VH13IM®
Hot Work Tool Steel

VILLARES METALS
a voestalpine company

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..

Edition 1, 03.2022

SIMILAR STANDARDS

VH13IM® is similar to the following grades: AISI H13, DIN X40CrMoV5-1 and W.Nr. 1.2344; BS BH13; UNS T20813; JIS SKD61; AFNOR Z40CDV5; EN X40CrMoV5-1-1. This steel is produced in accordance with ASTM A681, EN ISO 4957 and NADCA 207 Grade B standards.

GENERAL INFORMATION

VH13IM® is a 5% Cr hot work tool steel with good combination of properties such as high toughness and hot resistance. Its alloy design makes VH13IM® a very versatile tool steel, employed in several application in hot work tools and in plastic molds.

MAIN CHARACTERISTICS

VH13IM® presents a martensitic matrix mainly with MC type vanadium carbides and M_2C type molybdenum and chromium carbides. 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. In addition, VH13IM® presents high resistance to thermal fatigue, good machinability, polishability and high hardenability.

CHEMICAL COMPOSITION

Typical Analysis (Weight Percent)

C	Si	Mn	P	S	Cr	Mo	V	Fe
0,38	0,85	0,4	0.025 max	0.005 max	5,00	1,20	0,9	Bal.

STANDARD PRODUCTION RANGE

Production Route	Standard	Production Range	Finishing
Rolled Products	ASTM A681 NADCA 207 Grade B	Thickness between 8 to 152 mm with width between 25 to 320mm Rd. 5.50-152mm	Centerless ground Peeled Turned
Forged Products		Rd. 152 – 760 mm Thickness up to 400mm with width up to 1000mm	Turned Peeled Milled

*Other dimensions and conditions are available upon inquiry.

DELIVERY CONDITION

VH13IM® is usually available in round, square or flat bars in annealed condition with maximum hardness of 235 HB. This steel can also be supplied in the final heat treatment condition in accordance with ASTM A681 or NADCA 207 Grade B.
Identification Color: green, silver, green.

HEAT TREATMENTS

Soft Annealing

Soft annealing should be carried out by heating between 840 and 860°C for 2 hours controlled by the core, followed by slow cooling at 10 to 20°C per hour until 650°C and, then, by air cooling. In this treatment, the use of protective atmosphere is important to avoid surface oxidation and decarburization.

Stress Relief

In case of high removal during machining, a stress relief heat treatment shall be applied in order to avoid distortions during quenching and tempering heat treatments. The indicated procedure is slow heating to 500/600°C, or 50°C lower than the tempering temperature in case of hardened tool, holding until complete homogenization, and cooling in air or inside the furnace at least down to 200 °C. Considering dies or inserts for die casting, according to NADCA, tempering stress relief is not recommended under temperatures of 537°C.

Hardening

The austenitizing temperature should be between 1000 and 1040°C holding 30min in temperature.

For better toughness performance, it is indicated 1010°C and for better heat resistance response 1040°C can be applied. The choice of the ideal temperature should also consider aspects of design and finishing details of the parts.

After austenitization, the quenching can be performed in different quench media as:

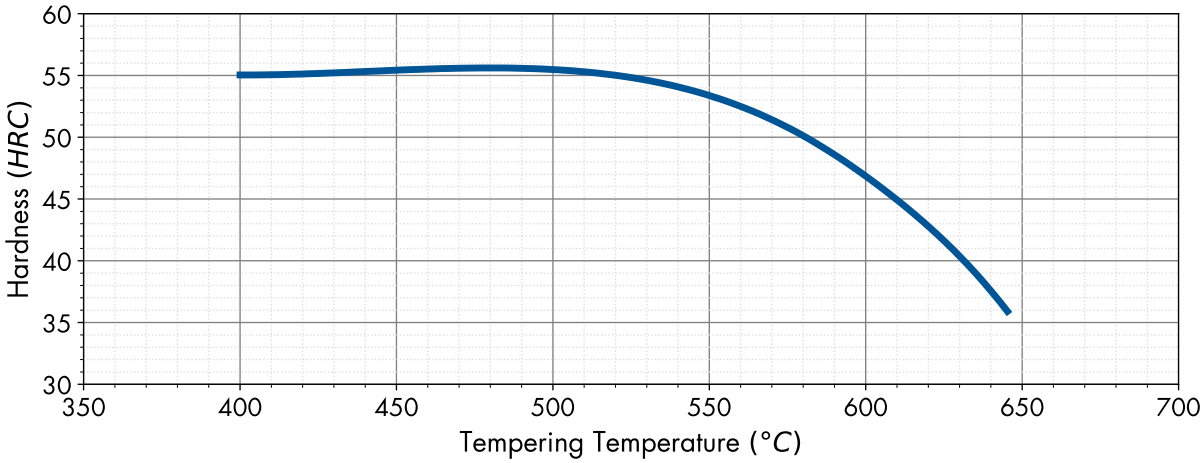
- Pressurized vacuum furnace with pressure higher than 5 bar.
- Warm oil, 40 - 70°C.
- Salt or fluidized bed between 500 - 550°C.
- Forced air cooling.

Tempering

After quenching, the parts shall be tempered immediately after quenching, i.e. as soon as they reach 60°C. It is necessary, at least, double tempering. After each tempering, parts shall be slowly cooled to room temperature.

Tempering temperatures are generally between 540-650°C, depending upon the desired hardness. The time of each tempering cycle shall be at least 2 hours in temperature. The temperature range between 450 and 540°C shall be avoided because it can promote an excessive loss in toughness.

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.



Tempering curve of VH13IM® after hardening at 1020°C. Tempering time: 2 hours
Curve obtained from specimens with cross section of 20 mm x 20 mm

Surface Treatments

Surface treatments as nitriding, PVD and CVD are recommended when higher values of surface hardness and high abrasion wear resistance are required. VH13IM® is an adequate substrate for nitriding, leading to surface hardness around 1100 HV. Surface treatments shall be employed after hardening and tempering and should be at least 50 °C lower than that of the tempering, in order to avoid decrease in core hardness. Surface must be in an adequate condition.

MAIN APPLICATIONS

The physical and mechanical properties of VH13IM® make possible its use in many applications, being classified as a general purpose hot work tool steel. Some typical application are presented below:

- Dies for die casting of aluminum or other light metals.
- Extrusion dies for aluminum or other non-ferrous alloys.
- Forging dies and die holders for steel or other ferrous and non-ferrous alloys.
- Hot shearing blades.
- Wear resistance parts, when nitrided.
- Injection or other molds for plastic.

MACHINABILITY

VH13IM® can be conventionally machined in the annealed condition. Due to its refined structured, VH13IM® presents good behavior in grinding operations. This contributes to reduce the risk to surface overheating and cracking. Care need to be taken in the selection of the tool and the speed in order to allow a good machinability. In order 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 was 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 thru fine grinding wheel and perform a tempering heat treatment in temperatures around 50°C lower than that of the last tempering.

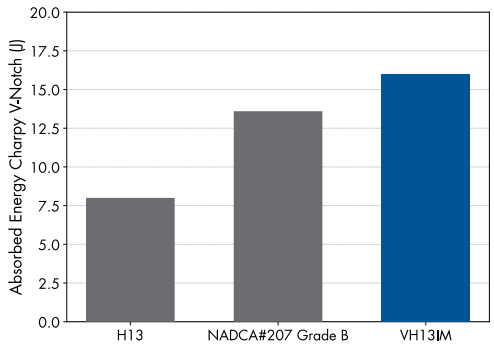
WELDING

It is not recommended to perform welding operations on VH13IM® steel. Welding operations will produce Heat Affected Zones (HAZ), which will reduce the performance of the steel in the application. HAZ produced during arc welding operation are harder and brittle, with risk of cracking unless great care is exercised. In exceptional cases and always considering that, the welding would be a temporary solution VH13IM® might be welded using special procedures to minimize the HAZ. The sequence of operations for repair welding VH13IM® 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.

MECHANICAL PROPERTIES

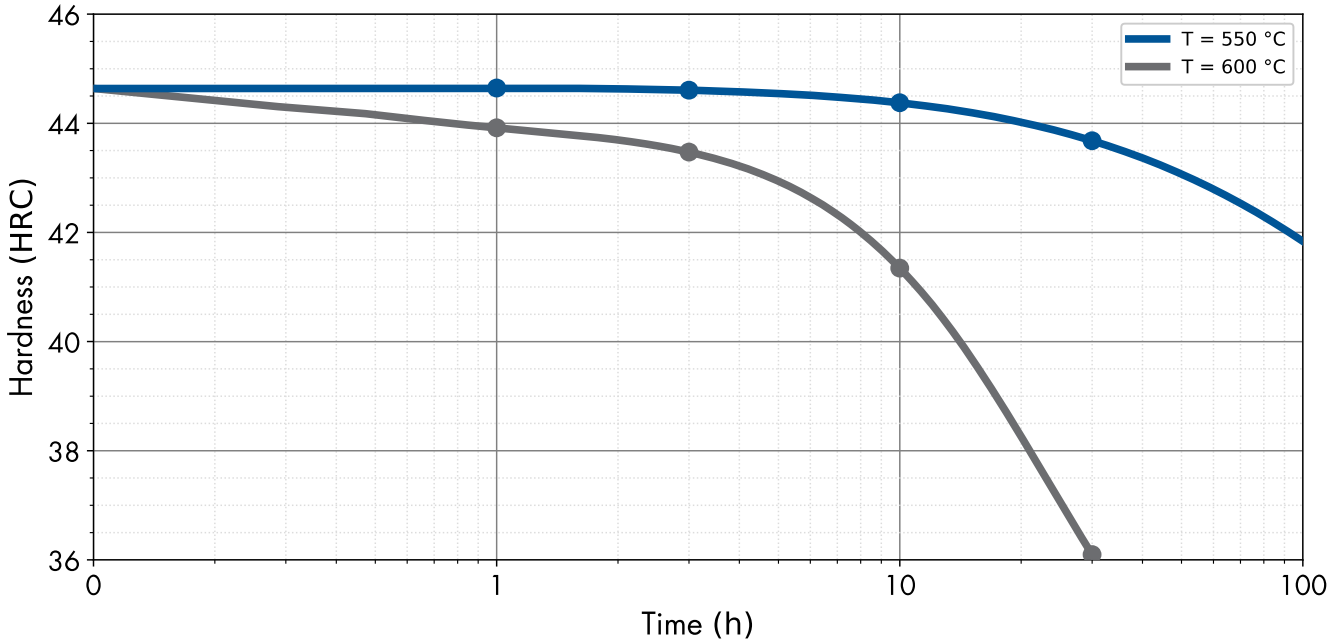
Impact energy is an adequate test for determining toughness and measuring tool steel quality. VH13IM® has higher transverse impact toughness, if compared to standard AISI H13 grade. Higher transverse values attained also mean higher isotropy. Transverse impact values in Charpy V-notch specimens classify VH13IM® as Superior

Quality AISI H13, meeting NADCA standard (North American Die Casting Association) requirements.



Transverse impact values, in Charpy-V specimens

VH13IM® is highly resistant to softening. After 30 h at temperatures higher than 550°C, the hardness decreases only 1,0 HRC at 550°C and 9,0 HRC at 600°C.



VH13IM® resistance to softening.
After 30 h, hardness decreases only 1,0 HRC at 550 °C and 9,0 HRC at 600 °C.

IMPROVEMENT OF TOOL LIFE

For optimizing the tool life, a proper heat treatment is absolutely necessary (see item before). Incorrect heat treatment cycles lead to considerable decrease in toughness and substantially reduce the tool life.

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

PHYSICAL PROPERTIES

Solidification:

Temperature	°C	°F
Melting Range	1350-1500	2460-2730

Density:

Temperature	g/cm³	lb/in³
20°C (68°F)	7.70	0.278

Specific Heat:

Temperature	J/kg.K	Btu/lb.°F

20 °C to (68°F to)		
100°C (212°F)	460	0.110

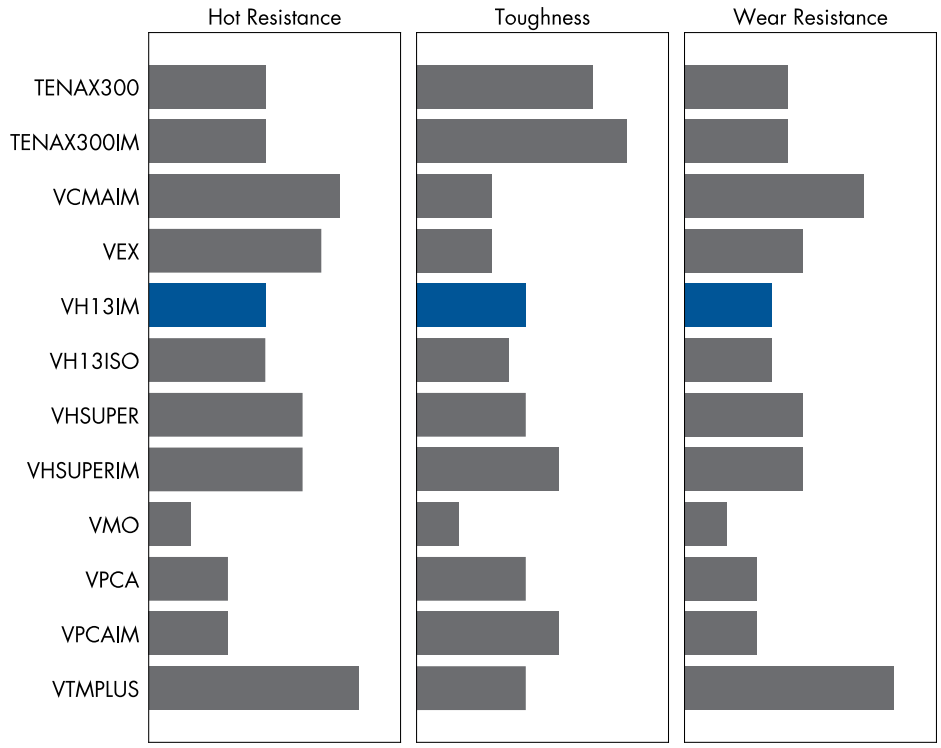
Thermal Conductivity:

Temperature	W/(m.K)	Btu.in/(h.ft².°F)
20°C (68°F)	25.0	173
350°C (662°F)	28.3	196
700°C (1292°F)	29.3	203

Thermal Expansion Coefficient:

Temperature 20 °C to (68°F to)	10^{-6}m/m.K	10^{-6}in/in.°F
100°C (212°F)	11.5	6.4
200°C (392°F)	12.0	6.7
300°C (572°F)	12.2	6.8
400°C (752°F)	12.5	6.9
500°C (932°F)	12.9	7.2
600°C (1112°F)	13.0	7.2

COMPARISON BETWEEN VILLARES METALS HOT WORK STEELS



VILLARES METALS
a voestalpine company

Headquarters

Villares Metals S.A.
Rua Alfredo Dumont Villares, 155
Jardim Santa Carolina | CEP 13178.902
Sumaré - SP
+55 19 3303 8000
metals@villaresmetals.com

Services & Solutions Centers

Sumaré
Rua Alfredo Dumont Villares, 155
Jardim Santa Carolina | CEP 13178.902
Sumaré - SP
0800 707 0577
cac@villaresmetals.com

Flores da Cunha
Rod VRS 814, KM 1
Lagoa Bela | CEP 95270.000
Flores da Cunha - RS
0800 707 0577
cac@villaresmetals.com

Joinville
Perini Business Park
Rua Dona Francisca, 8.300, bloco C7
Distrito Industrial | CEP 89219.600
Joinville - SC
0800 707 0577
cac@villaresmetals.com

Vespasiano
Parque Norte Business Center
Avenida Três, 105
Morro Alto | CEP 33200.000
Vespasiano - MG
0800 707 0577
cac@villaresmetals.com

Sales Office

Villares Metals International B.V.
Het Groot Handelsgebouw,
Unit E7.186 Stationsplein 45
3013 AK Rotterdam
Netherlands
+31 10 3033 720
info@villaresmetals.com

ISO 9001:2015
ISO 14001:2004 (ANAB and UKAS)
ISO 17025
ISO 50001
OHSAS 18001:2007
IATF 16949:2016
AS 9100 D
NORSOK M-650
NADCAP – Heat Treating and Non Destructive Testing