VPCAIM®
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..

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SIMILAR STANDARDS

VPCAIM® is similar to AISI H11, UNS T20811, DIN X38CrMoV5-1 and W.Nr. 1.2343, JIS SKD6. This steel is produced in accord with ASTM A681 and VDG M82.

GENERAL INFORMATION

VPCAIM® is a hot work steel with high toughness in comparison with other steels for the same application, as AISI H13. This steel presents good thermal conductivity and an adequate response to nitriding and polishing.

MAIN CHARACTERISTICS

VPCAIM® is a martensitic hot work steel intended to deliver high toughness associated with compatible mechanical resistance of AISI H13 steels. This steel is produced by ESR (Electro-Slag Remelting) process to assure high isotropy of mechanical properties; VPCAIM® 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
0,40	1,00	0,35	0.03 max	0.003 max	5,00	1,30	0,5	Bal.

STANDARD PRODUCTION RANGE

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

*Other dimensions and conditions are available upon inquiry.

DELIVERY CONDITION

VPCAIM® is usually supplied in the annealed condition with a maximum hardness of 235HB. VPCAIM® is also available in the hardened condition.

HEAT TREATMENTS

Soft Annealing

Soft annealing is recommended to machining operations. For an espheroidized microstructure, heat slowly to a temperature between 845 and 900°C, soaking time of 2h followed by furnace cooling until 540°C and then air cooling to room temperature. The maximum hardness of VPCAIM® steel will be 230HB.

Stress Relief

Stress relief 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 with draws and profiles, in which the machining removal has been higher than 30%, in other to minimize distortions after hardening.

Heat slowly to 600-650°C followed by furnace cooling until 200°C. Stress relief for hardened parts must employ a temperature 50°C lower than that of the last tempering temperature.

Hardening

The austenitizing temperature should be between 950-1050°C and, once the temperature from the center to the surface is equal, keep the part 30 min for each inch of thickness in the austenitizing temperature. For better toughness performance, it is indicated 995°C and for better heat resistance response 1025°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
- Oil between 40-70°C.
- Salt bath between 500-550°C.
- Air cooling.

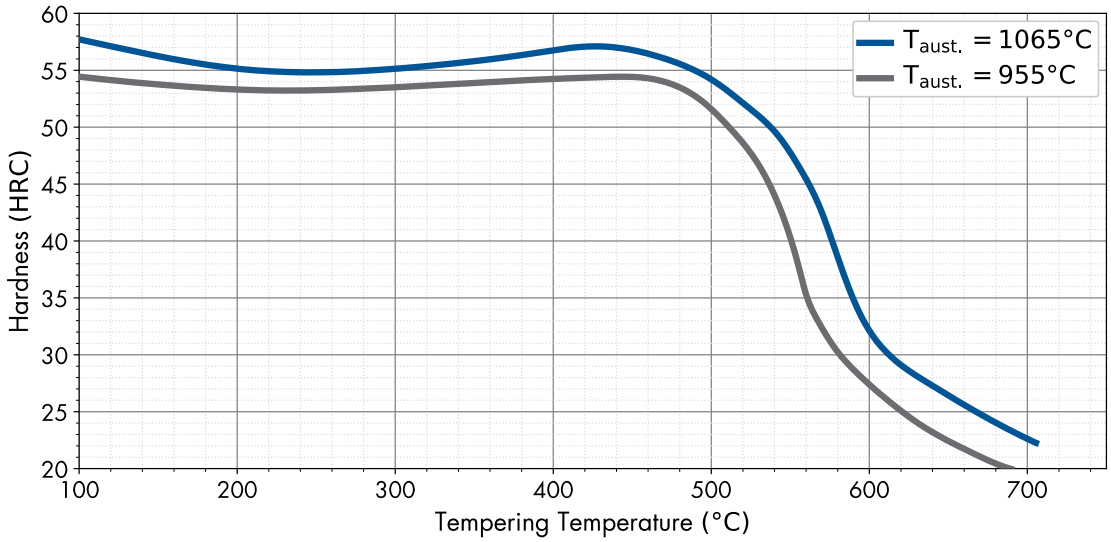
Tempering

After quenching, the parts shall be tempered immediately, i.e. as soon as they reach 60°C. It is necessary, at least, double tempering. After each tempering, cool slowly 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. 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, PVD and CVD are recommended when higher values of surface hardness and high abrasion wear resistance are required. Surface treatments shall be employed after hardening and tempering, since their temperatures is at least 50°C lower than the last tempering heat treatments.



Tempering curve of VPCAIM® after hardening at 980°C. Tempering time: 2 hours
Curve obtained from specimens with cross section of 20 mm x 20 mm

MAIN APPLICATIONS

VPCAIM® is recommended for:

- Dies, tools and components for die casting and extrusion of aluminum alloys and other non-ferrous alloys, such as zinc, tin and lead,
- Inserts, shear blades and all types of dies for hot work that involves shock,
- Plastic molds with high polishing requirements.

MACHINABILITY

VPCAIM® can be conventionally machined in the annealed condition. 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 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 thru fine grinding wheel. After grinding, it is recommended to perform a tempering heat treatment in temperature around 50°C lower than that of the last tempering.

WELDING

Welding is not recommended on VPCAIM® steel. The 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 VPCAIM® might be welded using special procedures to minimize the HAZ.
The sequence of operations for repair welding VPCAIM® 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.

MECHANICAL PROPERTIES

Typical Tensile Properties

Temperature		Ultimate Tensile Strength		Yield Strength		Elongation in 4D	Reduction of Area
°C	°F	MPa	ksi	MPa	ksi	%	%
20	68	1806	262	1482	215	10	35.8
150	300	1689	245	1358	197	10.1	36.1
425	800	1510	219	1289	187	11.4	38.7
540	1000	1241	180	965	140	11.0	35.4
650	1200	586	85	434	63	18.9	66.6

VPCAIM® steel after quenching from 1010°C in air and double tempered at 570°C for 2h with air cooling. Hardness of 50HRC.

PHYSICAL PROPERTIES

Density:

Temperature	g/cm³	lb/in³
20°C (68°F)	7.81	0.282

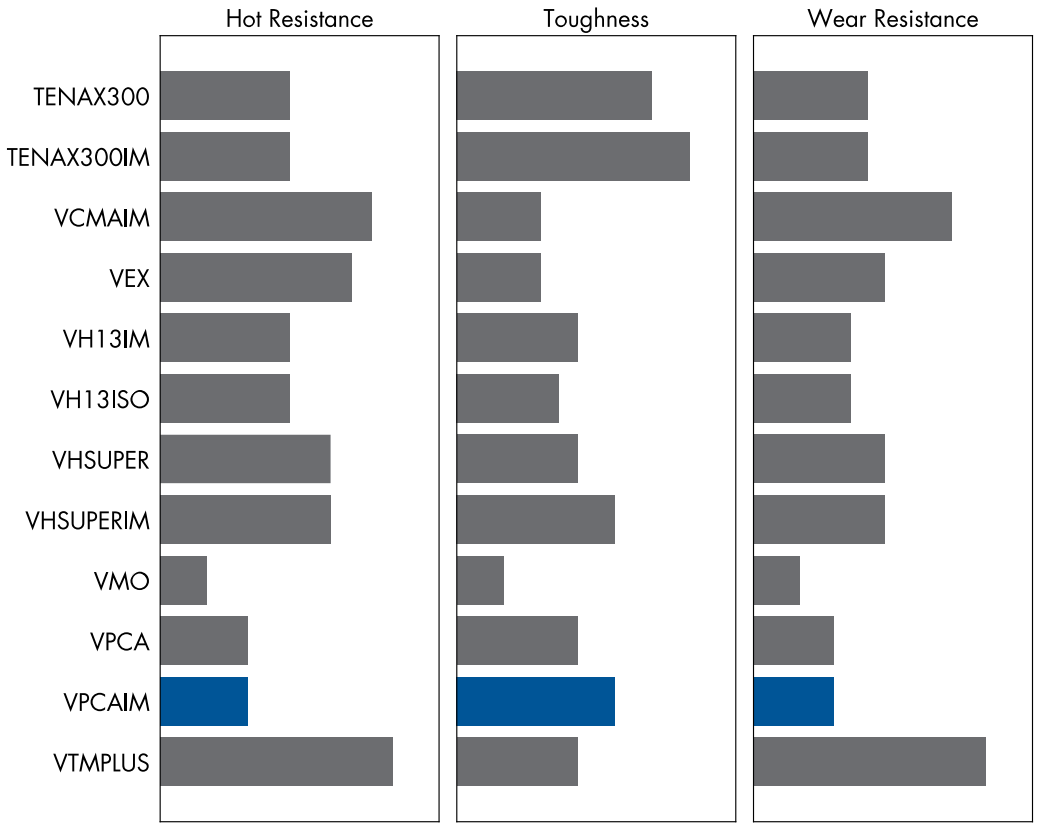
Thermal Conductivity:

Temperature	W/(m.K)	Btu.in/(h.ft².°F)
100°C (212°F)	23.0	159
350°C (662°F)	28.4	196
400°C (752°F)	33.4	231
675°C (1247°F)	30.1	208

Thermal Expansion Coefficient:

Temperature 20 °C to (68°F to)	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

COMPARISON BETWEEN VILLARES METALS HOT WORK STEELS



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