

Global Offices of Tool Steel Business in Proterial Group



A NORTH AMERICA

- Proterial America, Ltd.
- Diehl Tool Steel, Inc.

B MEXICO

- HC Queretaro, S.A.de C.V.

C BRAZIL

- Hitachi High-Tech do Brasil, Ltda.

D TURKEY

- KORKMAZ CELIK TICARETI VE SANAYI A.S.

E ITALY

- CS METAL EUROPE S.R.L.

F GERMANY

- Proterial Europe GmbH

1 Korea

- Proterial Korea Co., Ltd.
- GOLD STAR HEAT TREATMENT Co., Ltd.

2 Dalian

- Proterial Specialty Steel (Dong Guan) Co., Ltd. Dalian Branch

3 Tianjin

- UMETOKU TIANJIN CO.,LTD.

4 Shanghai

- Proterial Specialty Steel (Dong Guan) Co., Ltd. Shanghai Branch
- Proterial Specialty Steel (Ningbo) Co., Ltd.
- UMETOKU SHANGHAI CO.,LTD.
- Jiashan Changhe Special Steel Co., Ltd.

5 Guang Dong

- Proterial Specialty Steel (Dong Guan) Co., Ltd.

6 Taiwan

- Proterial Taiwan, Ltd.

7 PHILIPPINES

- Philippine Precision Technology, Inc.

8 THAILAND

- Proterial (Thailand) Ltd.
- Umetoku Thailand Co., Ltd.
- U.T.T. Engineering Co., Ltd.
- Fujimaki Steel Thailand

9 VIETNAM

- Pro-Vision Special Steel J.S.C
- Yamaichi Special Steel Vietnam Co., Ltd

10 MALAYSIA

- Umetoku (Malaysia) Sdn. Bhd.

11 SINGAPORE

- Proterial Asia Pacific Pte. Ltd.
- Tipson Industrial Trading Pte. Ltd.

12 INDONESIA

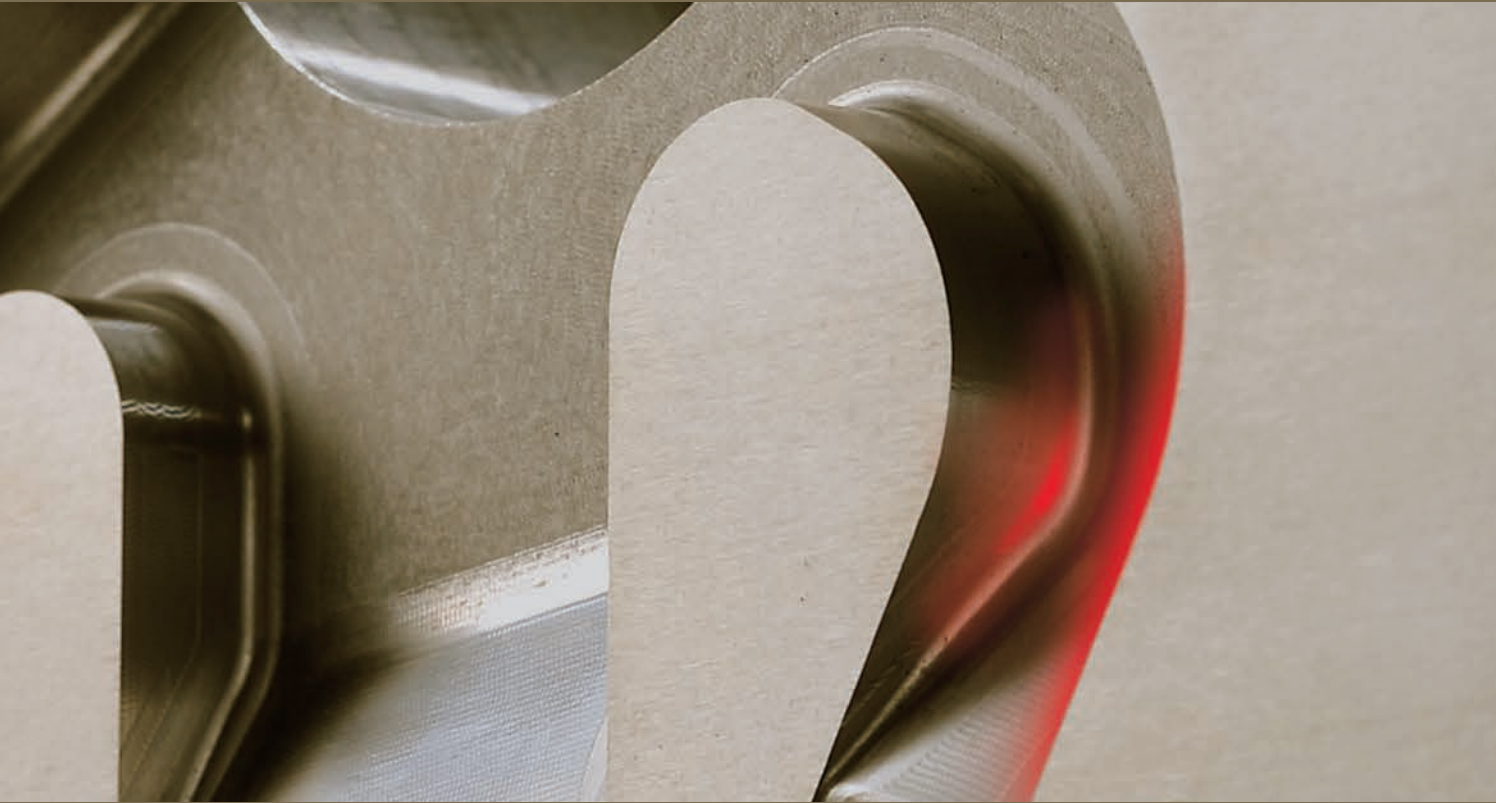
- PT. Stilmetindo Prima
- PT. Fujimaki Steel Indonesia
- PT. Umetoku Indonesia Engineering

13 INDIA

- Proterial (India) Private Limited
- GOEL STEEL COMPANY

Advanced Die Steel for Die Casting Molds

DAC-i®



Proterial, Ltd.

<https://www.proterial.com/>

Proterial Specialty Steel, Ltd.

<https://www.ss.proterial.com/>

Catalog No. YSS-TS-Y-72-F(E.)

YSS, **isotropy**, DAC, DAC-i, DAC-X, DAC-MAGIC, YXR, FDAC, and YAG

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OUR HERITAGE, YOUR ADVANTAGE **YASUGI SPECIALTY STEEL**



Advanced Die Steel for Die Casting Molds

DAC-i®

The power of i... originally comes from the breathtaking isotropy of DAC-P, and now it has been poured into the innovative new materials...

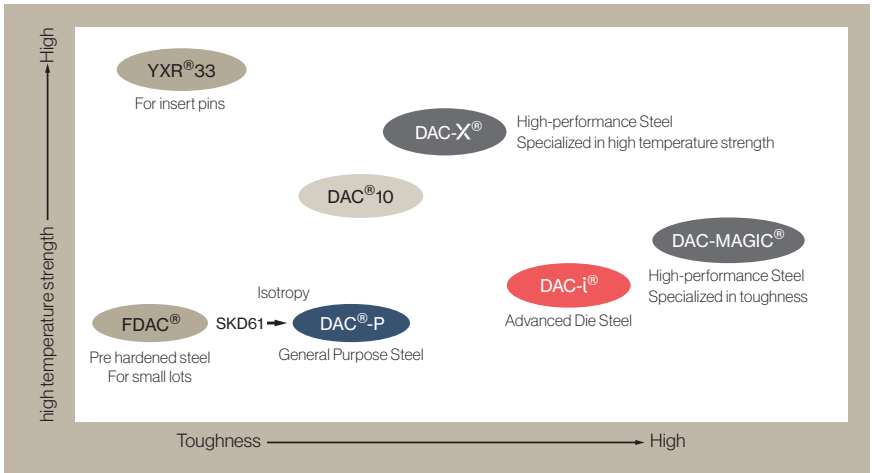
Firstly, we developed DAC-P with improved toughness under the concept of isotropy, when compared to H13, the conventional general-purpose steel for die casting molds. However, that was not all. Through chemical composition adjustment and manufacturing process innovation, we have further improved the toughness and high temperature strength of our steel—ultimately resulting in DAC-i, the advanced die steel for die casting molds.

- Improved toughness and high temperature strength ensure improved heat crack resistance, helping to extend the useful lifetime of die casting molds.
- Improved toughness promises fewer gross cracks in die casting molds —and reduced water leakage through cooling channels.

Tool steel for Die casting molds: Positioning of material properties

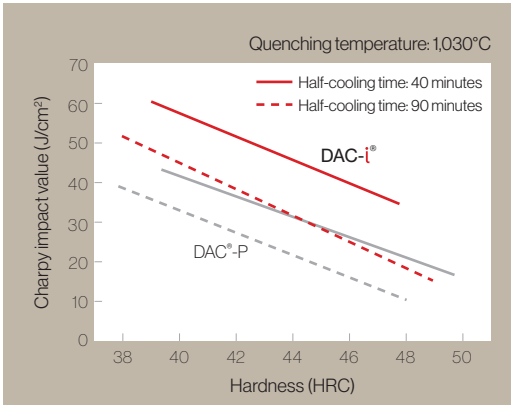
Proterial offers a wide range of steel grades for die casting molds in response to the diversification of aluminum die casting technologies—allowing each customer to select the optimal material for individual molding demand.

Positioning of material properties



Toughness (2U Charpy impact value)

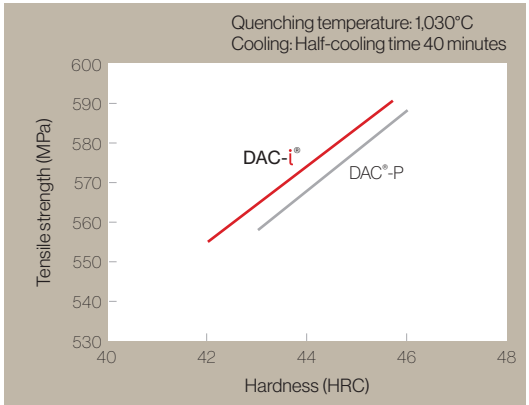
DAC-i offers higher toughness than DAC-P. This remains true even under conditions of slow quench cooling, as for larger products.



Half-cooling time: Time (in minutes) required to cool from quenching temperature to halfway point between quenching and room temperature (quenching temperature + room temperature)/2

High Temperature strength (650°C tensile-strength test)

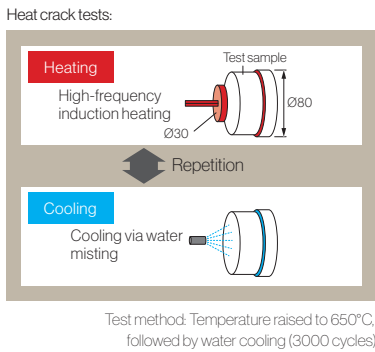
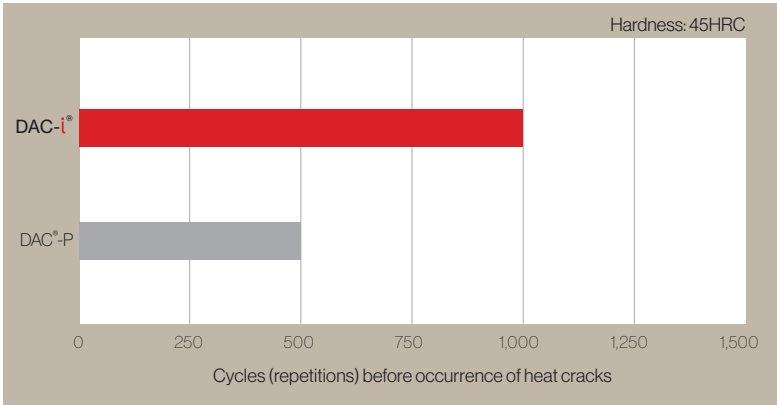
DAC-i offers better high temperature strength than DAC-P.



Heat crack resistance <Suppression of initial cracks>

Compared to DAC-P, DAC-i offers improved initial heat crack resistance and a greater number of cycles before the occurrence of heat cracks.

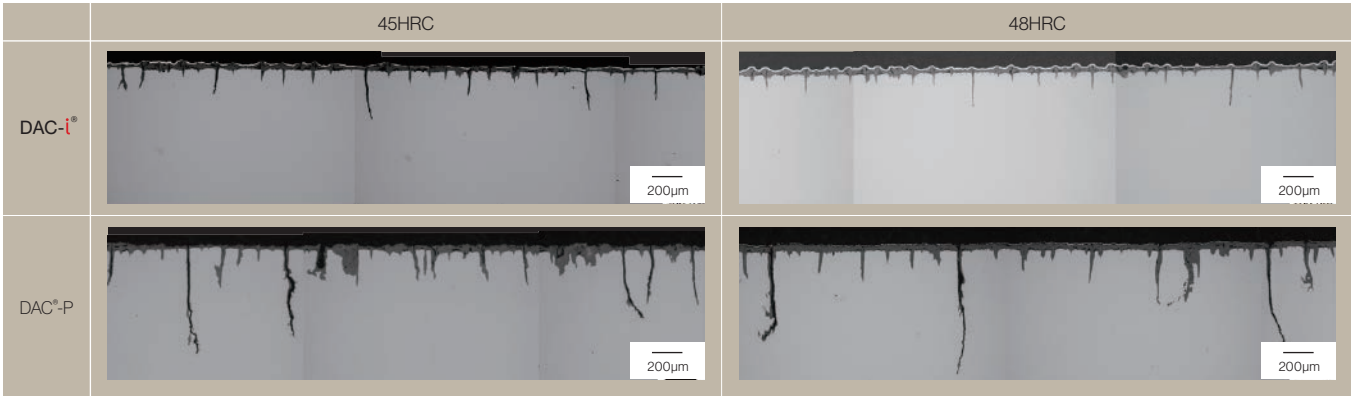
Number of cycles before occurrence of heat cracks



Heat crack resistance <Suppression of crack development>

Compared to DAC-P, DAC-i offers improved heat crack resistance and slower development of heat cracks.

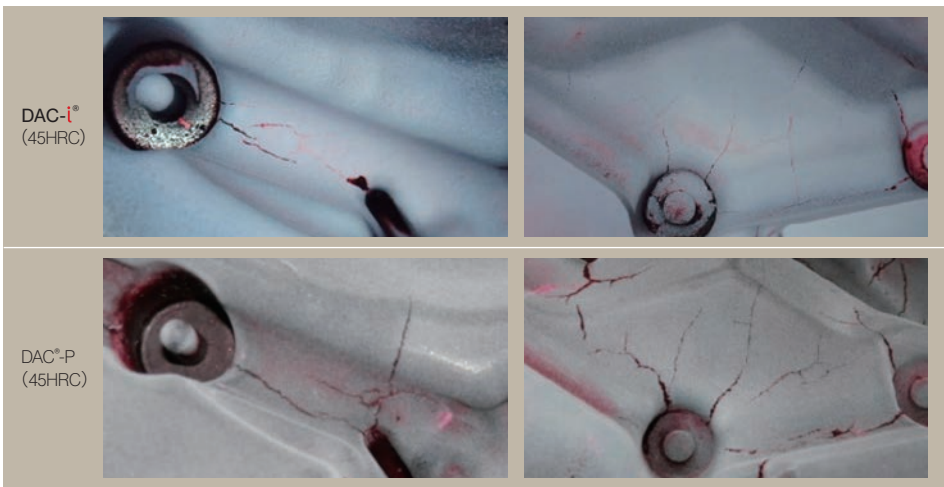
Cross-sectional view of cracks after 3,000 cycles



Die casting mold example <Fewer heat cracks>

Choosing DAC-i reduces heat cracks compared to conventional materials.

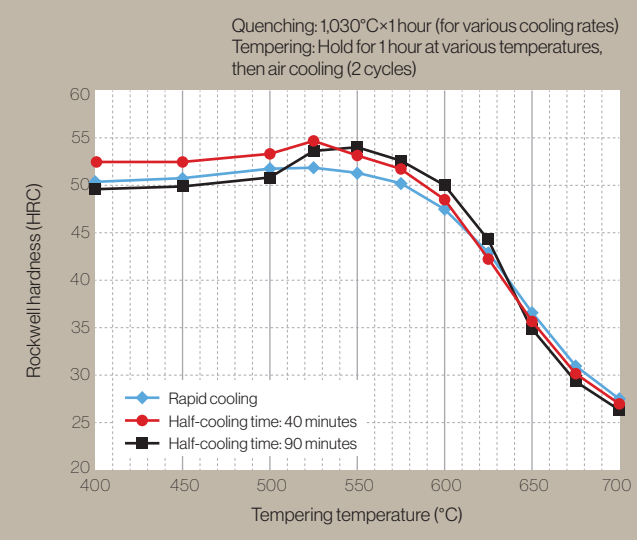
Comparison: Mold erosion after approximately 180,000 shots (mold machine size: 800 t)



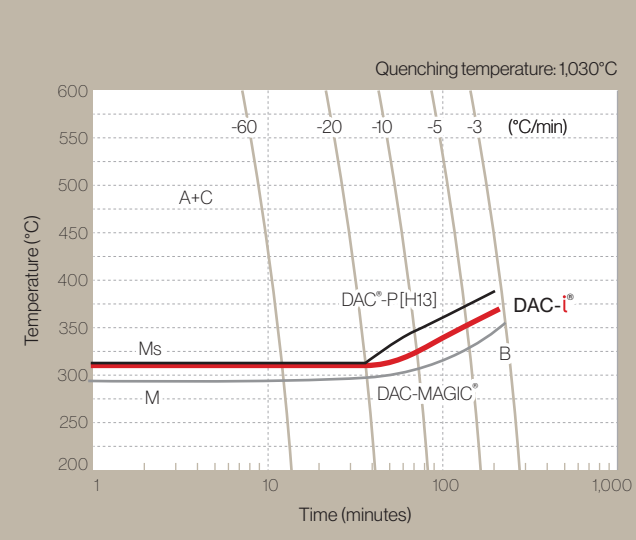


DAC-i[®] Heat Treatment Properties and Standard Heat Treatment Conditions

Tempered hardness curves

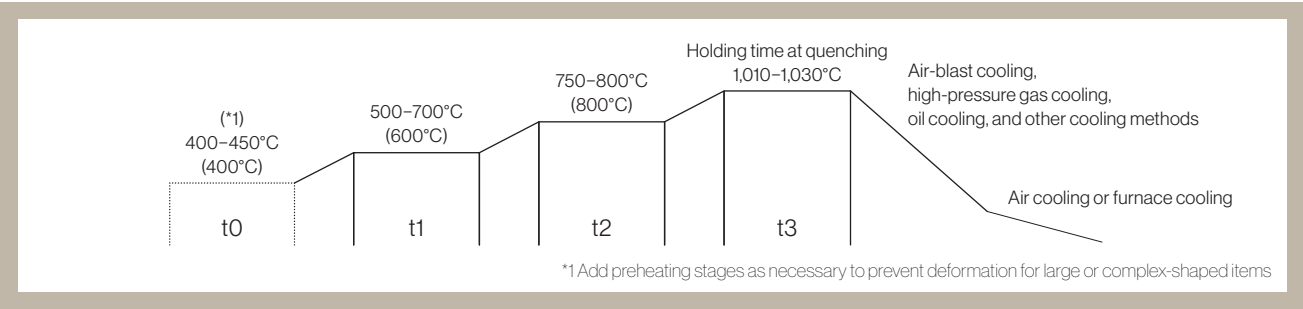


Continuous cooling transformation diagram



Standard heat treatment protocol

Quenching



<Holding time at quenching>

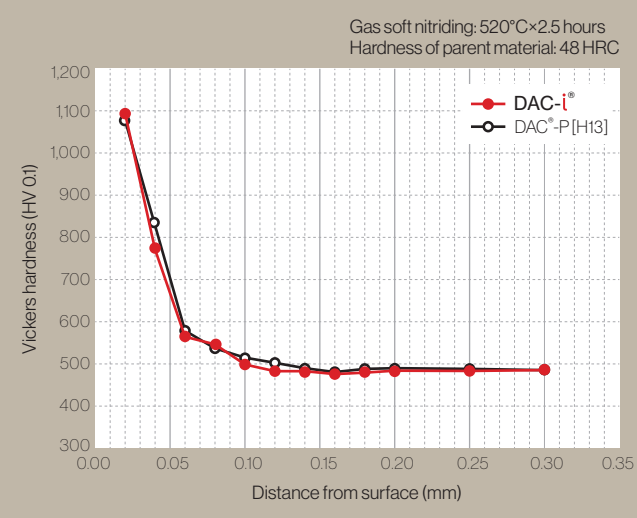
The holding time at quenching is determined based on the shorter of the following time intervals:

- (a) the time required for the gap between the maximal surface temperature and the material core temperature to drop below 5°C, plus 30 minutes;
- (b) the time required for the maximal surface temperature to reach the specified temperature, plus up to 90 minutes.

Standard holding times at quenching (t3 values) for treated products of various thicknesses are given in the following table.

Thickness [mm]	≤15	25	50	75	100	125	150	200	300
Holding time (t3) [min]	15	25	40	50	60	65	70	80	100

Nitriding behavior

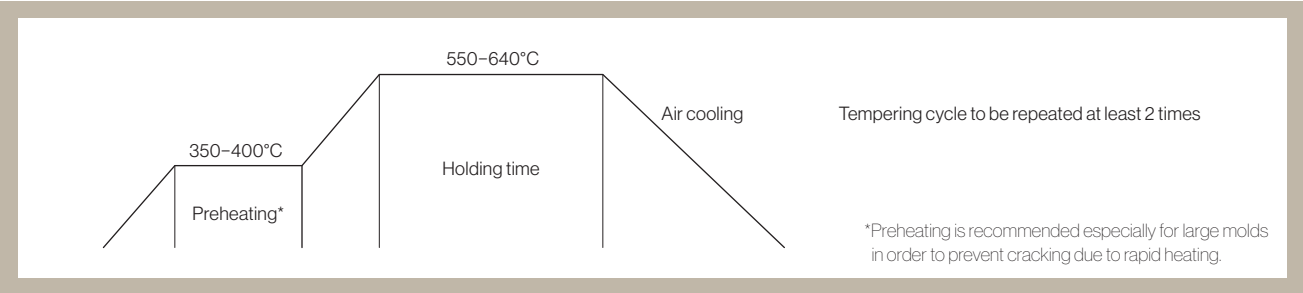


Standard heat treatment conditions

Heat treatment conditions	Annealing	820-870°C Slow cooling
	Quenching	1,010-1,030°C Air cooling / gas cooling / oil cooling
Hardness	Tempering	550-640°C Air cooling
	Annealed	≤229 HB
Hardness for general application*	Small and medium-sized items:	45-48 HRC
	Large-sized items:	45-48 HRC

*Note: Please adjust hardness values as appropriate for your applications and purposes.

Tempering

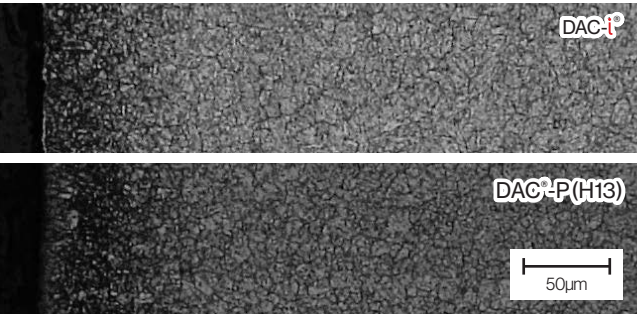


<Holding time at tempering>

The holding time at tempering is determined by the thickness of the treated product, with a baseline rate of 1 hour for every 25 mm of thickness.

Standard holding times at tempering for treated products of various thicknesses are given in the following table.

Thickness [mm]	≤25	26-35	36-64	65-84	85-124	125-174	175-249	250-349	350-499
Holding time [min]	60	90	120	180	240	300	360	420	480



Cross-sectional surface micrographs of surface layer after gas soft nitriding



Nitriding for die casting molds

Nitriding

Properties and characteristics of the nitrided layer vary depending on nitriding methods and conditions. Please choose the type of nitriding according to the right figure.

Comparison of various nitrided layers

	TYPE A	TYPE B	TYPE C	TYPE D
Nitriding depth and form (In the case of nitrided H13)	 ε phase (white layer) 0.1mm >1000HV	 Grain boundaries in the nitride layer 0.2mm >1000HV	 Sulfide, oxide layer 0.2mm >1000HV	 No compound layer 0.05~0.1mm 600~800HV
Heat crack resistance	B	C	C	A
Flaking resistance of the nitrided layer	B	C	C	A
Melting Resistance	B	B	A	C
Type of Nitriding	General nitriding	Deep nitriding	Sulfurizing and nitriding	Shallow nitriding

Excellent "A" → Ordinary "C"

Repair of die casting molds

The right figure shows standard repair welding methods in build-up welding due to design changes or repair welding due to heat cracks.

State of Die	Welding Rod	Welding Method	Welding Condition	Welding Process Chart	Temp. between weldlayers
Annealed State	DAC-P or same steel	TIG	○Welding bar 1.6~4.0 ϕ ○Current 80~200A		250°C Above
Hardened State	YAG300*		○Flux of Ar gas 8~15R/min		250°C Above

※ This product might be subject to the Export Trade Control Order. In some cases, it might be necessary to go through administrative procedures to obtain an export license from the government when exporting the product.

(Remarks)

- 1. YAG300 is our brand of high-grade welding rod (maraging steel). When using YAG300 welding rods, welding defects, such as "bead cracks" or "pinholes", are significantly less likely to occur than conventional welding rods.
- 2. TIG Welding Method(Tangsten Inert Gas Welding Method) is to make arc between tangsten electrode covered by argon gas and objects to be welded, and then wire is inserted into the heat pool generated by the arc.
- 3. In order to improve the performance of the weld metal, use a low current and a fine wire. To prevent crater cracking, do not allow the crater of the back pass to overlap the crater of the previous pass. Use intermittent welds with short beads to prevent overheating of the base metal.
- 4. Keeping time of Temper and Anneal after welding should be 1h/25mm in thickness.
- 5. A careful attention is to be paid of crack during grinding.

Applications and features

Tool steel for die casting molds: Applications and features

Application	Grade	JIS	Key features
		AISI/ASTM W.-Nr.	
Advanced die Steel for die casting molds	DAC-i	SKD61 modified H13 modified 1.2343 modified	Advanced die steel with higher toughness and better high temperature strength, achieved through composition adjustments and manufacturing process innovations.
New high-performance Steel for die casting molds	DAC-X	SKD61 improved H13 improved 1.2367 modified	New high-performance steel for die casting molds with better high temperature strength and toughness compared to conventional high-performance materials through improved chemical compositions and manufacturing process innovations.
General-purpose aluminum / zinc-alloy molds	DAC-P 0.4C-5.2Cr-1.3Mo-V	SKD61 H13 1.2344	Excellent balance between high temperature strength and toughness Good machinability, low heat treatment distortion
High-performance Steel for die casting molds	DAC-MAGIC	SKD61 improved H13 improved 1.2367 modified	High-performance mold steels achieve higher-dimensional balance between high temperature strength and toughness Heat crack resistance, resistance to stress corrosion, excellent cutting propeties
Precision Die casting molds	DAC10 5.2Cr-2.7Mo-V	SKD61 improved H13 improved 1.2367 modified	High temperature strength, excellent heat crack resistance
Long-lifetime pin components; components for insertion and removal	YXR33 4.2Cr-1.6W-2.0Mo-1.2V	N/A Matrix High speed steels	High temperature strength, Best erosion resistance
Small lots, Simple molds	FDAC 5.2Cr-1.3Mo-V-S	SKD61 modified Free-cutting H13 modified Free-cutting N/A	Free cutting pre-hardened steels (40HRC)