Data sheet: A5.2

ROQ-last® TH400

Hot Rolled, Roller Quenched Abrasion Resistant Steel Plate

General description

ROQ-last® TH400 abrasion resistant steel plate is available in as quenched steel grade, produced to give an optimal combination of hardness, toughness and weldability. This steel is made to fully killed, fine grain practice. It is also calcium treated and desulphurised to achieve low sulphur levels and a very low inclusion content with controlled sulphide shape.

The plates are heat treated in a roller quenching plant which subjects the entire plate to a rapid, high volume water quench. The high cooling rate ensures the maximum exploitation of the alloying elements to give the required properties throughout the thickness of the plate. In this way the composition can be kept sufficiently lean to provide a readily weldable product.

Care should be taken to distinguish between ROQ-last® and ROQ-tuf® steel grades. ROQ-last® is supplied as quenched. This gives it a high hardness for wear resistance and reduced toughness that is still adequate for such applications. ROQ-tuf® is tempered after quenching to increase its toughness for high strength structural applications.

The ROQ-last® TH400 grade is suitable for the following typical applications:

- Bucket lips
- Bulldozer blades and mould boards
- Chutes (e.g. ore, coal, gravel)
- Conveyor buckets
- Hoppers (e.g. ore, coal, gravel)
- Mine skip plates and liners
- Mine scrapers
- Screens (e.g. ore, coal, gravel)
- Dragline components
- Dump truck beds and liners
- Fan housing liners
- Baffle plates
- Blasting screens
- Brick and tile dies
- Concrete mixer spiral strips
- Foundry shake-out machines
- Mixer blades
- Sand and shot blasting equipment
- Tongs
- Shovel buckets and various other wearplate applications

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ArcelorMittal South Africa, PO Box 2, Vanderbijlpark 1900. Toll free number 0800 005043.

Chemical Composition

Table 1. Chemical composition specification (ladle analysis, percent)

Grade	Thickness	C	Mn	P	S	Si	B	Mo	Ni	Cr
ROQ-last® TH400	25mm max	0,25 max	1,60 max	0,030 max	0,010 max	0,20 - 0,60	0,005 max	0,75 max	1,30 max	0,80 max

1. $$CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Cu + Ni)}{15}$$

(Typical CE = 0,45)

2. $$P_{cm} = C + \frac{Si}{30} + \frac{(Mn + Cu + Cr)}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

(Typical Pcm = 0,30)

Hardness

Hardness of heat treated steel relates to the condition at the surface, whereas hardenability of the steel is a measure of the depth to which the hardness can be maintained in the steel. To obtain the required hardness in thick plate, it is essential to increase the ability of the steel to be hardened. Hardenability of a steel is determined by the chemical composition. The alloy content must be increased with increasing plate thickness to obtain the required hardenability. The required hardness is obtained by fully exploiting the hardenability in a carefully controlled heat treatment process.

The hardness indicates the nominal Brinell hardness value of the steel at the surface. This steel is produced to meet specific nominal surface hardness requirements and not to conform to any tensile requirements. There is however a correlation between hardness and tensile strength as set out below:

Table 2. Hardness and tensile strength

Grade	Surface hardness (Brinell)	Approximate tensile strength (MPa)
ROQ-last® TH400	360 - 420	1350

Weldability

ROQ-last® is readily weldable. Low hydrogen electrodes (Type E110XX or E70XX) must be used to avoid cracking in the heat affected zone. In addition, low tensile strength consumables should be used to minimise residual stresses. Recommended preheating temperatures are shown in the table below. High heat inputs will reduce the hardness in the heat affected zone and should be avoided, especially in multi-pass welding.

1. Preheating, Inter-pass temperatures and Heat input rates

The objective of preheating is to ensure an acceptable microstructure and avoid H2 cracking in the heat affected zone (HAZ) by reducing the cooling rate.

An excessive cooling rate is caused by:

- insufficient heat input during welding
- too low a temperature of the parent plate
- too thick a plate

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In such cases a brittle martensitic microstructure, which is susceptible to hydrogen cracking, could arise in the HAZ. Increasing the temperature of the parent plate by preheating is usually the easiest way to prevent the problem.

The recommended temperatures are given in Table 3. They are based on AWS O14.3 (Welding of Earth moving & Construction equipment).

Table 3. Recommended minimum preheating temperatures

Grade	Thickness range (mm)	Preheating temperature (°C)[1]
ROQ-last® TH400	6 to 20 >20 up to 38	None 50

Note:
1. These temperatures are applicable only if low hydrogen levels in welding consumables can be guaranteed.
2. Alternatively refer to AWS Table 4.

Table 4. Recommended minimum heat input rates

Plate thickness t (mm)	Minimum heat input rate[1] (kJ/mm)
t = 6	0,6
6 < t ≤ 12	1,1
12 < t ≤ 25	2,1
t > 25	2,3

Note:
1. *Heat input rate* HI *in welding is defined as:*

$$HI\ (kJ/mm) = \frac{current\ (amps)\ x\ voltage\ (volts)}{speed\ (mm/sec)\ x\ 1000}$$

2. Limiting heat input

It is not possible to avoid a certain amount of hardness reduction in the HAZ during welding, but this can be minimised by limiting the heat input to a predetermined maximum value

3. Hydrogen level control

Low hydrogen welding processes are widely used. These processes entail the selection of low hydrogen consumables and ensuring that manual metal arc electrodes and submerged arc fluxes are thoroughly dried in accordance with the manufacturers' specifications. Plates must be free of moisture, oil or grease before welding commences.

4. Reduction of hardness in the heat affected zone (HAZ)

The desired properties of ROQ-last® plates are achieved by water quenching. Heating such as during welding and cutting, will inevitably reduce the hardness of the plate in these areas.

5. Weld procedure tests

Before any critical welds are made, it is advisable to conduct a weld procedure qualification to check the hardness profile across the weldment. Welding procedures should be qualified in accordance with National or International welding codes or standards such as ISO, BS, EN or AWS.

6. Residual stress level

The residual stress in a weldment is determined mainly by external restraint, fit-up and yield strength of the weld metal.

6.1 External restraint

Since the method of installing wear resistant plates usually induces a high level of external restraint, particular attention must be given to fit-up and yield strength of the weld metal.

6.2 Fit-up

Fit-up is important, especially in single run welds where the aim should be to keep the root gap below 0,4mm.

6.3 Yield strength of the weld metal

The selection of the correct filler metal is essential to restrict the residual stresses in the weldments. During cooling, either the parent plate or the weld metal must yield to accommodate the shrinkage stresses. Since the parent plate has very high yield strength, it is imperative to use a filler metal with low yield strength to prevent the generation of excessive residual stresses.

If it is considered essential to provide for abrasion resistance of the weld bead itself, it is advisable to deposit 'soft' beads initially and to apply wear resistant beads on the surface.

Formability

ROQ-last® TH400 may be readily formed, provided the following precautions are met:

- for bending transverse to the rolling direction, a diameter D of at least 6 times the plate thickness t should be maintained;
- for bending parallel to the rolling direction, D should be at least 10t;
- a sharp blade should never be used for bending operations;
- a die opening W of at least 8,5t should be used to ensure successful transverse bending, and at least 10t for longitudinal bends;
- U-bottom rather than V-bottom is recommended for any bending up to 90˚.

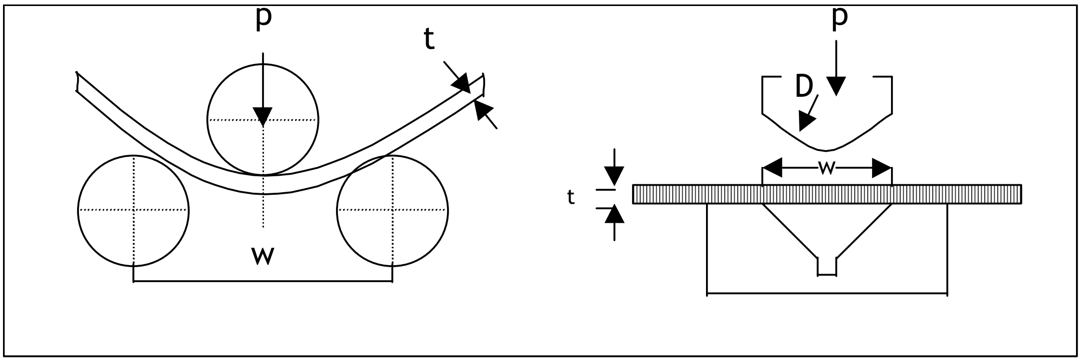

Table 7. Recommended ratios for bending

Transverse bending		Longitudinal bending	
D/t	W/t	D/t	W/t
≥ 6	≥ 8,5	≥ 10	≥ 10

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1. Machining

Machining can be performed by using high speed tool steels and cutting speed reduced to 50% of normal carbon steels.

2. Shearing and punching

ROQ-last® plates can be sheared in thicknesses up to 25mm. Because of the high hardness of ROQ-last® compared to structural steel, the machine capacity should be decreased to 40% of the normal capacity. Punching of ROQ-last® is not recommended.

3. Gas cutting

This steel can readily be cut by oxy-acetylene flame. With excessive heat input, some distortion could be experienced during cutting. If subsequent bending must be done, grinding of the flame cut edges is recommended. ROQ-last® can also be successfully cut by plasma, laser and hydrojet cutting techniques.

4. Hot working

The desired properties of ROQ-last® plates are achieved by water quenching to ensure that full hardness is obtained. Hot working of ROQ-last® TH400 is therefore not recommended.

Ultrasonic testing

As part of the Quality Assurance system all plates are ultrasonically guaranteed to EN 10160 S_0 (QA). Ultrasonic testing to stricter criteria is available on enquiry

Edge condition

Plates thicker than 12,0mm normally have flame cut edges, whereas plates 12,0mm and thinner normally have sheared or plasma cut edges.

Dimensions

For the dimensions available, refer to the data sheet: Plate Mill Products - Plate Dimensions (file reference A1.3).

Certification

All material is supplied with test certificates verifying hardness and chemical composition.

Supply conditions

ROQ-last® plates are supplied in terms of Price List 111 and ArcelorMittal South Africa's General Conditions of Sale.

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