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- Please contact a representative of our Specialty Steel Division if there are any questions or problems.

YSS Advanced Plastic Mold Steel for General Purposes

HI-PM MAGIC™

40HRC Prehardened Steel

It is developed with a view of total cost reduction of resin product manufacturing!

Our address and contact indicated in this catalog are those as of June 2009. If you cannot put a call through, please contact our Corporate Communication Group in Tokyo below.

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With high durability and steady mirror polishability which contributes to total cost reduction of resin product manufacturing.

HI-PM MAGIC™

HI-PM MAGIC is the steel for plastic molds which pursues practicability with consideration of performance balance.

- » "Hardness" (37 to 41 HRC) supports quantity production of precision molding for resin products
- » "High toughness and excellent weldability" reduce problems when developing new products
- » "Excellent high feed machinability at high-speed and steady mirror polishability" improve working efficiency, and save energy

Steady mirror polishability

Excellent high feed machinability at high-speed

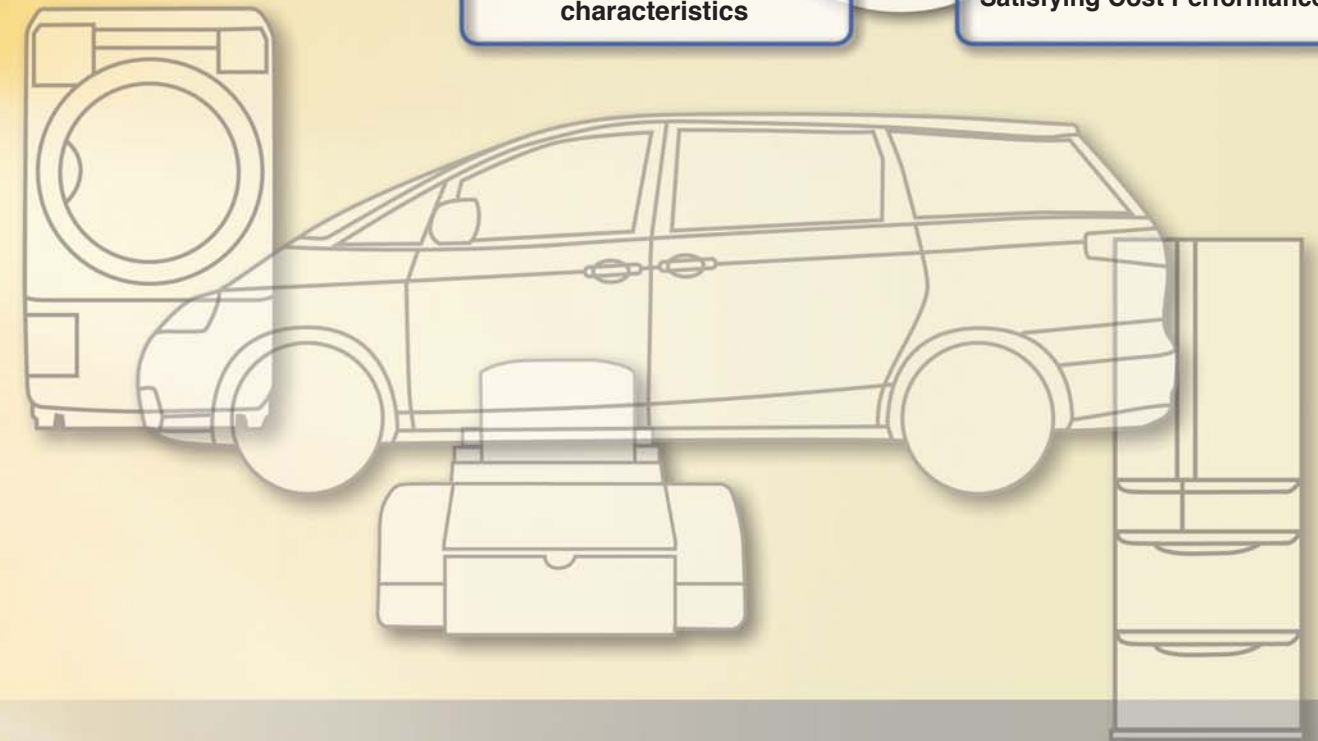
High toughness compared with the conventional 40HRC class

HI-PM MAGIC Features

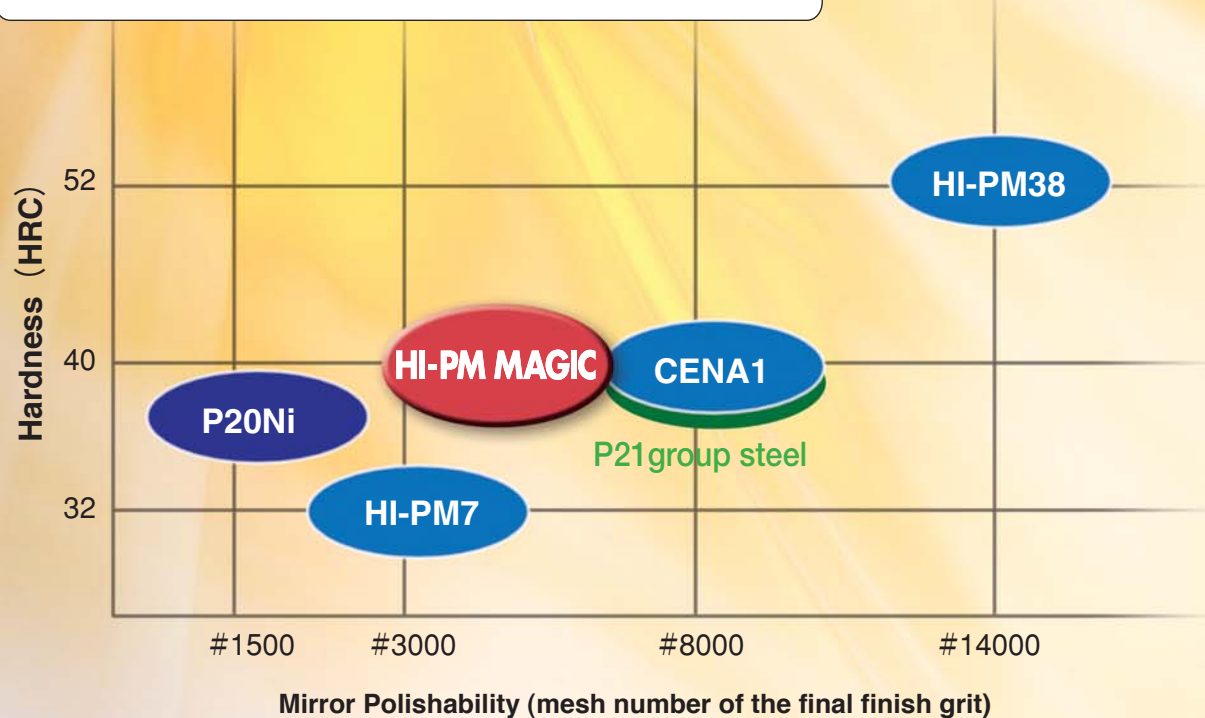
Excellent weldability

Excellent nitriding characteristics

Satisfying Cost Performance



Rating of hardness and mirror polishability



Characteristics Comparison

Item		HI-PM MAGIC	P21 Group Steel	P20 Ni Steel
Durability	Hardness (HRC)	40	40	37
	Toughness	◎	×	○
Weldability		○	△	×
Mirror Polishability (≥#3000)		○	◎	△
EDM Finishability		○	◎	○
Machinability		○~△	△	△

Excellent ◎>○>△>× Poor

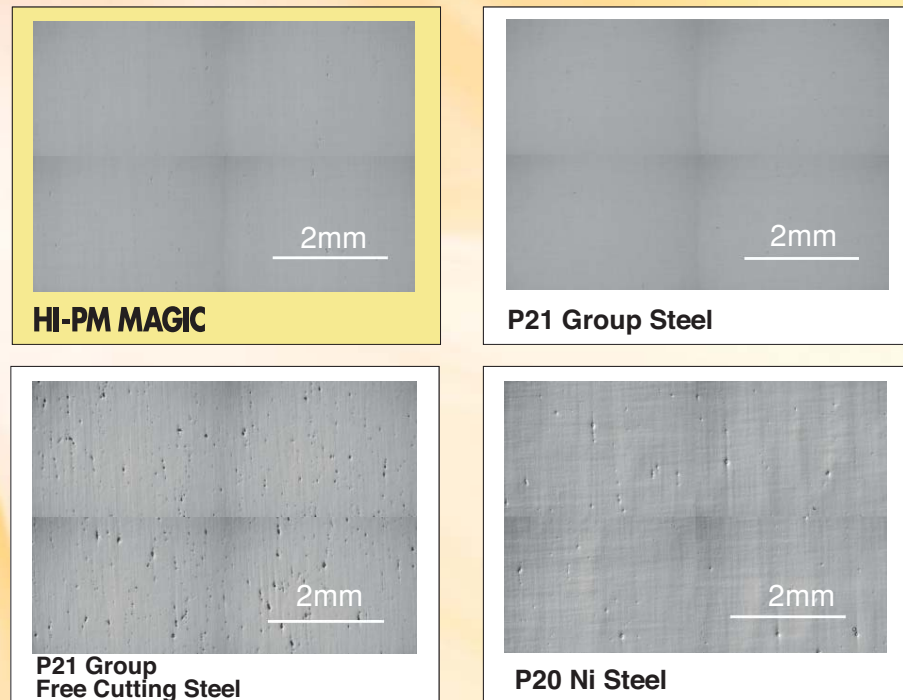
■ Compared steels

Indicates respectively P20Ni steel - the same as AISI P20 steel with added 1% Ni; P21 group steel - NiAl precipitation hardening type low carbon steel (same as our company's HI-PM 50); P21 group free cutting steel - free cutting steel (same as our company's HI-PM1).

HI-PM MAGIC combines both, "steady mirror polishability" and "high toughness". The mold steel for general purpose equips with characteristics needed for resin products forming molds.

Mirror Polishability

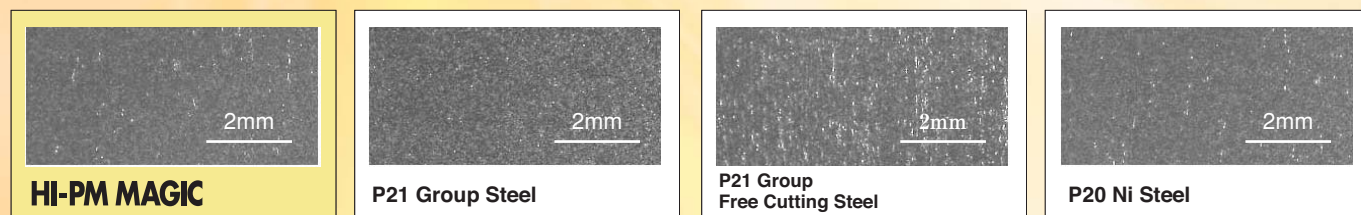
It has steady mirror polishability and supports grit size #3000 polish and #5000 glazing.



Differential interference figure comparison of #5000 mirror polished surface (2 x 2 sequential photographs)

Electric Discharge Machinability

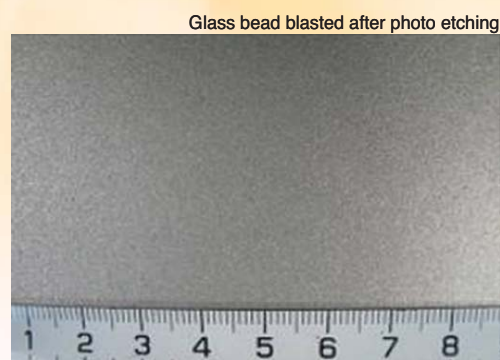
Comparatively uniform electric discharge machined surface can be gained, as well as is relatively soft surface, so post-processing is easy.



Comparison of electric discharge machined surface

Crepability

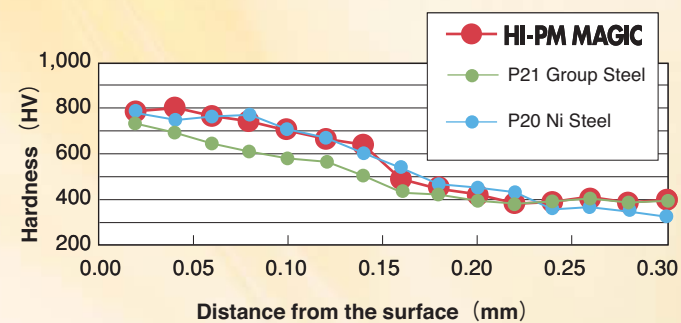
It has good crepability.



Example of precise creping

Nitriding Property

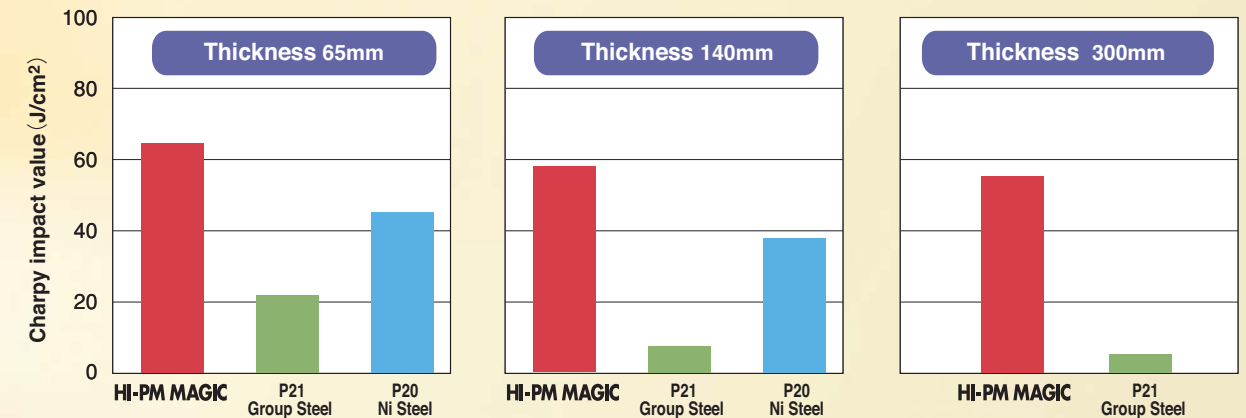
It has good nitriding properties.



Nitriding property (540°C x 5h gas nitrocarburizing process)

Toughness

Properties in comparison with the conventional prehardened steel are that it is extremely tough, and gives little difference in material dimensions. It is also suitable for big molds, and there are few worries about unexpected damage to the mold.

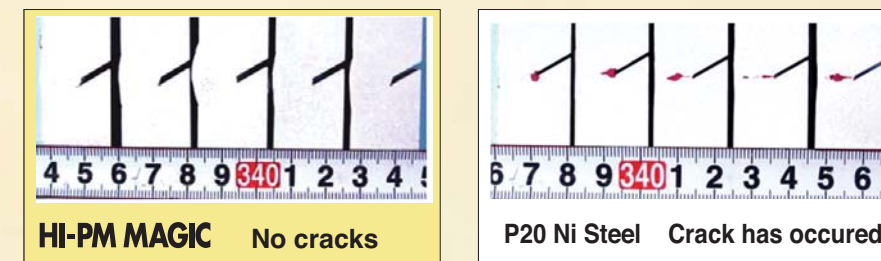


Comparison of 2mmU notch Charpy impact values, classified by material dimensions (example of measurement by our company)

Weldability

The susceptibility of weld cracks is low. The hardness of welded part does not become high, and so welding application and post-processing are easy, and uniform finishing is allowed.

Susceptibility of weld cracks



Penetrant indication after Y-groove weld cracking test

- [Welding conditions]
- JIS-Z3158 Y-groove weld cracking test
 - Welding Process : TIG welding
 - Welding Rod : Die material
 - Welding Current : Direct current 140A
 - Ar Gas Flow Rate : 8 L/min
 - Preheating : 180 °C
 - Post-Heating : None

Polish characteristics after welding

Unevenness does not occur easily in the process of the mirror surface polishing and creping after welding.

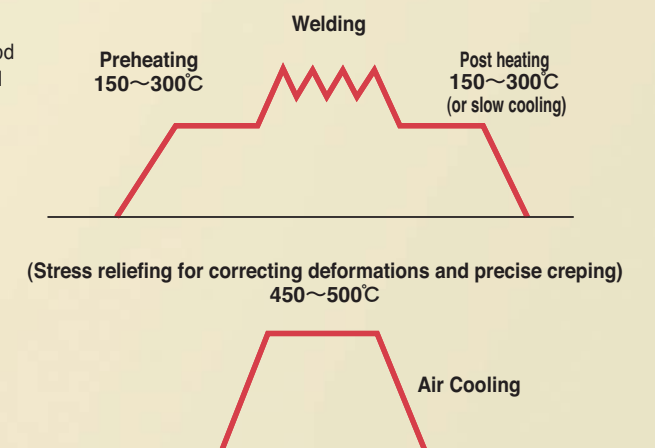


Differential interference micrographs comparison of the polish surface after welding

- [Welding conditions]
- Welding Process : TIG
 - Welding Rod : The welding rod for each steel grades
 - Welding Current : 80 to 120A
 - Ar Gas Flow Rate : 10 L/min
 - Preheating : 250°C
 - Post Heating : 400°C

Welding application line chart

Usage of HI-PM MAGIC-W welding rod is recommended.



HI-PM MAGIC allows application of high-speed high feed processing conditions. Reduction of working time in mold production is expectable.

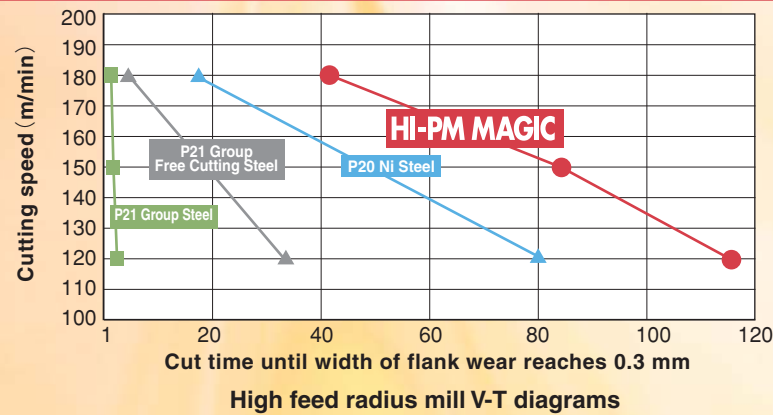
Machinability

It has excellent machinability, especially under conditions with higher ejection volume of cutting chips (high efficiency), such as high feed processing.

Cutting Volume (cm ³ /min)	Example of processing method (Tool)	Steel Grade			
		HI-PM MAGIC	P21 Group Steel	P21 Group Free Cutting Steel	P20 Ni Steel
>10	Face milling cutter, high feed radius mill	A	D	C	B
1-10	Solid high feed end mill	A	C	B	B
0.1-1	High-speed steel drill, solid ball end mill	B	A	A	C
0.01-0.1	High-speed steel drill, small end mill	B	A	A	C

A (Excellent) ⇔ D (Poor)

High feed radius mill In comparison with the conventional steel, it is possible to achieve significant improvement in cutting efficiency.



End mill Little damage on the tool at high-speed and at big load conditions is also a strong point.

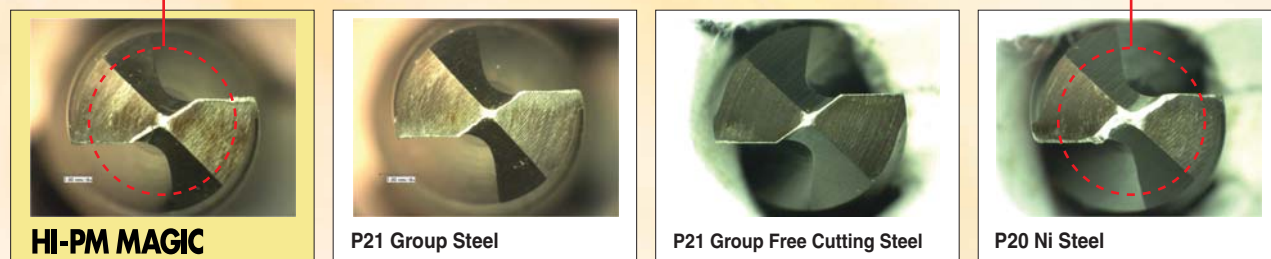


[Cutting conditions]
 • Processing model : Vertical type machining center (BT40)
 • Tool used : CEPR6080TH (φ 8 - 6 teeth square end mill)
 • Cutting speed : 200 m/min
 • Main axis revolution : 8,000 min
 • Feed per tooth : 0.05 /tooth
 • Cutting depth : 12 (1.5D)
 • Cut width : 0.8 (0.1D)
 • Cutting fluid : Air blow
 • Cutting time : 50 min

Comparative example of tool damage in high load conditions of coating carbide end mill

Drill Please pay attention to the ejection of cutting chips by choosing proper stepped drilling for longer tool life.

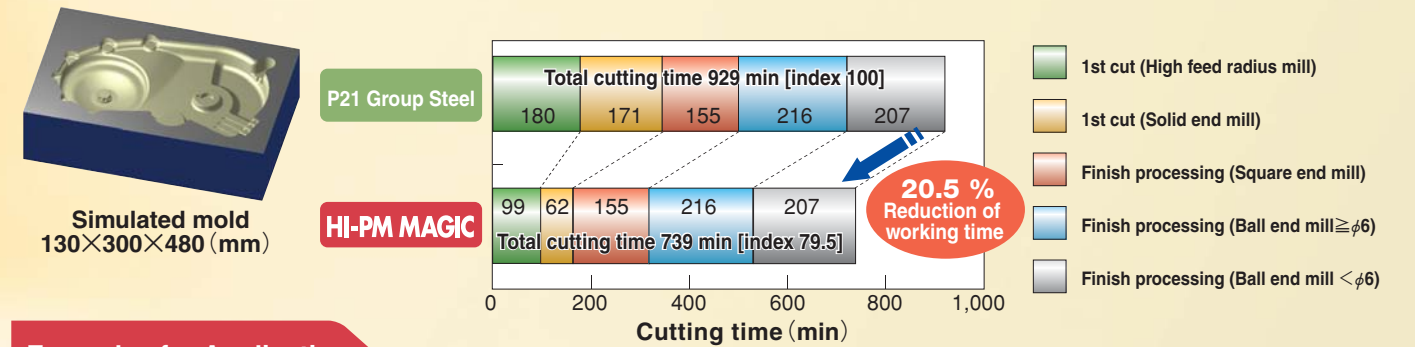
The strong point is that there is little wear in comparison with P20Ni steel



Tool Wear Comparison

[Cutting conditions]
 • Drill : φ 4.9 powder high-speed steel + coating • Hole depth : 25 mm • Number of holes : 100 holes • Cutting speed : 20 m/min
 • Main axis revolution : 1,299 min • Feeding speed : 65 mm/min • Feed per revolution : 0.05 mm/rev • Step feed : 2.5 mm
 • Coolant : water-soluble cutting fluid External oil supply

Example of Trial Calculation of Working Time in Mold Processing



Examples for Application

Usage	Conventional applied steel	Good evaluated properties	Mold external appearance
Molding tool for intake manifolds	P21 Group Steel (40HRC)	<ul style="list-style-type: none"> Good Machinability (20% work improvement) Electric Discharge Machining surface (4 μm surface roughness) Weldability Ease of polishing (working time) 	
Molding tool for copying machine cases and trays	P21 Group Steel (40HRC)	<ul style="list-style-type: none"> Machinability Creepability Weldability 	
Molding tool for rear combi lamp lenses	P20 Group Steel (32HRC)	<ul style="list-style-type: none"> Mirror polishability (easy gloss reproduction) Mirror quality of product Machinability Weldability 	

Mechanical Properties

Steel Grade	Representative example of the tensile test results			
	0.2% Yield strength (N/mm ²)	Tensile strength (N/mm ²)	Elongation (%)	Reduction of area (%)
HI-PM MAGIC	1,020	1,200	18	45

Physical Properties

	Steel Grade	20°C	100°C	200°C	300°C
Thermal conductivity (W/m·K)	HI-PM MAGIC	31.4	34.1	37.7	40.2
	P21 Group Steel	28.5	32.6	36.4	38.7
	P20 Ni Steel	32.4	36.5	39.9	40.8
Thermal expansion coefficient* (x 10 ⁻⁶ /°C)	HI-PM MAGIC	—	11.5	12.3	12.9
	P21 Group Steel	—	12.5	12.8	13.2
	P20 Ni Steel	—	11.2	12.0	12.7
Young's modulus (GPa)	HI-PM MAGIC	206	—	—	—
Density (g/cm ³)	HI-PM MAGIC	7.85	—	—	—

*The average value from 30°C