guarantees in respect of existence of certain properties or utilisation of material mentioned are valid only if agreed upon in writing.

## Our Customer Service is happy to give you further information

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