# TENAX300IM®

# Hot Work Tool Steel

VILLARES METALS
a voestalpine company

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The presented information in this datasheet is only for technical guidance and represents our present state of knowledge of this product. This information shall not be considered as warranty of specific properties or fitness for a particular application of this product..

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## SIMILAR STANDARDS

TENAX300IM® is similar to AISI H11 Modified - Superior grade with reduced Si and controlled residual elements. This steel is similar to UNS T20811, DIN X38CrMoV5-1 and W.Nr. 1.2343. This steel is produced in accord with ASTM A681 and NADCA 207 Grade E.

## GENERAL INFORMATION

TENAX300IM® is a hot work steel with higher toughness compared to others hot working steels, as AISI H13 and AISI H11. TENAX300IM® presents higher thermal conductivity and an adequate response to nitriding and polishing.

## MAIN CHARACTERISTICS

TENAX300IM® is a martensitic hot work steel intended to deliver high toughness associated with compatible mechanical resistance of AISI H13 and AISI H11 steels. This steel is produced by ESR (Electro-Slag Remelting) process to assure high isotropy of mechanical properties. Due to its high isotropy, this steel is commonly indicated for applications where the resistance to initiation and propagation of mechanical and thermal cracks are essential. In these situations, toughness is the most important property and determines the tool life.

## CHEMICAL COMPOSITION

Typical Analysis (Weight Percent)

| C | Si | Mn | P | S | Cr | Mo | V | Fe |
|---|---|---|---|---|---|---|---|---|
| 0.37 | 0.30 | 0.30 | 0.02 max | 0.003 max | 5.08 | 1.45 | 0.45 | Bal. |

## STANDARD PRODUCTION RANGE

| Production Route | Standard | Production Range | Finishing |
|---|---|---|---|
| Rolled Products | ASTM A681<br>NADCA 207 Grade E | Thickness between 8 and 152 mm with width between 25 and 320mm<br>Rd. 5.50-152.40mm | Centerless ground<br>Peeled<br>Turned<br>Milled |
| Forged Products | | Rd. 152.40 – 760 mm<br>Thickness up to 550mm with width up to 1000mm | Turned<br>Peeled<br>Milled |

*Other dimensions and conditions are available upon inquiry.

## DELIVERY CONDITION

TENAX300IM® is supplied in the annealed condition with a maximum hardness of 230HB. It can also be supplied in hardened condition.
Identification Colors: black, blue, black 

## HEAT TREATMENTS

### Soft Annealing

Soft annealing should be carried out by heat parts between 860 – 890 °C for two hours controlled by the core; cool slowly at a rate that does not exceed 15°C per hour to temperature of 650°C, then air cooling. Use of protective atmosphere is important to avoid surface oxidation and decarburization.

### Stress Relief

Stress relief heat treatment aims to reduce the residual stress of the part and it shall be employed after machining and before hardening. It shall be applied in dies in which the machining removal has been higher than 30% or for complex shapes, in other to minimize distortions during and after hardening.

Stress relief heat treatment consists in a slowly heating to 650°C followed by furnace cooling until 200°C. In hardened parts, the stress relief must employ a temperature 50°C lower than the last tempering temperature. According to NADCA, stress relief is not recommended under temperatures of 560°C.

### Hardening

The austenitizing temperature should be between 1010-1020°C. For better toughness performance, it is indicated 1010°C and for better heat resistance austenitize at 1020°C. The choice of the ideal temperature should

also consider aspects of design and finishing details of the parts. The heating cycle shall provide preheating depending upon the geometry of the part. After austenitization, the quenching can be performed in different quench media as:

- Pressurized vacuum furnace with pressure higher than 5 bar, according to NADCA.
- Oil between 40-70°C.
- Salt bath between 500-550°C.

### Tempering

Temper immediately after quenching, i.e. as soon as parts reaches 60°C. Double tempering, at least is recommended and after each tempering cycle, parts shall be slowly cooled to room temperature.

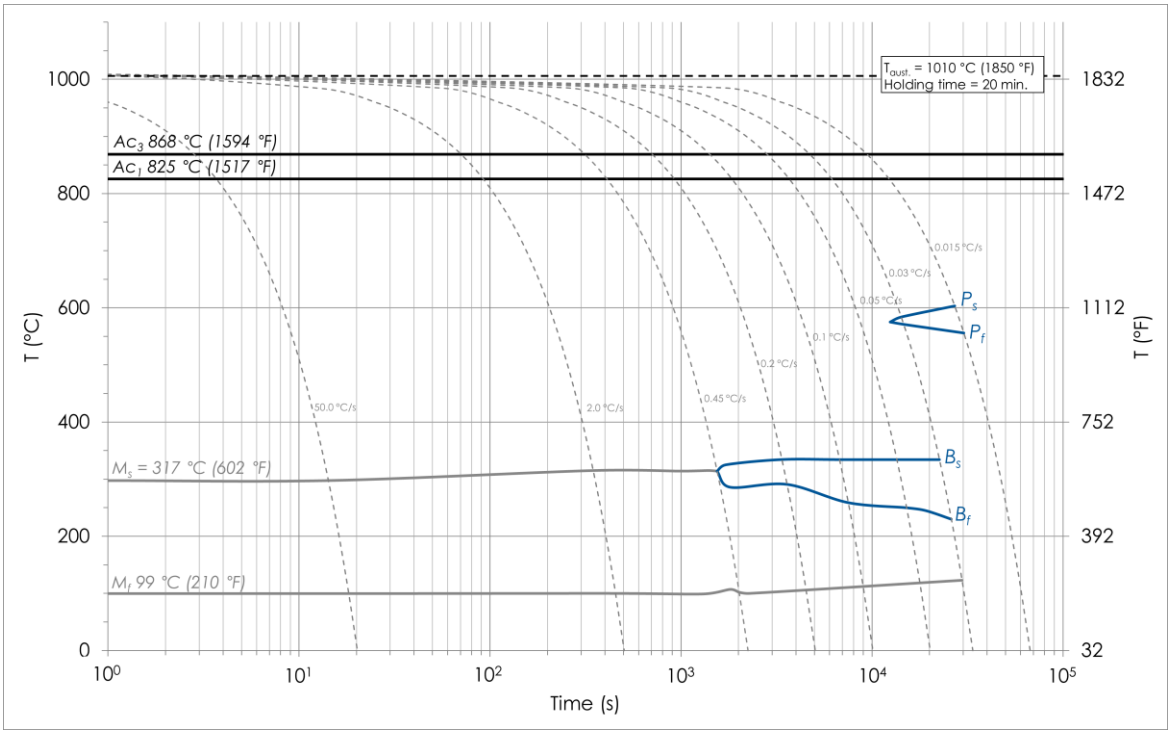
Tempering temperatures are generally between 550-650°C, depending upon the desired hardness. The time of each tempering cycle shall be at least 2 hours in temperature. For parts with thickness larger than 70 mm, the time at temperature should be calculated according to their size, being a reference for calculation about one hour for each inch of thickness.

### Surface Treatments

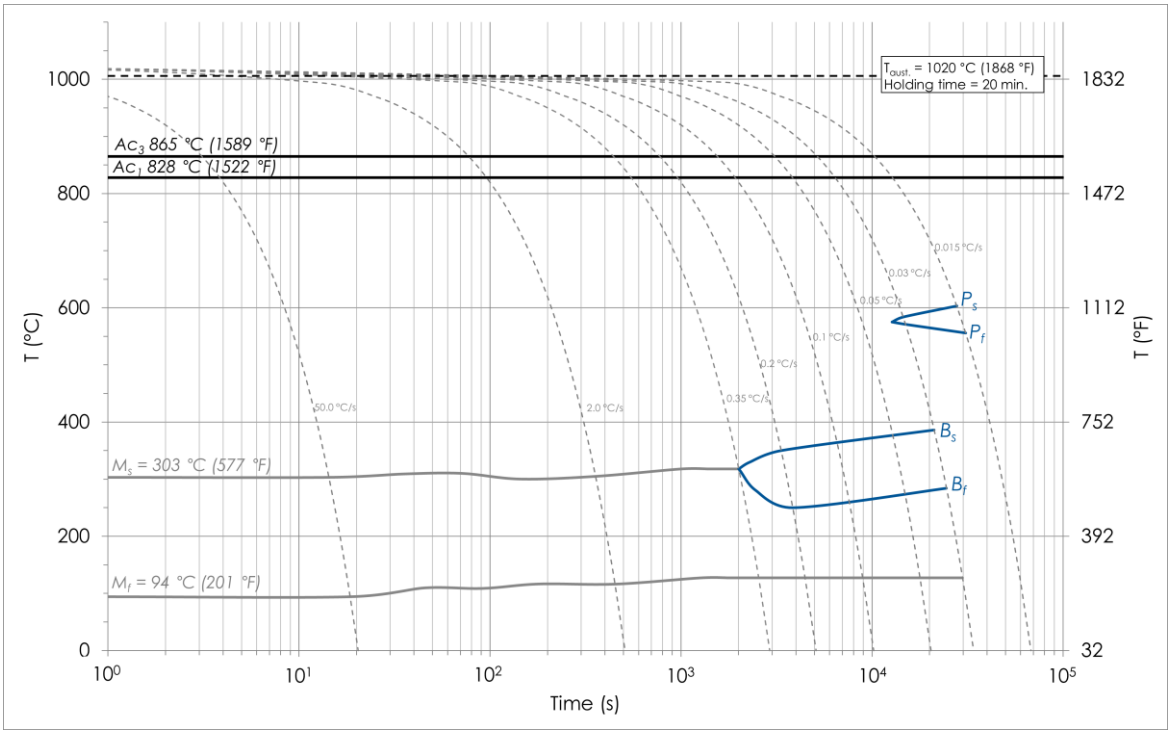
Surface treatments as nitriding and PVD are recommended when higher values of surface hardness and high abrasion wear resistance are required. Surface treatments shall be employed after hardening and tempering. Nitriding temperature shall be of at least 50°C under the last tempering temperature.

## CCT diagrams

**TENAX300IM® cooling chart. Austenitizing temperature 1010°C (1850°F).**

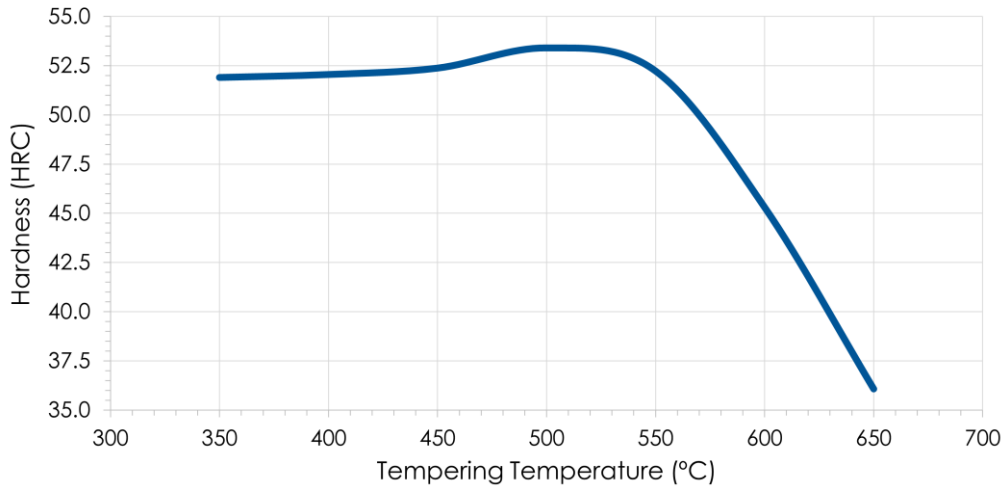



**TENAX300IM® cooling chart. Austenitizing temperature 1020°C (1868°F).**



## Tempering curve

Tempering curve of TENAX300IM® after hardening at 1010°C. Tempering time: 2 hours. Curve obtained from specimens with 20 x 20 x 20 mm.




## MAIN APPLICATIONS

TENAX300IM® is recommended for:

- Dies and components for die casting of aluminum alloys and other non-ferrous alloys, such as magnesium, zinc, tin and lead;
- Tools for hot extrusion of Al alloys, brass and magnesium alloys, including hot-upsetting;
- Inserts, shear blades and all types of dies for hot work that involves shock;
- Injection molds for not chlorinated thermoplastic polymers, due to its high capability to polishing;
- Parts with high abrasion wear, when nitrided.

## WELDING

Welding is not recommended for TENAX300IM®. This process generates Heat Affected Zones (HAZ), which may significantly reduce performance. The HAZ comprise brittle and therefore prone to cracking regions unless the welding process is performed with extreme care. In exceptional cases and always considering that welding would be a temporary solution, TENAX300IM® might be welded using special procedures to minimize the occurrence of cracks.

The instructions of the appropriate welding electrode manufacturer should be followed.

The sequence of operations for repair welding TENAX300IM® depends upon its prior heat treatment.

As a general guideline, it is recommended to: (a) preheat, (b) weld with appropriate filler metal, (c) perform a stress relief heat treatment, (d) machine, (e) quench and temper if in the annealed condition or stress relief if already hardened and (f) grind to final dimensions. The qualification of a specific welding procedure for repair is the key point to obtain the desired quality.

The skill and experience of the welder is also a vital factor in obtaining satisfactory results.

## IMPROVEMENT OF TOOL LIFE

Before starting operation, pre-heat slowly between 200 and 300°C, to obtain thermal homogenization of core and surface. Periodic stress relieving heat treatment during the use of tools is recommended to improve the tool life.

## PHYSICAL PROPERTIES

### Density:

| Temperature | g/cm³ | lb/in³ |
|---|---|---|
| 20°C (68°F) | 7.80 | 0.282 |

### Thermal Conductivity:

| Temperature | W/(m.K) | Btu.in/(h.ft².°F) |
|---|---|---|
| 200°C (392°F) | 25.7 | 178 |
| 300°C (572°F) | 29.0 | 201 |
| 400°C (752°F) | 30.6 | 212 |
| 500°C (932°F) | 32.0 | 222 |
| 600°C (1112°F) | 32.8 | 228 |

### Thermal Expansion Coefficient:

| Temperature | $10^{-6}$m/m.K | $10^{-6}$in/in.°F |
|---|---|---|
| 100°C (212°F) | 10.5 | 5.8 |
| 200°C (392°F) | 10.7 | 5.9 |
| 300°C (572°F) | 11.0 | 6.1 |
| 400°C (752°F) | 11.3 | 6.3 |
| 500°C (932°F) | 11.7 | 6.5 |
| 600°C (1112°F) | 12.1 | 6.7 |

### Modulus of elasticity:

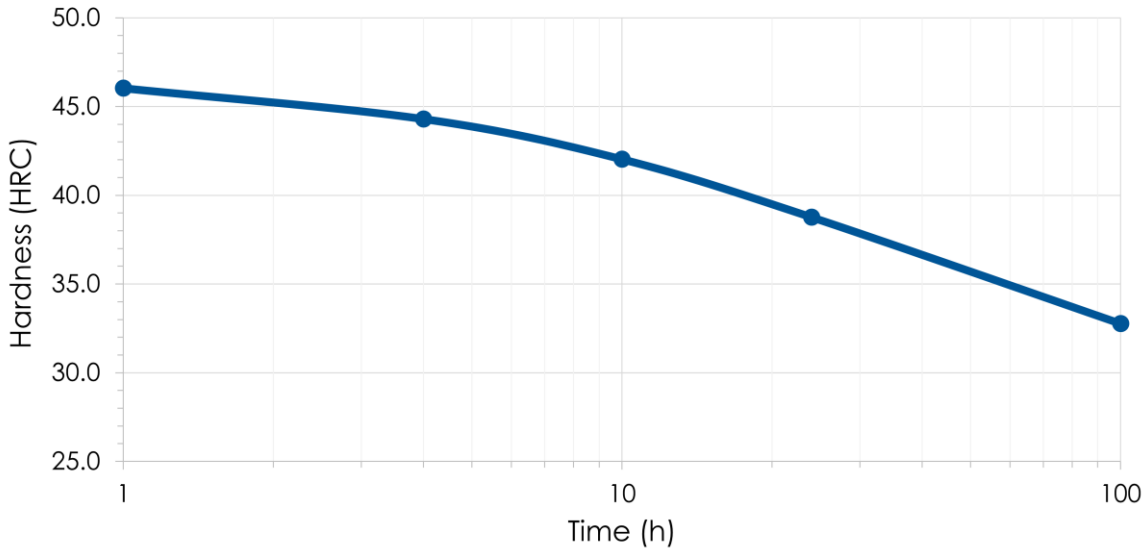
| Temperature | GPa |
|---|---|
| 25°C (77°F) | 210 |

## MECHANICAL PROPERTIES

Samples in heat treated condition (44-46 HRC) show impact toughness higher than 19J (14ft.lb) for Charpy V-notch test, according to NADCA#207. Other mechanical properties are shown on the table below.

| Tensile Strength ($R_m$) | | Yield Strength (0,2%) | | Elongation | Reduction of area | Impact toughness NADCA#207 | |
|---|---|---|---|---|---|---|---|
| [MPa] | [ksi] | [MPa] | [ksi] | Longitudinal [%] | Longitudinal [%] | [J] | [ft.lb] |
| 1590 | 230 | 1310 | 190 | 17.5 | 50.0 | > 19 | > 14 |

TENAX300IM® resistance to softening. The specimens were hardened at 1010°C, tempered to 45 HRC and exposed to 600°C for times varying from 1 to 100 hours.



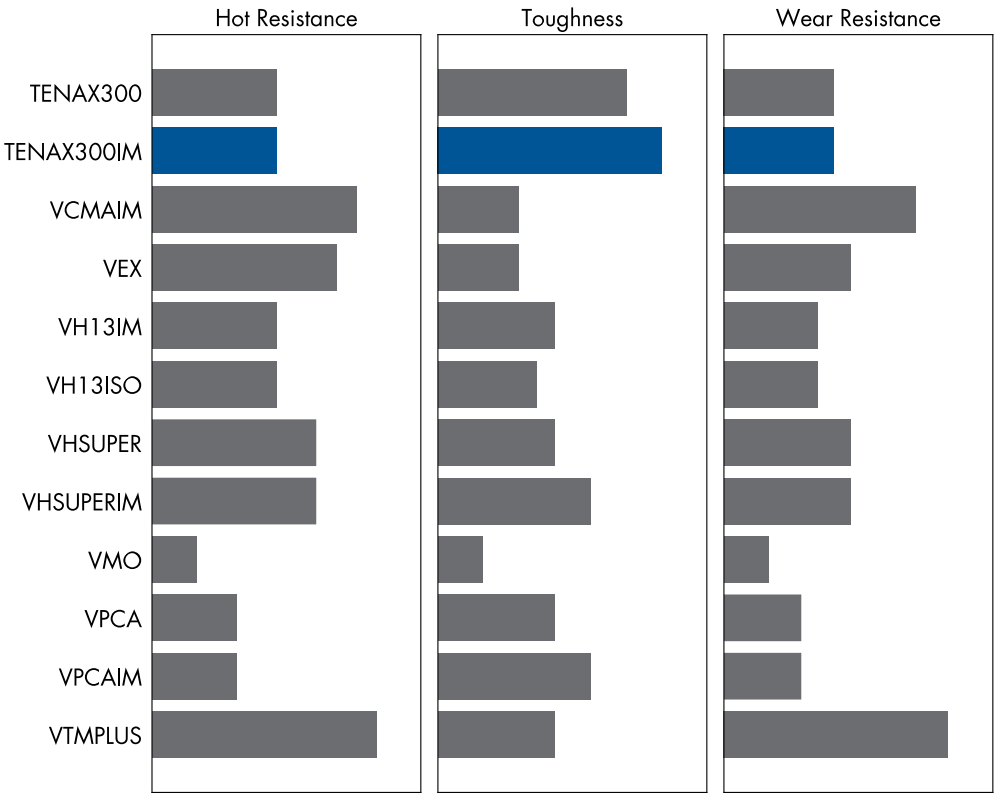

## MACHINABILITY

TENAX300IM® can be conventionally in the annealed or hardened condition. For a better machinability, it is recommended the use of TiAlN coated carbide inserts. The cutting parameters below should be considered as guidelines and must be adapted to local machining conditions.
To avoid distortions on the part during hardening and tempering, it is recommended to perform a stress relief heat treatment before hardening if more than 30% of part weight is removed in machining operations. Electro-erosion process can be employed in heat treated dies or molds. After electro-erosion machining it is recommended to remove the superficial layer through fine grinding wheel.
For the drilling process up to diameter of 20 mm in hardened and tempered condition is recommended to use TICN coated carbide drills with a cutting speed of 4–6 m/min and a feed of 0.10–0.30 mm/rev.

| Condition | Annealed | | Hardened and Tempered | |
|---|---|---|---|---|
| Hardness | 160 - 220 HB | | 44 - 48 HRC | |
| Machining Process | Rough Turning | Finish Turning | Rough Turning | Finish Turning |
| Cutting speed (m/min) | 160-190 | 190-220 | 40 - 60 | 70 - 90 |
| Feed (mm/rev) | 0.2 – 0.4 | 0.05 - 0.2 | 0.2 - 0.4 | 0.05 - 0.2 |
| Depth of cut (mm) | 2 - 4 | 0.5 - 2 | 1 - 2 | 0.5 - 1 |
| Carbide (ISO Class) | P20/25 TiAlN coated | P10/15 TiAlN coated | P20/25 TiAlN coated | P10/15 TiAlN coated |

| Condition | Annealed | | Hardened and Tempered | | |
|---|---|---|---|---|---|
| Hardness | 160 - 220 HB | | 44 - 48 HRC | | |
| Machining Process | Rough Milling | Finish Milling | Rough Milling | Finish milling | Ball Nose End Milling |
| Cutting speed (m/min) | 130 - 170 | 160 - 200 | 90 - 130 | 130 - 160 | 150 - 180 |
| Feed (mm/rev) | 0.2 - 0.4 | 0.1 - 0.2 | 0.2 - 0.5 | 0.1 - 0.2 | 0.1 - 0.2 |
| Depth of cut (mm) | 2 - 4 | 0 - 2 | 0.1 - 2 | 0.1 - 2 | 0.1 - 2 |
| Carbide (ISO Class) | P20/25 TiAlN coated | P10/15 TiAlN coated | P20/25 TiAlN coated | P10/15 TiAlN coated | P10/P15 TiAlN coated |

## COMPARISON BETWEEN VILLARES METALS HOT WORK STEELS



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ISO 50001
OHSAS 18001:2007
IATF 16949:2016
AS 9100 D
NORSOK M-650
NADCAP – Heat Treating and Non Destructive Testing

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