

# RAKU-TOOL®

## Rapid Prototyping



## Applications

- » **Prototypes**  
Aesthetic models / first prototypes  
Design studies
- » **Functional parts**  
Design verification  
Functionality testing  
Performance testing  
Simulation of series materials
- » **Pilot series**
- » **Small series**

## Advantages of Rapid Prototyping

It saves **time** and **money** in product development.

- » Shortening of development times (time to market)
- » Helps to eliminate costly development and design mistakes
- » Minimizes losses during design changes / product revisions
- » Extends product life cycles through revisions/enhancements and changes during the early product design stages
- » Helps to make product decisions

## Advantages of RAKU-TOOL Rapid Prototyping Systems



- » **Easy and quick imitation of thermoplastics** like polyethylene (PE), polypropylene (PP) as well as acrylonitrile butadiene styrene (ABS). The **use** of RAKU-TOOL Rapid Prototyping Systems **already pays off for small numbers**, since no large investments for tools are necessary.

Thermoplastic systems are processed using an injection molding process which is normally only economically viable when large quantities are produced since the investment for the tools (metal) is very high and set-up costs for low numbers are also very high.

- » **Can be produced in relatively simple plastic molds (epoxy or polyurethane).**
- » **Efficient and rapid production** of samples and small series.
- » **Can be used for small and large parts.**

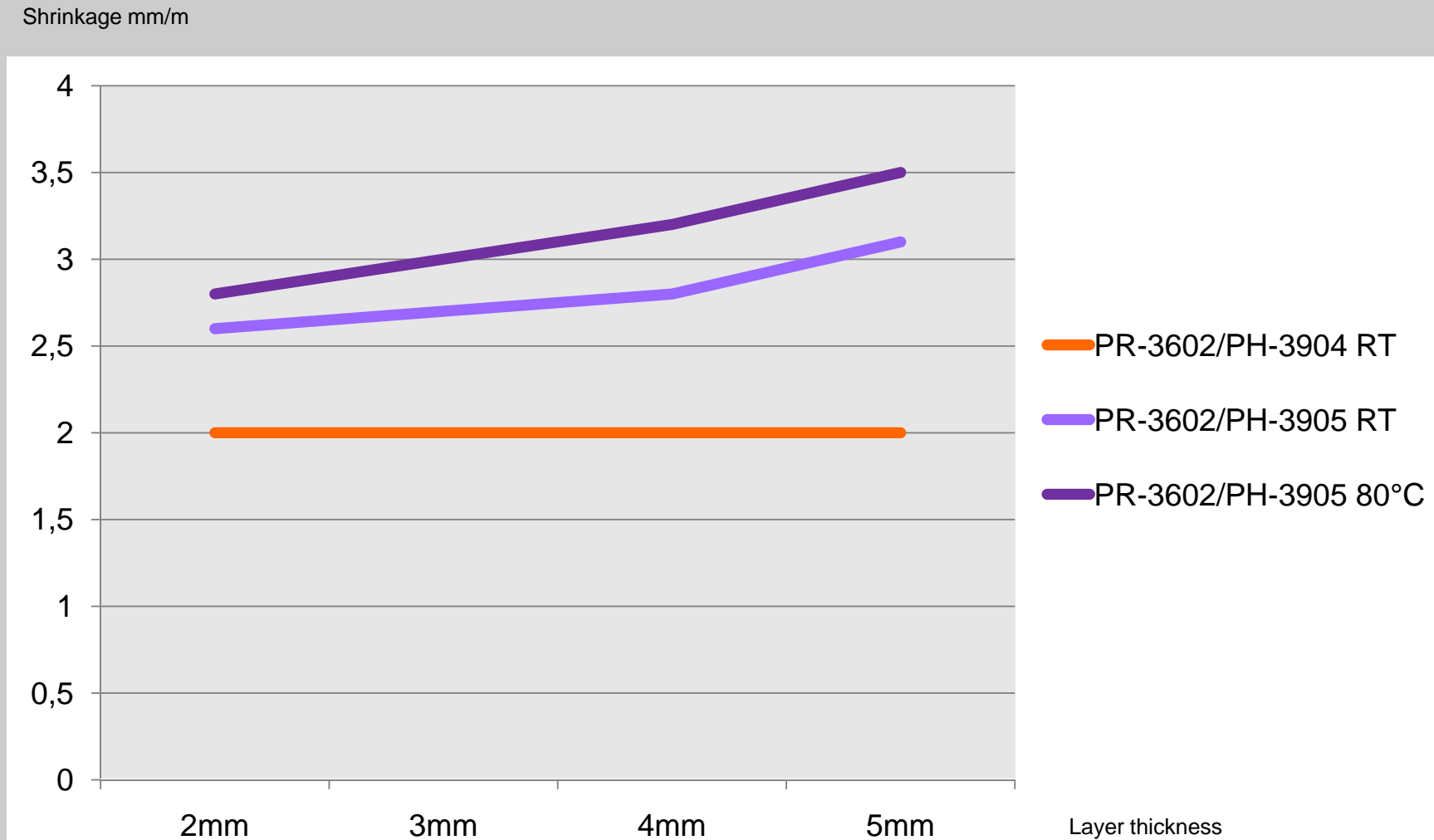
# RAKU-TOOL® Overview

## Polyurethane Prototyping Resins: Core Range



RAKU-TOOL			PR-3600 PH-3900	PR-3600 PH-3904	PR-3602 PH-3904	PH-3602 PH-3905
Simulates			rubber	rubber	PE/PP	PE/PP
<b>Processing data</b>						
Mix ratio	pbw		<b>100:40</b>	<b>100:33</b>	<b>100:80</b>	<b>100:80</b>
Pot life at 25°C	sec		90	90	65	60
Max. layer thickness	mm		4	4	4	4
Demoldable after (RT)	min		15-25	15-25	15-20	10-20
<b>Mechanical properties after cure (cure cycles see individual data sheets)</b>						
Appearance	visual		black	black	black	black
Density	ISO 1183	g/cm <sup>3</sup>	1.14	1.14	1.14	1.14
Shore Hardness	ISO 868		80-85 A	65-70 A	65-70 D	70-75 D
Deflection temperature (HDT)	ISO 75	C°	-	-	50-55	85-90
Tensile strength	ISO 527	MPa	8-10	7-9	20-25	25-30
Elongation at break	ISO 527	%	100-150	380-430	70-75	20-25
Flexural strength	ISO 178	MPa			30-35	35-40
Flexural modulus	ISO 178	MPa			700-800	800-900
Linear shrinkage		mm/m			2	2,7
Impact strength charpy edgewise	ISO 179-1/1eU	KJ/m <sup>2</sup>			165-170	70-75
Tear strength	DIN 53515	N/mm	9-10	13-18		
Abrasion	Taber	mm <sup>3</sup> /100R	30-35	23-28	30-35	50-55

# Shrinkage Overview – RT and post cure at 80°C



# RAKU-TOOL® Overview

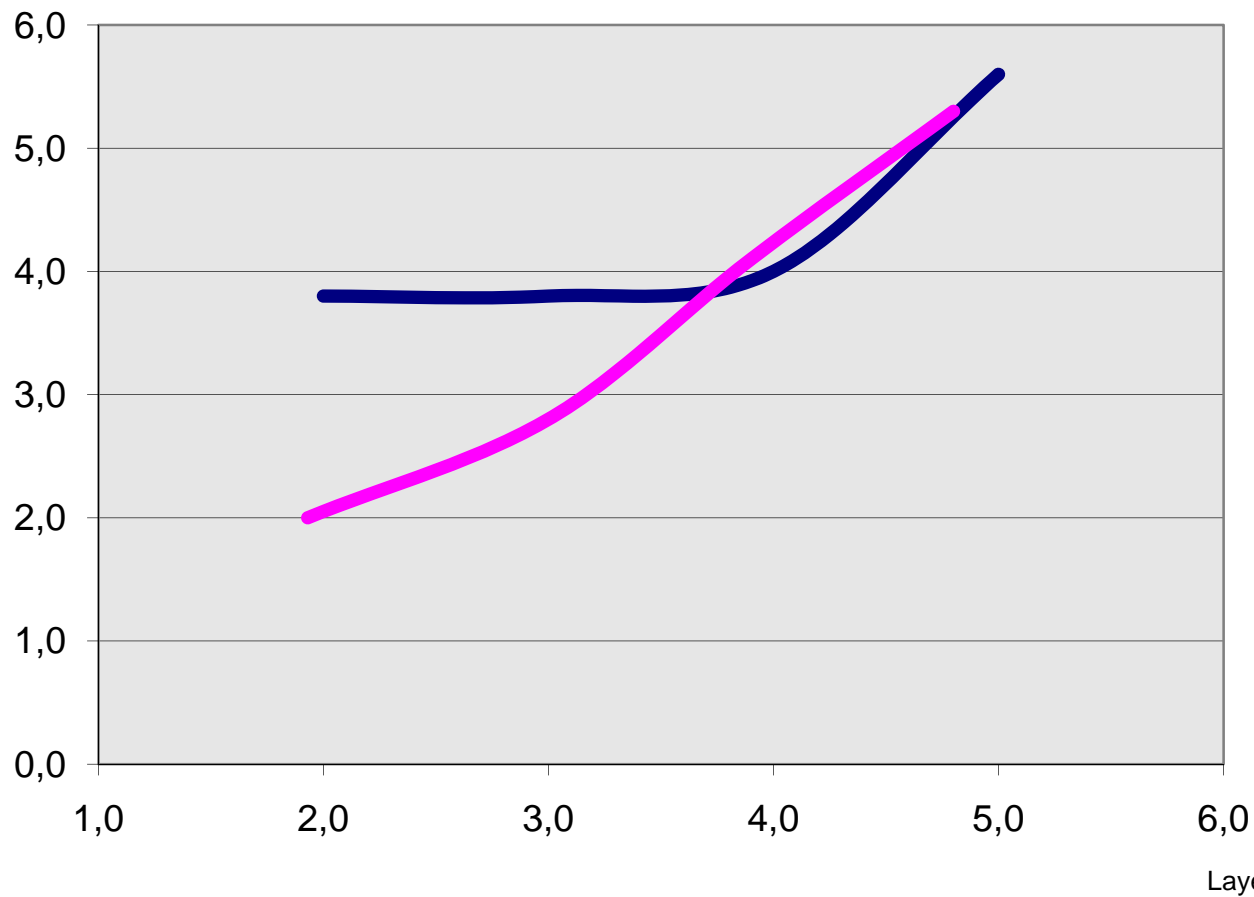
## Polyurethane Prototyping Resins: Core Range



RAKU-TOOL			PR-3603 PH-3904	PR-3603 PH-3905	PR-3608 PR-3905	PR-3652 PH-3905	PR-3654 PH-3905
Simulates			PP/ABS	PP/ABS	PP/ABS	ABS/PP	ABS/PP
<b>Processing data</b>							
Mix ratio	pbw		100:80	100:80	100 : 80	100:68	100:55
Pot life at 25°C	sec		50-60	50-60	50-60	50-60	50-60
Max. layer thickness	mm		4	4	4	4	4
Demoldable after (RT)	min		15-20	15-20	10-20	10-20	10-20
<b>Mechanical properties after cure (cure cycles see individual data sheets)</b>							
Appearance	visual		black	black	black	black	black
Density	ISO 1183	g/cm <sup>3</sup>	1.17	1.2	1.19	1.27	1.35
Shore Hardness	ISO 868		75-80 D	70-75 D	75-80	75-80 D	80-85 D
Deflection temperature (HDT)	ISO 75	C°	65-70	75-80	130-135	128-133	128-133
Tensile strength	ISO 527	MPa	25-30	30-35	38-43	35-40	38-43
Elongation at break	ISO 527	%	20-25	38-43	10-15	6-8	6-8
Flexural strength	ISO 178	MPa	45-50	48-53	55-60	65-70	68-73
Flexural modulus	ISO 178	MPa	1200-1500	1100-1400	1200-1500	1500-1800	2000-2400
Linear shrinkage		mm/m					
Impact strength charpy edgewise	ISO 179-1/1eU	KJ/m <sup>2</sup>	70-80	65-75	40-45		
Tear strength	DIN 53515	N/mm					
Abrasion	Taber	mm <sup>3</sup> /100R					

# Shrinkage Overview – post cure at 80°C

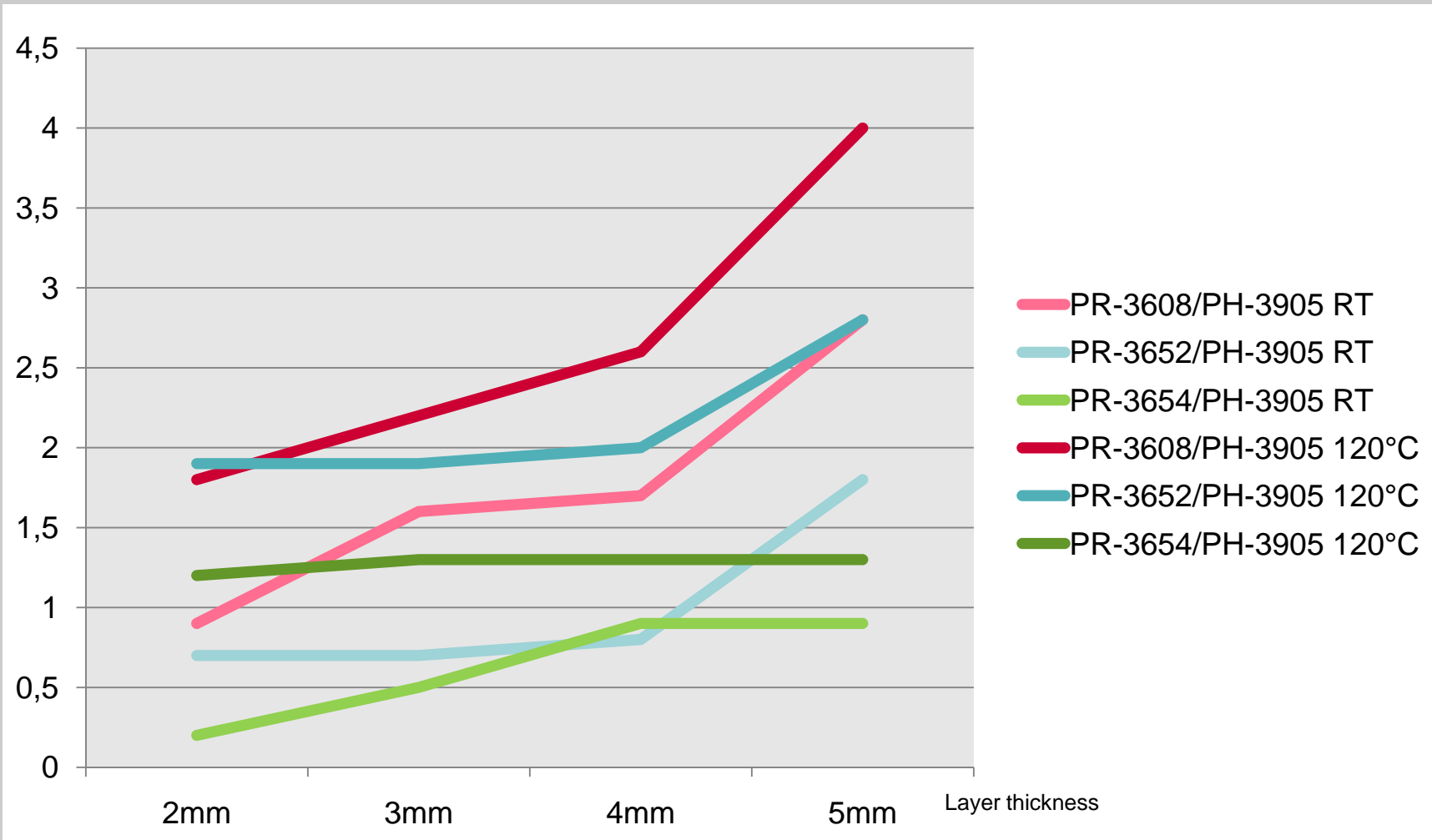
Shrinkage mm/m



# Shrinkage Overview – RT and post cure at 120°C



Shrinkage mm/m



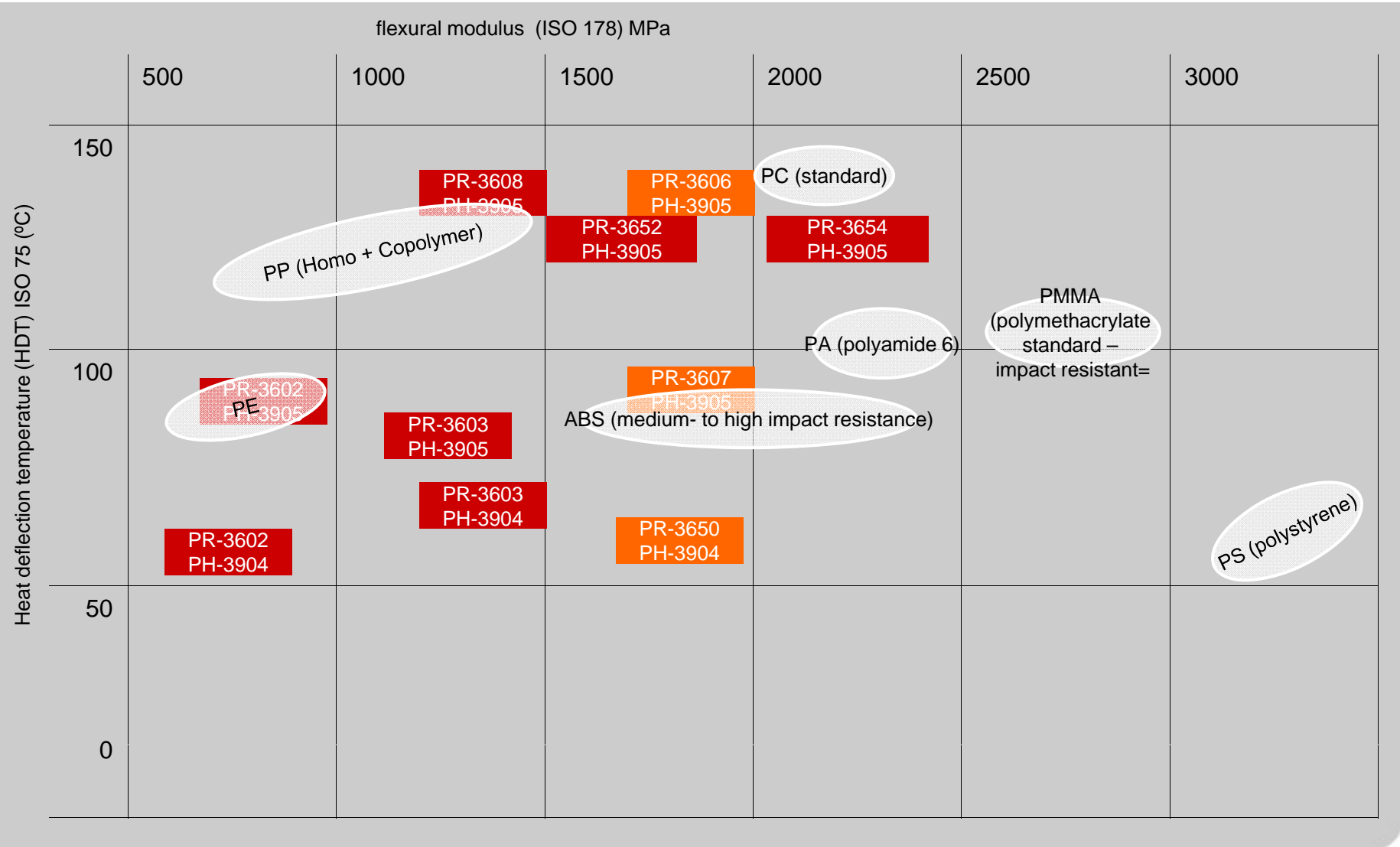
# RAKU-TOOL® Overview

## Polyurethane Prototyping Resins: B Range



RAKU-TOOL			PR-3606 PH-3905	PR-3607 PH-3905	PR-3650 PH-3904
Simulates			ABS/PP	ABS	PE/PP
<b>Processing data</b>					
Mix ratio	pbw		100:100	100:65	100:65
Pot life at 25°C	sec		65	60	70-80
Max. layer thickness	mm		4	4	4
Demoldable after (RT)	min		15-20	10-20	15-25
<b>Mechanical properties after cure (cure cycles see individual data sheets)</b>					
Appearance	visual		black	beige	beige
Density	ISO 1183	g/cm <sup>3</sup>	1.18	1.26	1.16
Shore Hardness	ISO 868		80-85 D	75-80 D	70-75 D
Deflection temperature (HDT)	ISO 75	C°	130-135	85-90	55-60
Tensile strength	ISO 527	MPa	50-55	45-50	24-26
Elongation at break	ISO 527	%	10-15	10-15	35-40
Flexural strength	ISO 178	MPa	85-90	75-80	40-43
Flexural modulus	ISO 178	MPa	1800-2000	1800-2000	900-1000
Linear shrinkage		mm/m	1,5		
Impact strength charpy edgewise	ISO 179-1/1eU	KJ/m <sup>2</sup>	35-40	35-40	58-63
Tear strength	DIN 53515	N/mm			
Abrasion	Taber	mm <sup>3</sup> /100R	60-65	40-45	70-75

# Search diagram (properties of the thermoplastic to be imitated)



## Mold Costruction

» **Known build-up methods (lay-up/shell structure/milling) can be used**

- **Mold material: epoxy/polyurethane/board material or close contour casting**
- **Molds do not have to be heated up.** When parts with a wall thickness  $>6\text{mm}$  are used the molds must be heated up to ca.  $70\text{-}75^{\circ}\text{C}$ , e.g. in a fan oven. This measure compensates for any sink marks as the cure works from the outside inward, a way of „pressure gelling“. Preliminary tests regarding shrinkage should be carried out. Systems and semi-finished products with a higher heat resistance should preferably be used.

## Mold Construction

- » **Mold surfaces must be completely sealed**, tiniest air bubbles (pin holes) may lead to flaws in the final part as the air expands during the reactivity of the resin.
- If board material with a density of less than  $1.0 \text{ g/cm}^3$  is used, the mold surface must be sealed (micro porosity).
  - Metal-sprayed surfaces (e.g. TAF A 400) are not suitable. These are micro porous and contain too much air between the individual metal particles which leads to surface flaws in the final part.



## Mold Construction

- » **Molds must be well reinforced**, the surface pressure when using an injection pressure of ca. 0.8 bar is very high
- » **Gating and ventilation should be inserted into the parting line if possible**  
= easier to demold, no damage to the mold
  - if possible, put a thin exhaust around the parting line (15 x 0,2mm)



## Pre-treatment

- » Release agents containing water should not be used as the water does not aerate at room temperature and leads to foam formation with polyurethanes.
- » When solvent containing release agents are used, let the solvents aerate well, especially in corners and indentations of the mold as this can otherwise lead to foam formation within the part due to evaporating solvents.
- » Normal wax containing release agents should be lightly brushed up if possible.
- » Recommended release agents: RAKU-TOOL AC-9102/AC-9103, preferably **AC-9102** for standard applications.
- » When semi-permanent release agents are used the manufacturing instructions **must be observed**.

## Processing

- » Material to be heated up to RT (18-23°C) before use
- » Mix/metering equipment to be heated up to RT (18-23°C)
  - material temperatures that are too low increase the viscosity and change the set mixing ratio on the meter, mix and dispensing equipment (change in quality)
- » The polyol must be stirred/shaken before it is put into the machine
  - The material contains damp protection which settles. If the damp protection has not been stirred/shaken well it will lead to foaming
- » Before work commences the polyol must also be stirred or recycled in the machine.



## Processing

- » Injection nozzle to be held as blunt as possible, not to be inserted too much into the gating, avoid swirling of material in gating (air bubbles)
- » A little bit of material must be passed through the mixer outside of the mold before casting into the mold. This will flush any air out of the mixer.
- » Cast as slowly as possible, low output. Observe the pot life.
- » Material overlaps = air entrapment. This should be avoided.
- » Continue casting as long as possible, to flush through any remaining air.



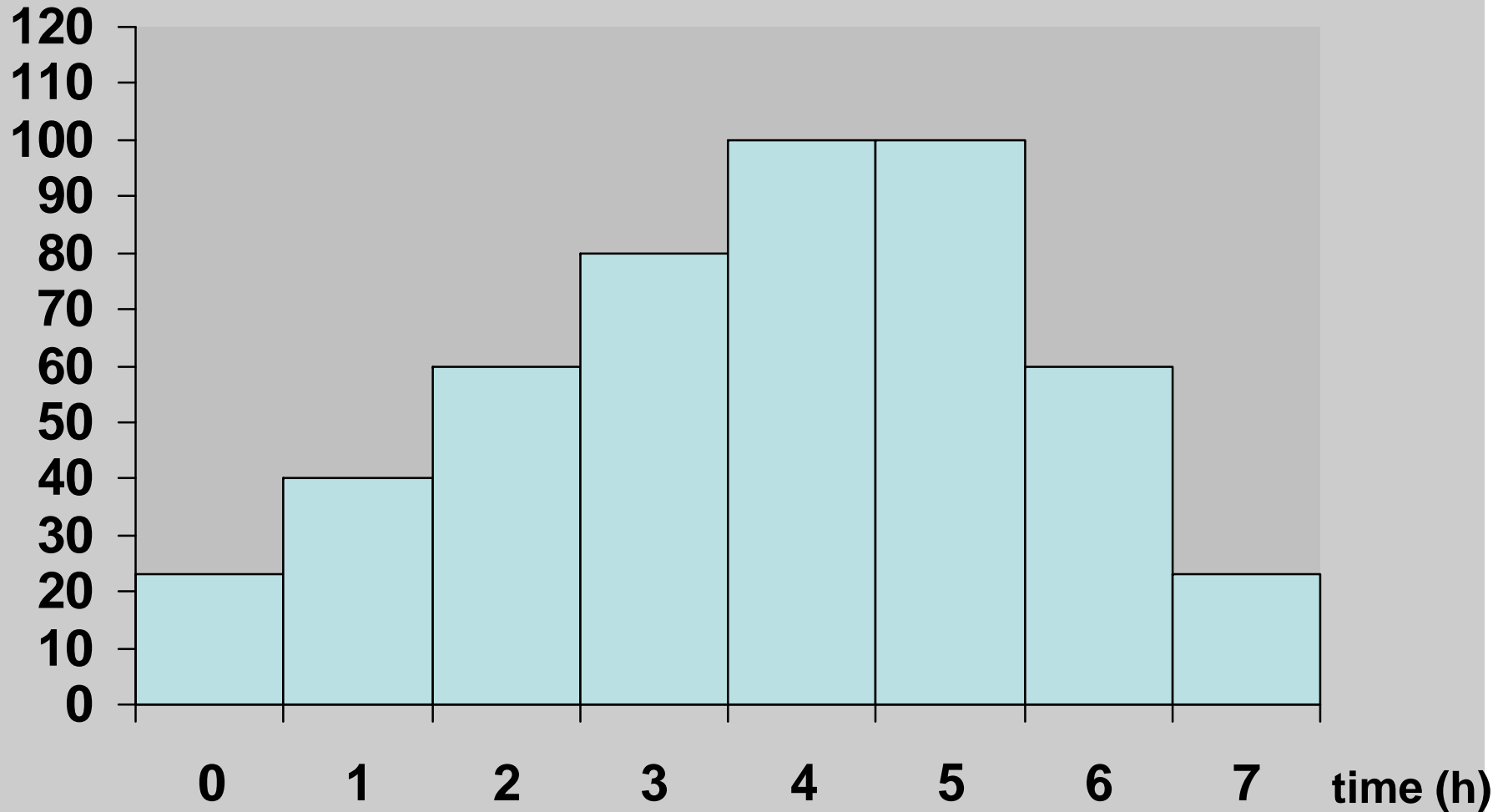
## Thermal post cure

- » The mechanical properties can be improved through a post cure.
- » Higher temperature resistances can only be obtained through a post cure
  - parts to be post cured in a fan oven on a supporting structure
  - after post cure parts need to be cooled down slowly

# Temperature curve RAKU-TOOL® PR-3606 / PH-3605 Polyurethane Prototyping Resin



temperature (C°)



A supporting structure should always be used during the post curing process.

# Problem Scout

Problems with the part	incorrect mix ratio	components have not been mixed correctly	curing temperature too low	curing temperature too high	air humidity is too high	incorrect mold construction	incorrect storage	incorrect pre-treatment	polyol has not been stirred	mold is damp	Too few vents in mold
cure too slow	▼		▼								
pot life too short	▼			▼							
tacky surface	▼		▼		▼						
poor shore hardness	▼	▼	▼								
foaming					▼		▼	▼		▼	
not fully cured bubbles or lines		▼							▼		
brittle			▼				▼				
air bubbles					▼	▼		▼			▼
surface foam					▼			▼	▼	▼	▼
foam within the part					▼		▼	▼	▼	▼	
high shrinkage				▼			▼				
part sticks to the mold	▼	▼						▼			
single component has crystallised							▼				
skin formation on single component					▼		▼				
sedimentation of single component									▼		

## Application example

www.rampf-gruppe.de

Production aid:  
Paint/assembly protection  
door sill

made out of:

**RAKU-TOOL**<sup>®</sup>

**PR-3650 / PH-3904**

Properties:

- » imitates PE / PP
- » high impact strength
- » fast demold time



## Application example

Blanking frame  
for oil ventilation grill

made out of:

**RAKU-TOOL**<sup>®</sup>

**PR-3602 / PH-3905**

Properties:

- » imitates PE / PP
- » fast demold time
- » good impact strength
- » temperature resistant

