VPCA®
Hot Work Tool Steel

VILLARES METALS
a voestalpine company

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SIMILAR STANDARDS

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

GENERAL INFORMATION

VPCA® is a hot work steel with higher 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

VPCA® is a martensitic hot work steel intended to deliver high toughness associated with compatible mechanical resistance of AISI H13 steels. This steel is produced conventional casting and is recommended when higher toughness is required 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.
For higher toughness applications, consider the use of VPCAIM® (ESR version)

CHEMICAL COMPOSITION

Typical Analysis (Weight Percent)

C	Si	Mn	P	S	Cr	Mo	V	Fe
0,40	1,00	0,35	0.03 max	0.03 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 Rounds: 5.50-152.40mm	Centerless ground Peeled Turned Milled
Forged Products		Thickness up to 400mm with width up to 700mm Rounds: 152.40 – 760 mm	Turned Peeled Milled

*Other dimensions and conditions are available upon inquiry.

DELIVERY CONDITION

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

HEAT TREATMENTS

Soft Annealing

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

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 with draws and profiles, in which the machining removal has been higher than 30%, 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.

Hardening

Preheat the part to 780- 820°C in two steps, until the temperature from center to surface is equal in each step. Austenitizing temperature should be between 950 and 1050°C holding 30min in temperature.

For better toughness performance, it is indicated 995°C and for better heat resistance response 1025°C can be applied. The choice of ideal temperature should also consider aspects of design and finishing details of the parts.

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

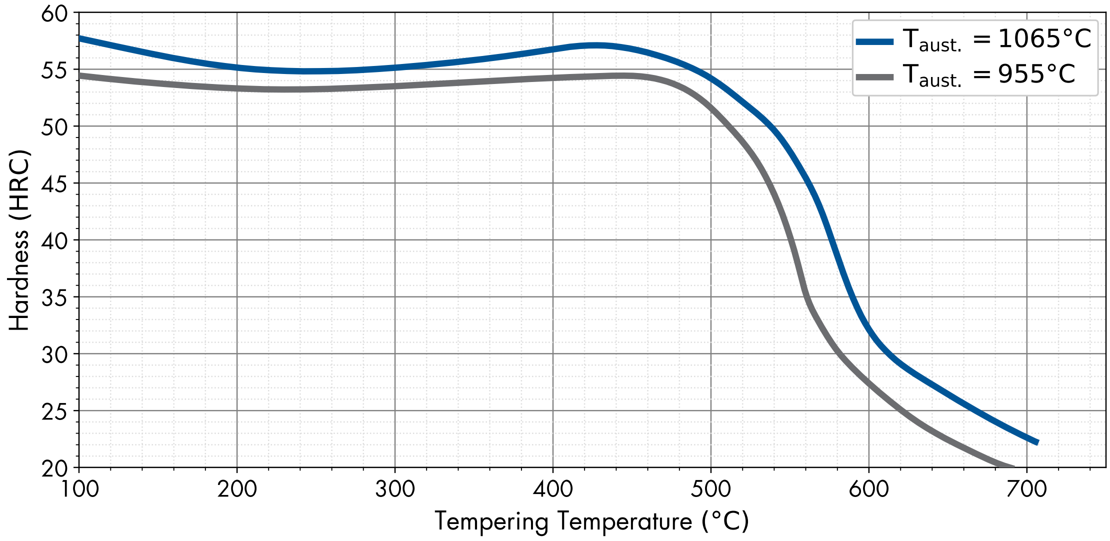
Temper immediately after quenching, i.e. as soon as parts reaches 60°C. Double tempering, at least is recommended and after each tempering cycle, parts shall be slowly cooled to room temperature.

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. Avoid temperature range between 450 and 540°C as 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.

Surface Treatments

Surface treatments as nitriding, PVD and CVD are suitable processes 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 VPCA® after hardening at 980°C. Tempering time: 2 hours
Curve obtained from specimens with cross section of 20 mm x 20 mm

MAIN APPLICATIONS

VPCA® main applications are:

- 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.
- For higher toughness and isotropic properties, consider use of VPCAIM®.

MACHINABILITY

VPCA® can be conventionally machined in the annealed condition. Care need to be taken in the selection of the tool and the speed to allow a good machinability. 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

It is not recommended to perform welding operations on VPCA® 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 VPCA® might be welded using special procedures to minimize the HAZ. The sequence of operations for repair welding VPCA® 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

VPCA® 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

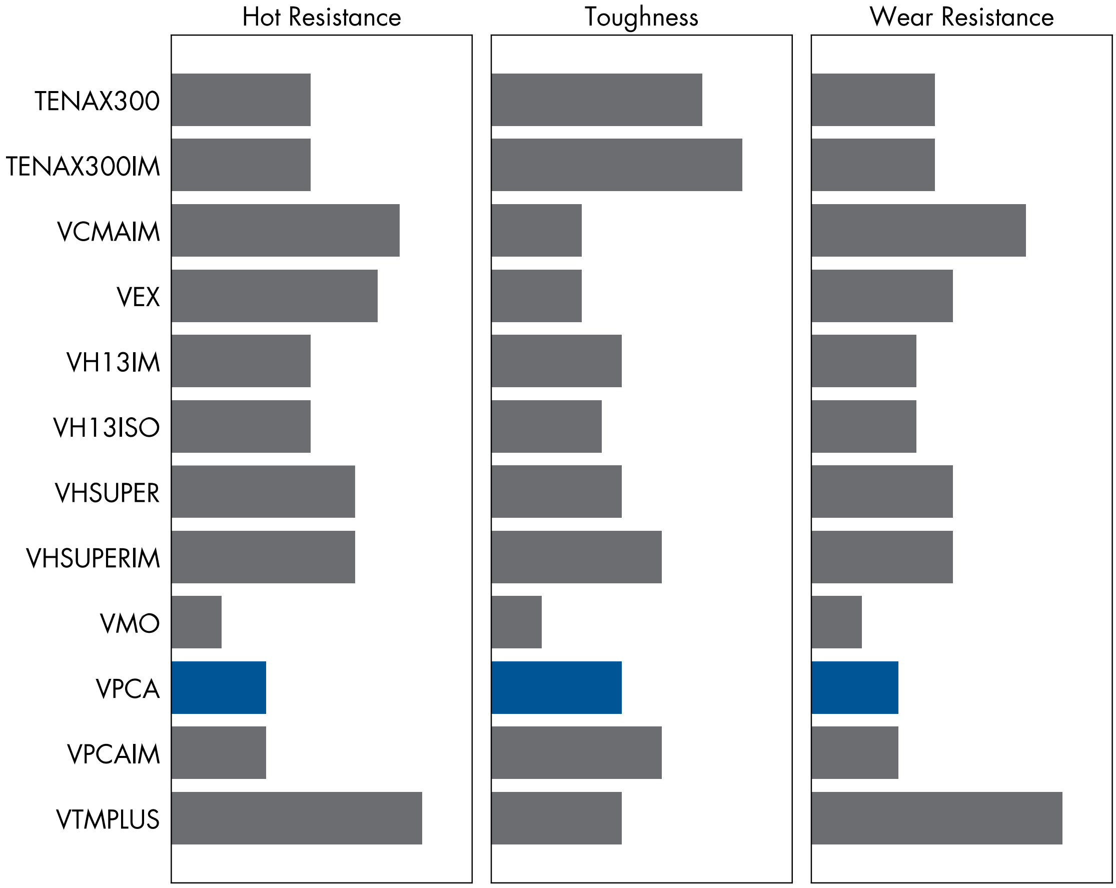
Thermal Conductivity:

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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NADCAP – Heat Treating and Non Destructive Testing

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