

FM ALLOY[®]

Mold Steel for Plastic with Corrosion Resistance and Mirror finish-ability

PROVA Series





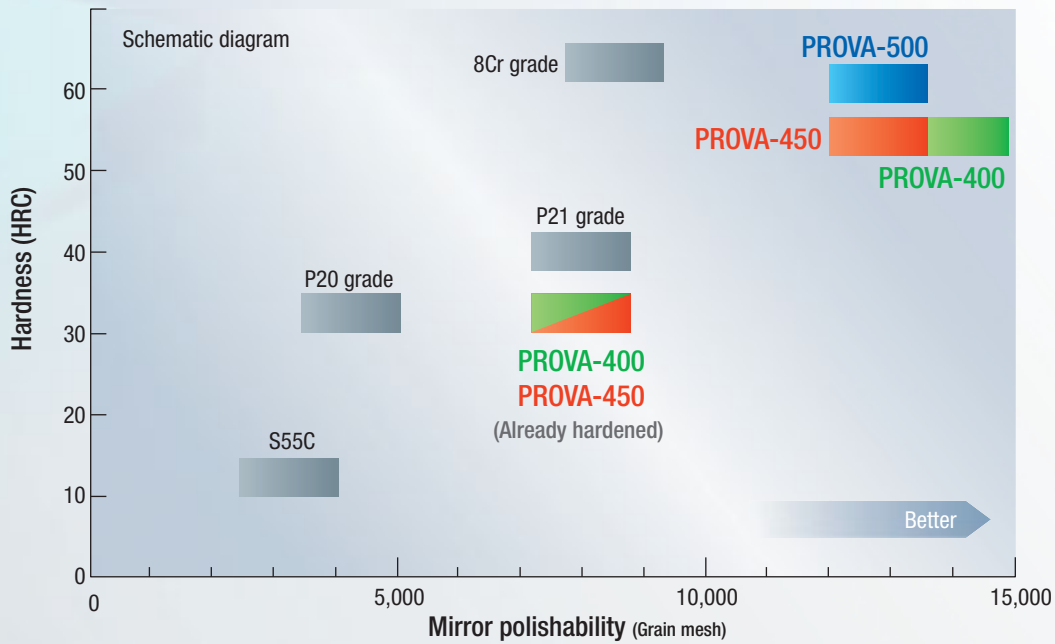
Mold Steel for Plastic with Corrosion Resistance and Mirror finish-ability

PROVA Series

The PROVA series are high quality stainless steels that are the best for molds on plastic molding.

Features	• Excellent mirror finish-ability.
	• Good machinability.
	• Superior corrosion resistance.
	• Good wear resistance.
	• Small deformation by heat treatment.
	• Materials can be provided as already hardened (32HRC).

Relationship



Steel Grade

Grade	Mirror finish-ability	Corrosion resistance	Wear resistance	Cost
PROVA-400	◎	○	○	○
PROVA-450	○	○	○	◎
PROVA-500	○	○	◎	△

Applications

- Mold for plastic with fire-retarding material or PVC which are strongly corrosive **Corrosion Resistance**
- Mold for thermo-setting resin or plastic with glass fiber ... **Wear Resistance**
- Mold for transparent plastics which are used for optical or medical devices **Mirror Finish-ability**
- Mold for high-pressure plastic injection (PROVA-500) **Rigidity**

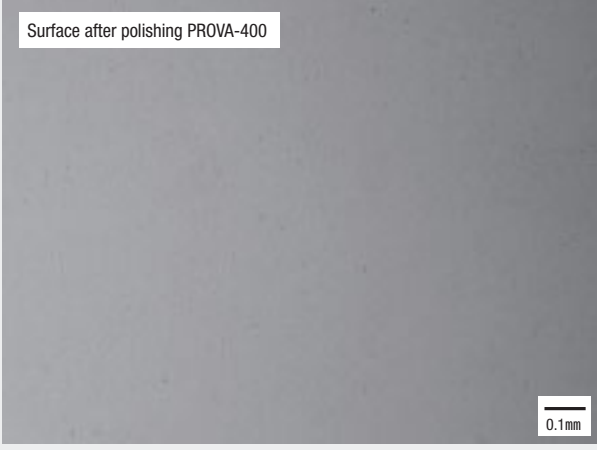
Plastic Material	Examples of finish product
PVC, PS, PE, PF, PC, PMMA, PP, EP, flame resistant materials	Light guide plates, cellular phone enclosure, lense, high-quality plastic containers, and more

PROVA Series characteristics

Mirror finish-ability (PROVA-400)


◆ PROVA series have minimum non-metallic inclusions to show superior mirror like finish.

Example: Polishing the mold for a cellular phone enclosure to a mirror finish



Surface after polishing PROVA-400

0.1mm



Surface after polishing Equivalent material in market

0.1mm

⊘ : pinholes

Sample hardness: 53 HRC, Polishing condition: #1,500 Emery paper → Diamond compound (#2,000 → #3,000 → #5,000)

◆ Mirror surface polishing procedure (example)

- 1 Oil stone (using kerosene)..... #180 → #240 → #320 → #400 → #600 → #800
↓
- 2 Sandpaper (using kerosene)..... #600 → #800 → #1,000 → #1,200 → #1,500
↓
- 3 Diamond compound #1,200 → #1,800 → #3,000 → #8,000 → #14,000

- Polish with as light a load as possible to reduce unevenness and pinholes on surface being polished.
- When changing grade of abrasive, also change polishing direction 90° and check that no polish marks remain.
- Completely remove all the previous abrasive powder when changing abrasive grades.
- Do not skip any grades of abrasive.
- Only diamond compound can be used.
- Use rust prevention measures when polishing work is interrupted.

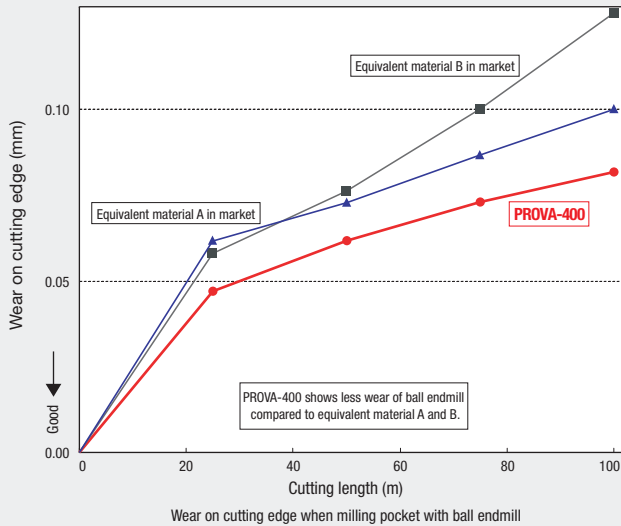
◆ Mirror finish quality

Grade	Hardness (HRC)	Mirror finish quality	Application
PROVA-400	Already hardened 29 to 35	Maximum #8,000	Transparent product
	Hardened/tempered 50 to 53	Maximum #15,000	Ultra-mirror finish product
PROVA-450	Already hardened 29 to 35	Maximum #8,000	Transparent product
	Hardened/tempered 50 to 53	Maximum #13,000	Mirror finish product
PROVA-500	Hardened/tempered 58 to 62	Maximum #13,000	Mirror finish product

Machinability (PROVA-400)

- ◆ Optimized design of components in PROVA series gives it superior machinability, which reduces tool costs and improves automation.

Results of test for machinability with ball endmill



Condition

Cutting tool (Ball endmill): NACHI GS Mill Ball R3 x 9 x 80 x ϕ 6 2GSR3
Cutting speed at cutting point: 42 m/min (RPM: 7900 min⁻¹)
Feed: 920 mm/min (feed rate 0.058 mm/t)
Cutting Depth: cutting depth aa = 0.12 mm x 2 passes, pick feed Pf = 0.3 mm
Cutting Fluid: Water soluble emulsion
Test machine: Matsuura FX-5
Work dimension (test specimen): 40 x 40 x 200 hardened and tempered (53 HRC)

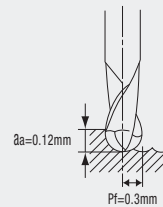
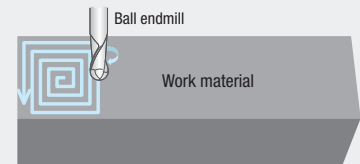


Image of work



Comparison of wear on cutting edge of ball endmill after rough cutting of mold

Condition

Cutting tool: Carbide Ball endmill R3.0 x 12.0, tooth length 12, shank ϕ 6
Cutting speed at cutting point: 81 m/min (RPM 4300 min⁻¹)
Feed: 520 mm/min (feed rate 0.06 mm/t)
Cutting Depth: aa = 0.2 mm, pick feed Pf = 1.5 mm, cut length 19 m



Possible to continue using tool



Excessive damage to cutting edge ends life of tool

- ◆ Surface roughness of PROVA series after grinding is good, which helps shorten lead times.

Comparison of finish quality using ball endmill

Condition

Cutting tool: Carbide Ball endmill R2, tooth length 8, underhead 8, shank ϕ 4, rpm: 20,00 min⁻¹
Feed: 1,600 mm/min, Cutting Depth aa = 0.001 mm, Cutting Fluid: oil mist, machine: YASUDA YBM640V

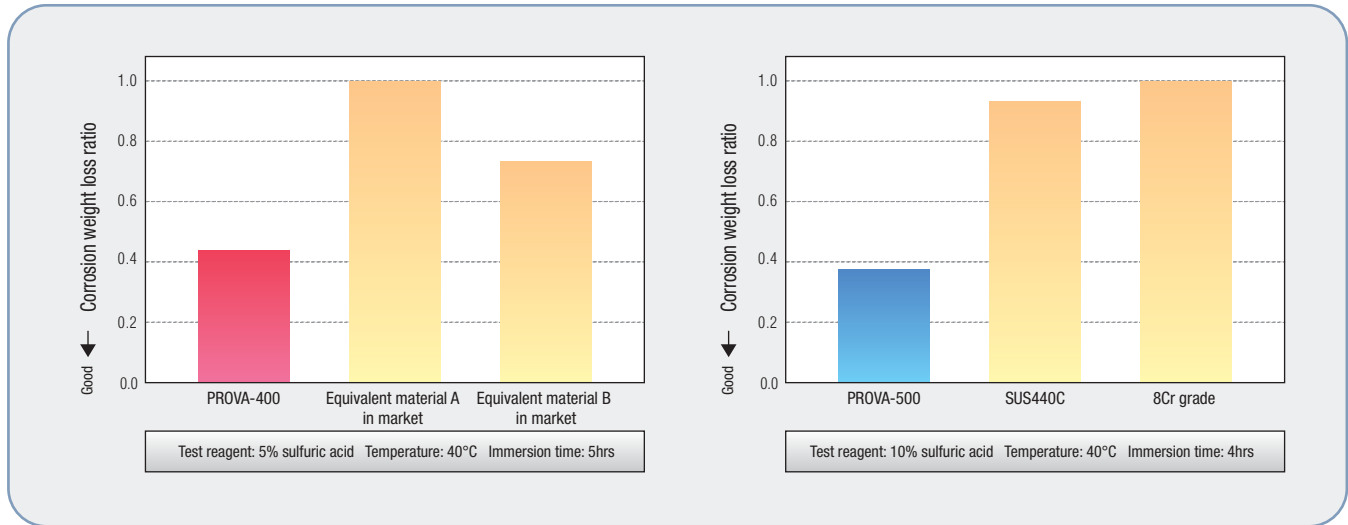
Rt: Maximum cross-section height of roughness curve

Grade	Results of measuring surface roughness	Rt
PROVA-400 (52HRC)		1.7
Equivalent material in market (52HRC)		3.5

PROVA Series characteristics

Corrosion resistance (PROVA-400, 500)

◆ PROVA Series are superior for corrosion resistance.



Cleanliness (PROVA-400, 450)

◆ PROVA series has dramatically reduced non-metallic inclusions.

Non-metal inclusions ranking (ASTM-E45 D reg)

Grade	A sulfide		B aluminum		C silicate		D granular oxides	
	T	H	T	H	T	H	T	H
PROVA-400	0	0	0	0	0	0	0.5	0
PROVA-450	0	0	0	0	0	0	0.5	0.5
Equivalent material in market	0	0	1.0	0	0	0	1.0	0

Physical properties

Grade	Coefficient of thermal expansion (x 10 ⁻⁶ /K)				
	30~100°C	30~200°C	30~300°C	30~400°C	30~500°C
PROVA-400, 450	10.9	11.4	11.8	12.2	12.5

Grade	Coefficient of thermal conductivity (W/m·K)						Specific heat (J/kg·K)
	Room temperature	100°C	200°C	300°C	400°C	500°C	
PROVA-400, 450	20.6 (27°C)	21.6	23.2	24.5	25.4	26.0	455 (27°C)
PROVA-500	16.6 (22°C)	18.1	19.8	21.4	22.5	23.3	443 (22°C)

PROVA-400, 450 : Quenched and tempered (53 HRC) PROVA-500 : Quenched and tempered (61 HRC)

Mechanical properties (PROVA-400, 450)

Tensile strength (N/mm ²)	Elongation (%)	Drawability (%)	Impact resistance (J/cm ²)*
1950	11.8	35.5	49.5

Test material is quenched and tempered (53 HRC) material, φ20 rolled round steel used in rolled direction *Room temperature #4 impact test material (JIS Z2202 mold material impact test)

Welding (PROVA-400, 450)

Status of heat treatment	Weldability	Heating temperatures	
		Pre-heat	Post-heating
Already hardened 29 to 35 HRC	AWS : ER420 (JIS : SUS420J2)	200~250°C	650°C
Quenching-tempering 50 to 53 HRC	AWS : ER420 (JIS : SUS420J2)	200~250°C	250°C×2 (When anti-corrosion is important) 510°C×2 (When breakage during EDM is important)

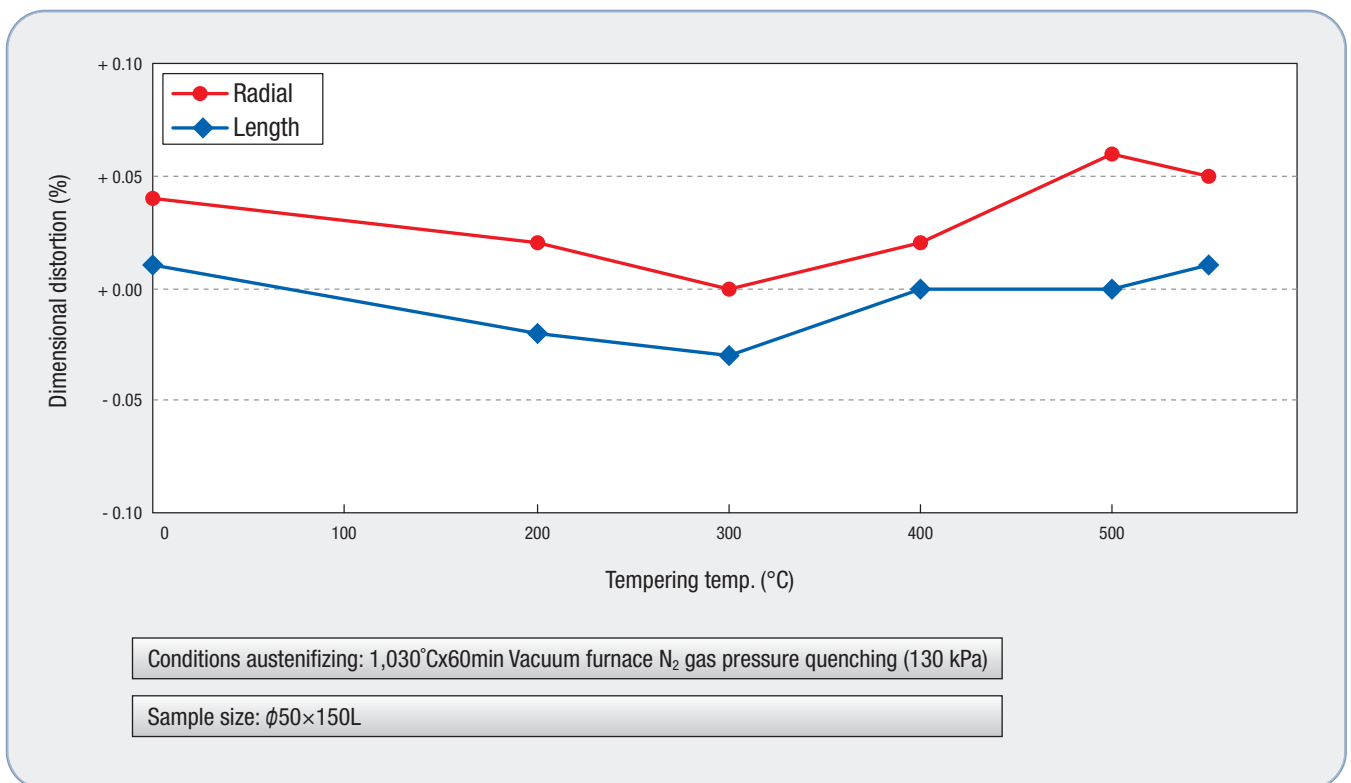
PROVA Series heat treatment

Heat treatment conditions

Grade	Hardening		Tempering		Demand properties
	Pre-heat (°C)	Austenitizing (°C)	Temperature (°C)	Hardness (HRC)	
PROVA-400	600~850	1,000~1,050	200~400	51~53	Corrosion resistance / Low age-deformation
			490~510	51~53	Avoid breaking at electric discharging
PROVA-450	600~850	1,000~1,050	200~400	51~53	Corrosion resistance / Low age-deformation
			490~510	51~53	Avoid breaking at electric discharging
PROVA-500	820~860	1,070~1,120	150~200	60UP	Corrosion resistance / Low age-deformation
			500~550	58UP	Avoid breaking at electric discharging

Dimensional distortion (PROVA-400, 450)

◆ Homogenizing process greatly reduces dimension variations during heat treatment.



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