TORAY

Innovation by Chemistry

Dolder Seminar

Resins for Automotive Applications, part 1

Date: 26. September 2019

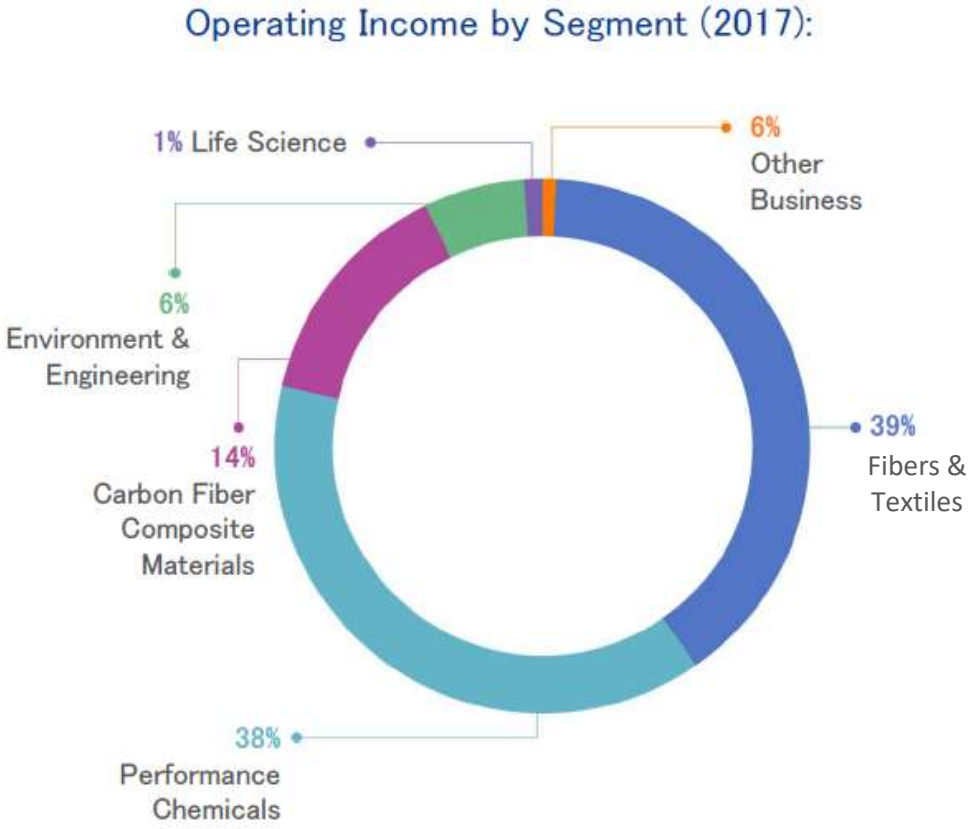
Toray Resins Europe GmbH

Mr. Ingo Maier

Agenda

- About TORAY
- TORAY - Global Resin Business
- TORAY - Resins for Automotive Applications

Facts & Figures



TORAY

Key Figures Fiscal Year 2017/2018

Name	**Toray Industries, Inc. (Tokyo, Japan)**
Established	**January 1926**
Net sales	**20.7 billion USD / 17.5 Milliarden €** (Year ended in March 31, 2018)

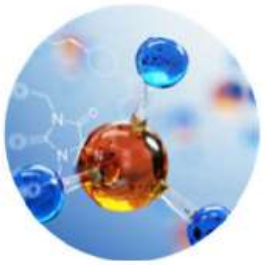
Geographic Segments

	Employees	Companies	Sales (USD bn)
Japan	18,215	100	9.5
International	27,547	157	11.2
Consolidated	45,762	257	20.7

Extensive Competence in Material Technologies

Toray offers material technology for a broad range of applications and comprises five business segments:

Fibers & Textiles:
all three mayor synthetic fiber groups



Performance Chemicals:
plastics and chemicals for a wide range of applications

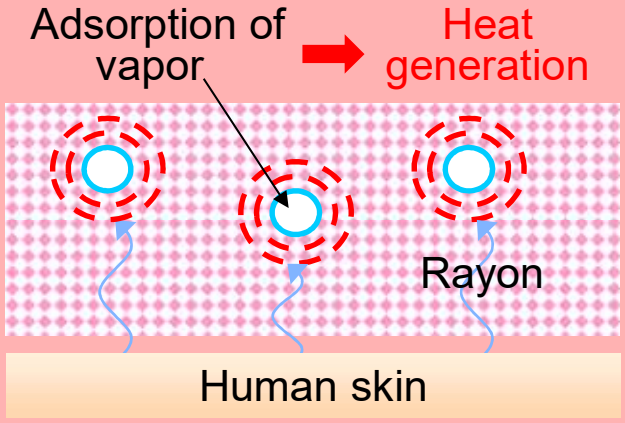
Carbon Fiber Composite Materials:
world's largest manufacturer of PAN-based carbon fibers

Environment & Engineering:
construction materials, engineering equipment and water treatment membranes

Life Science:
medical products, pharmaceuticals and bio-tool products

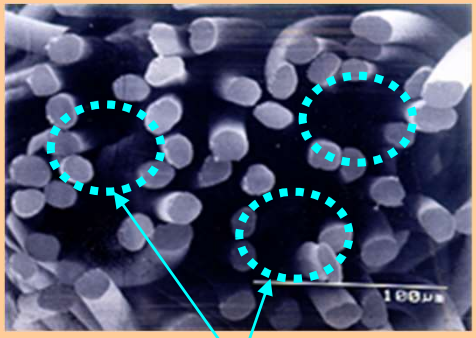
Challenge to ultimate : Comfortability

Moisturization / Heat generation



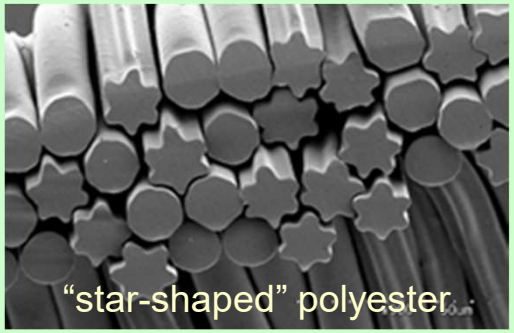
Rayon fiber can trap vapor from human skin and generate heat (moist heat generation)

Thermal insulation



Small space between acrylic fibers

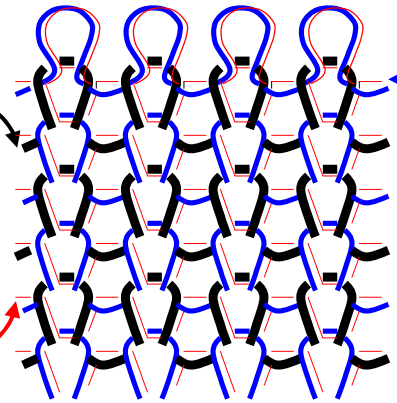
Easy to dry



“star-shaped” fiber can diffuse vapor and sweat to lessen unpleasant feeling

Mixture of staple fibers

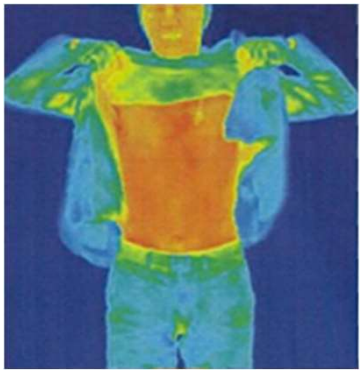
Elastic polyurethane fiber



Textile of「HEATTECH ®」

UNIQLO LifeWear

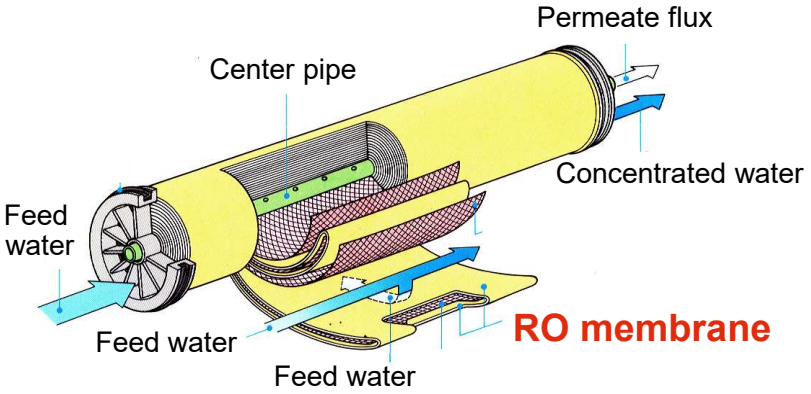
HEATTECH JAPAN TECHNOLOGY



「HEATTECH ®」is trade mark of First Retailing company

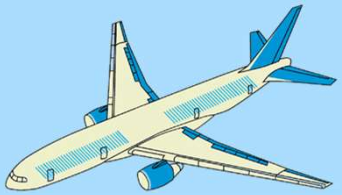
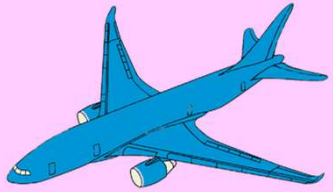
Water Treatment Business

RO element of Toray



Desalination capacity:
140 kton/day, drinking water for people of 560,000

Contribution of carbon fiber to aircrafts

Application	Boeing 767('82)	Boeing 777('95)	Boeing 787('11)
			
: Composite Parts	Ladder/Spoiler 	Stabilizer Floor Beam 	Main Wing/Fuselage/ Stabilizer 
CFRP ratio	2%	12 %	50 %
CF volume	1.5 ton	10 tons	35 tons

Boeing 787

- More than 1200 best seller, and more than 500 currently shipped
- 3 Japanese Heavy Industries produce 35% of 787 parts - Made with JAPAN -
- Update design and manufacturing Scheme
- Improve 20% fuel efficiency, Reduce 30% maintenance cost

Open Innovation Hubs for Expanding Business in Growth Fields

(Automotive/aerospace development hub) Completed in 2009

(Environment/energy development hub) Completed in 2011

Automotive Material Strategic Planning Dept.

Strategy/planning collaboration

A&A Center

Site: Nagoya

E&E Center

Site: Seta

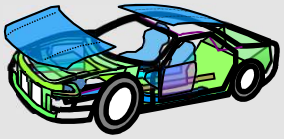
Strategy/planning collaboration

Global Environment Business Strategic Planning Dept.

Automotive and aerospace

Automotive/aerospace

- Structural materials and CFRP
- Exterior/interior materials and finishings NANOALLOY® resin, decorative film electronics materials

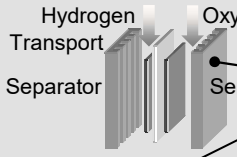


Wind power

- CFRP blades

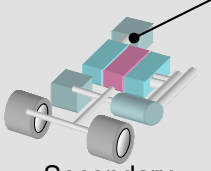
Common areas

HV, PHV, PHV, EV, FCV, HV



Fuel cell/LIB

- Electrode materials and electrolyte membranes
- Separators, positive/negative materials



Secondary battery

Interior material

Biomass materials

Living environment energy efficient materials

Materials to reduce heat loss at home

Environment and energy

PV cells

- Backsheet, encapsulants

Residential fuel cell (stationary)

Confidential

TORAY

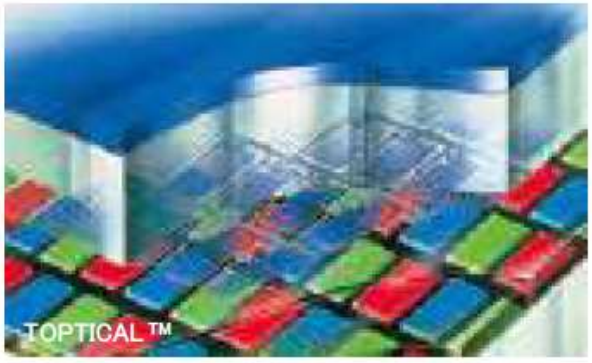
Performance Chemicals

As an integrated chemical company, Toray is involved in production process from the raw material to the end product. Performance Chemicals in Europe include:

Resins and chemicals

Films

Electric and Information Material

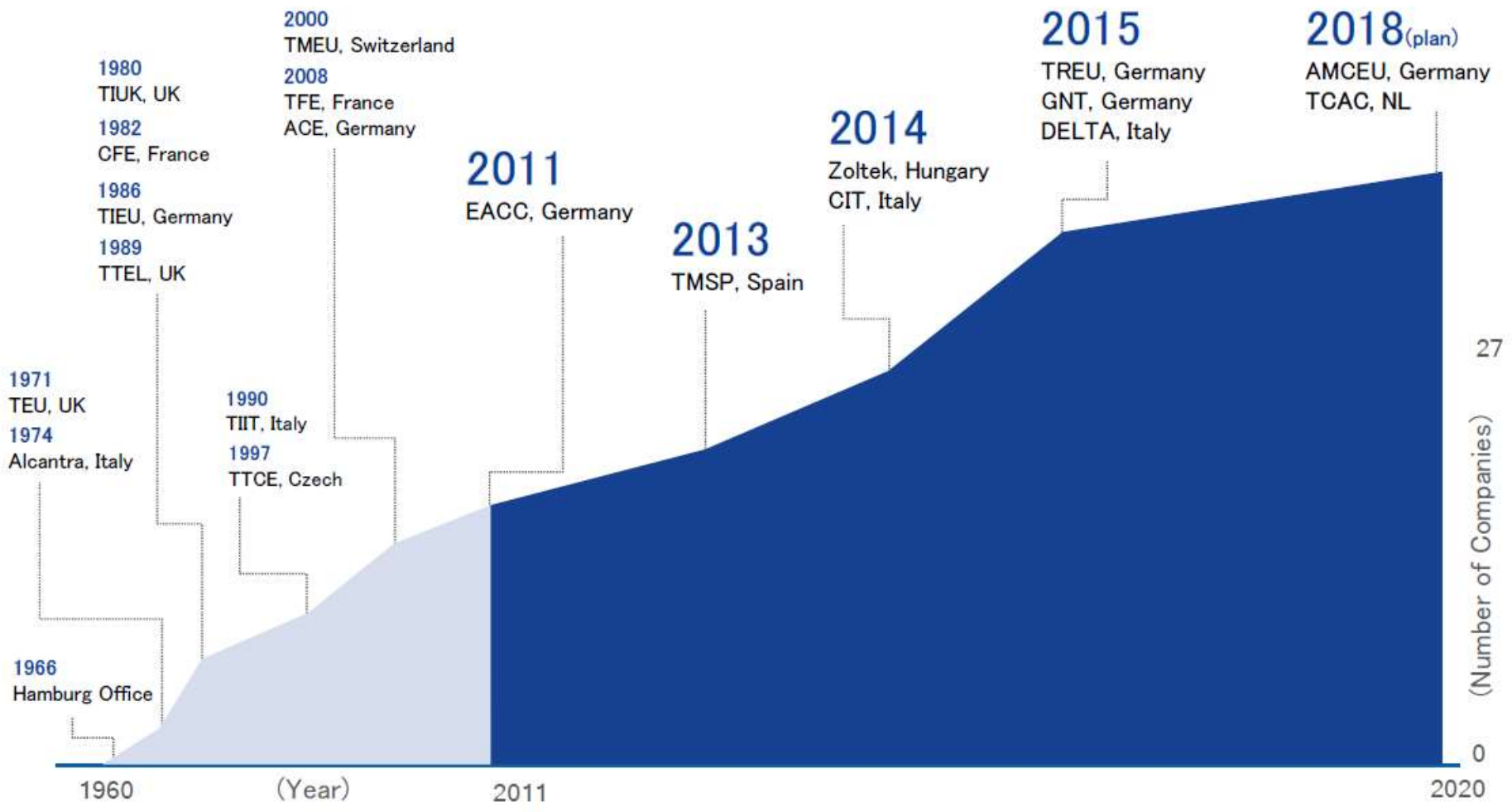


Toray´s Presence in Europe

Toray has been an active player in the European market for years and is strengthening its presence

TORAY

Toray in Europe: A History of Growth



TORAY

TORAY - AMCEU


ultrasuede

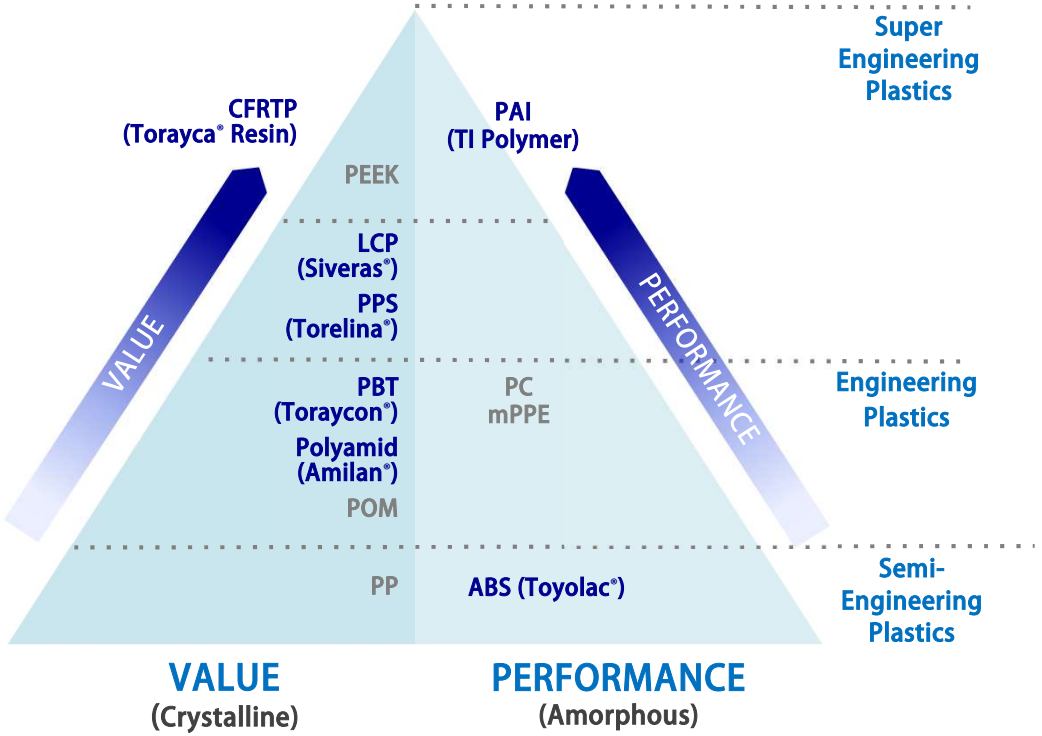

ultrasuede
Gewichtsreduzierung
Weight reduction


Powertrain
Antriebsstrang
Powertrain


"SYNTHEFIBER™ NT" Schalldämmendes Material mit Nanofaser-Vliesstoff

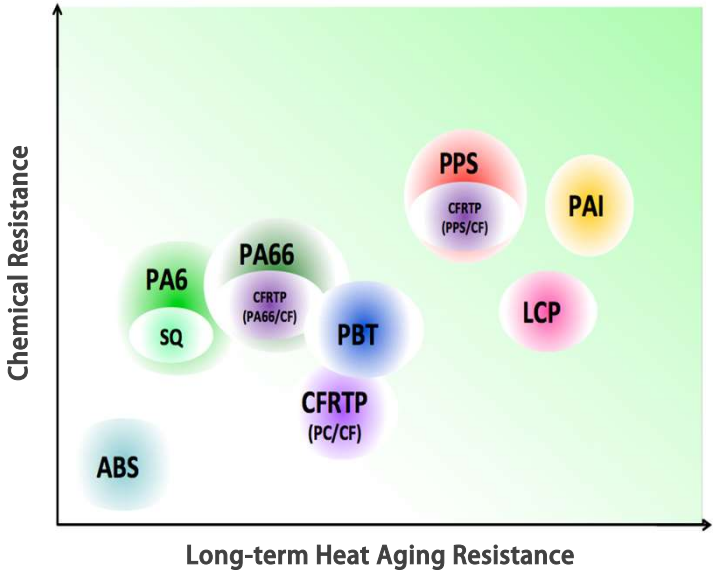
TORAY Resins

Range of TORAY Plastics



Toray Products (brand names in brackets) Other Products

Broad Portfolio of Engineering Plastics



TOYOLAC. ABS Resin

Amilan. Nylon Resin

SIVERAS. LCP Resin

TORAYCA Carbon Fiber Reinforced Thermo Plastics

TORAYCON. PBT Resin

TORELINA. PPS Resin

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TORAY Resins – PPS Portfolio

	Unreinforced	GF30	GF40	GF+MD	
Cross-Linked		*Standard* A503X05 *High Flow* A503F1	*Standard* A504X90 *Low Flash* A504X95	*High Flow* A504FG1 *High Rigidity* A505D7	*Standard* A310MX04 *High Flow* A400MX01	*CTI Rank 2* A310E
Linear	*Unreinforced* A900		*Standard* A604 *Low Flash* A604X95	*Low Chlorine, High Toughness* A604L02	*Standard* A610MX03 *Low Chlorine* A625HL01	*Low Flash, High Flow* A610MG1
Tough	*Unreinforced* A670SE1B *Unreinforced* A670T05	*High Impact* A673MTB	*High Impact, Heat Cycle Resistance* A674MTB		A675GS1	*Heat Cycle Resistance, High Flow* A575W20
Specialized		*High Tribological Property* A514 *CF30% Reinforced* A630T30	*Antistatic* A515	*Antistatic* A756MX02 *High Heat Dissipation, Conductive* H501	*High Heat Dissipation, Insulated* H718L	*CTI Rank 0* A660HVB *Good Epoxy Adhesion* A610EA1

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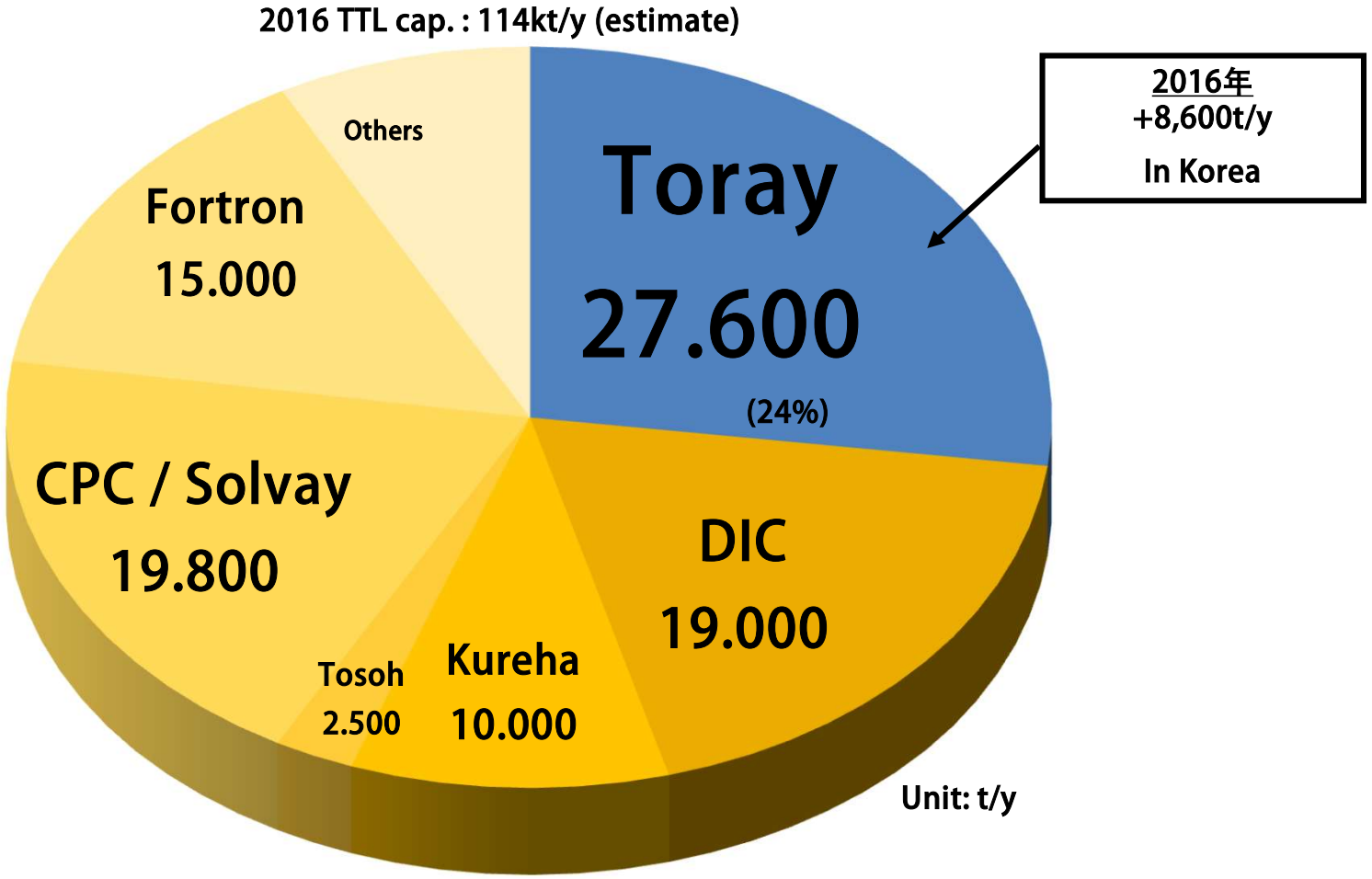
Polymer Production Capacity

Polymer	Brand	Polymer Capacity	
ABS	TOYOLAC™	402.000	t/a
PA	Amilan™	54.000	t/a
PBT	TORAYCON	54.000	t/a
PPS	TORELINA	(2016) → 27.600	t/a
LCP	SIVERAS	2.000	t/a
Polyolefin Foam	TORAYPEF	7.000	t/a

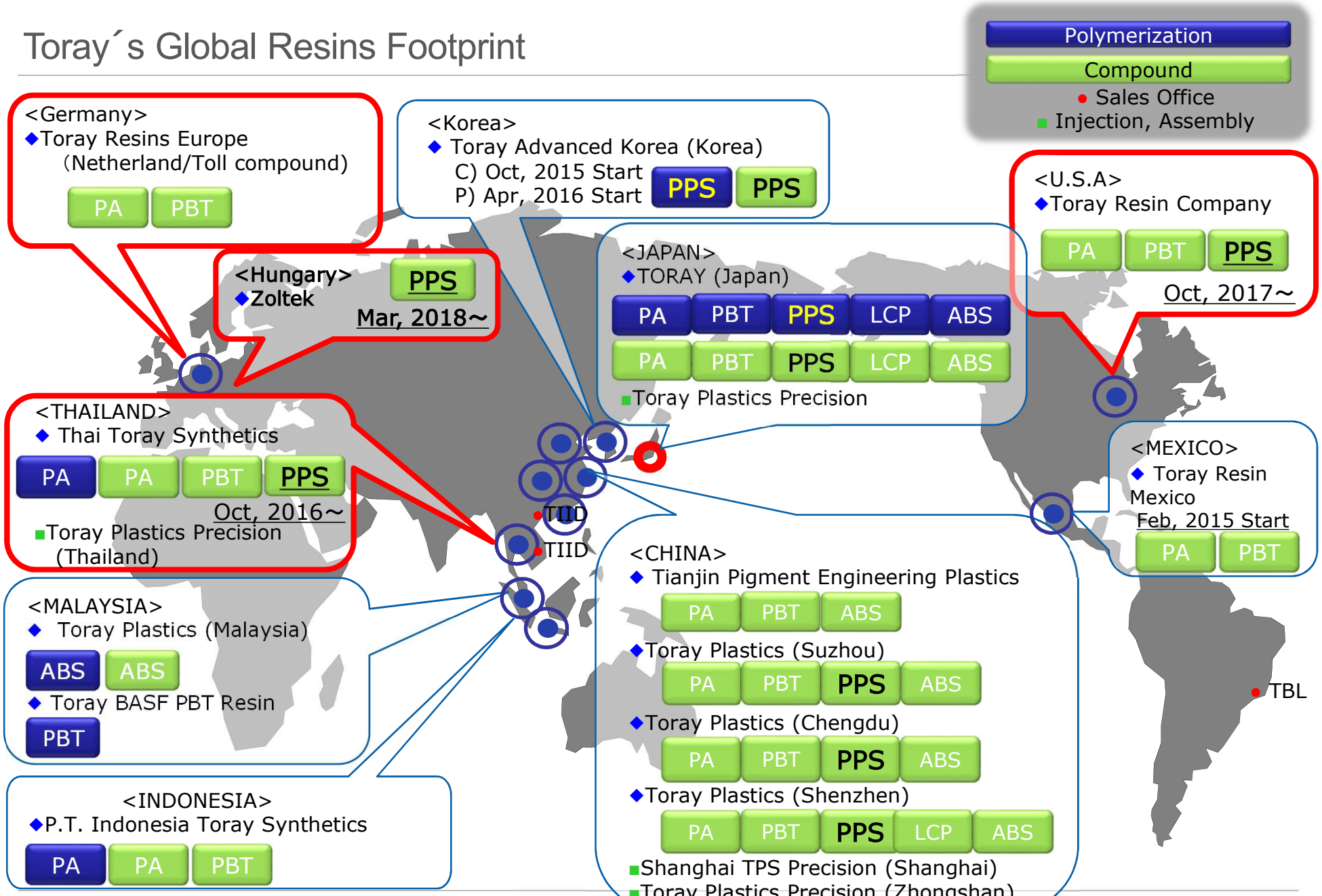
PPS Worldwide Polymer Capacity /Toray Position

Global No. 1 supplier



Others: including China operating capa.

Toray´s Global Resins Footprint



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TORAY – Torelina® PPS

PPS (Polyphenylene sulfide) is a simple chemical construction consisting of benzene ring and sulfur atom.

High Thermal stability

Filler reinforced PPS : short terms thermal stability is 260℃ over,
long terms thermal stability is 200℃ over.
Tm280℃, Tg90℃ ⇒ high electric stability, high strength and modulus under high Temp.

High Chemical stability and High humidity stability

Highest chemical stability next to PTFE in a lot of acid ,alkali and organic solvent.
Low water absorption and water barrier, retaining high properties under high hot moisture.

Flame resistance

UL flammability lank is V-0 without flame retardant

High dimensional stability

Coefficient of thermal expansion is low level and it is easier to conclude high amount of filler ⇒ High dimensional stability and high modulus

TORAY – Torelina® PPS Products

Both types of resin enable wide range of applications.

TORAY PPS

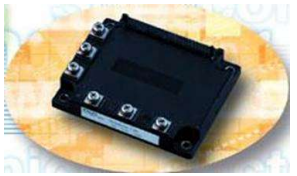
"TORELINA"

- **Cross-linked**
- **Linear**

Engineering resin for injection and blow molding

Ignition Coil

Lamp reflector



Power module

Performance films

Condenser, Insulated material
Industrial mold release material

Performance Fibers

Filtration for thermal power generators
Screen paper,
Dryer parts for paper machine cloth

Extrusion for machining Profiles and Stock Shapes

Semi-conductor applications, etc.

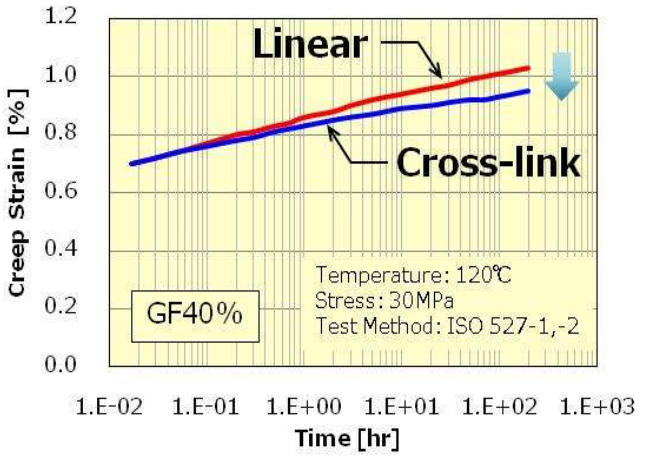
TORAY – Torelina® PPS Products




Properties of Linear and Cross-link PPS

- **Tensile Strength** Linear = Cross-link
- **Anti-Creep** Linear < **Cross-link**
- **Stiffness** Linear < **Cross-link**
- **Out Gas** **Linear** > Cross-link
- **Weld Strength** **Linear** > Cross-link
- **Toughness** **Linear** > Cross-link

Creep Properties



TREU - Toray Resins Europe GmbH(2015/8/01~)

TREU location

Company name	**Toray Resins Europe GmbH**
Location	Neu-Isenburg Germany
Launch	2015/5/1 (Register 5/21～) （Business transfer from TIEU 2015/8/1～）
Capital fund	2 Million EUR
Shareholder	TORAY 100 %
Business	Sale and Marketing, Developmental support

1.CAE Analysis

Technical Center

1. **CAE Analysis (Flow, Structure, Impact)**
2. **Analytical Equipment for quick trouble shooting (①SEM-XMA, ②DSC, ③FT-IR & ④TGA)**

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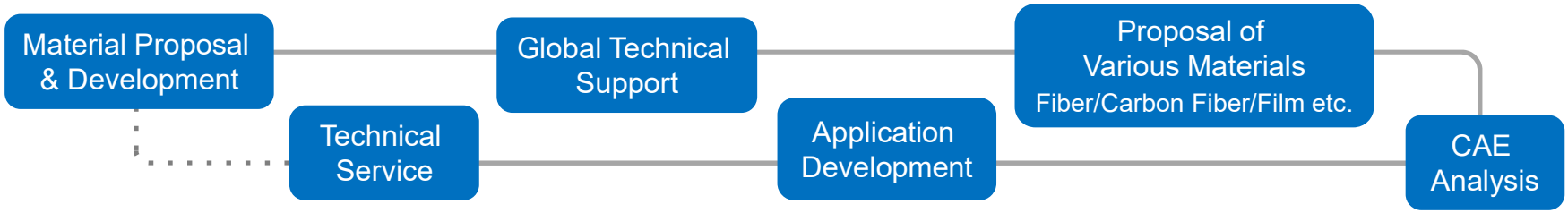
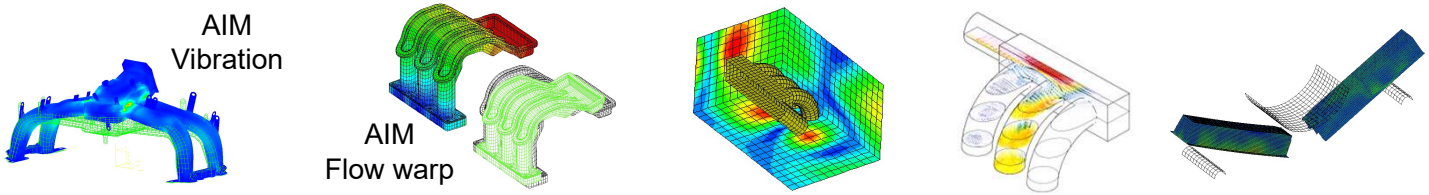
TORAY - Global Resin Business



- TORAY provides professional technical support based on its original CAE software
- TORAY has supported many developments with its CAE technologies
  — 250 reports/year
  — More than 4,000 CAE case studies in 30 years

TORAY Plastics CAE



Structural Analysis
- Strength Stiffness, Contact, Vibration, Heat transfer, etc.

Injection Molding CAE ("3D TIMON")

Acoustic Analysis

Flow Analysis

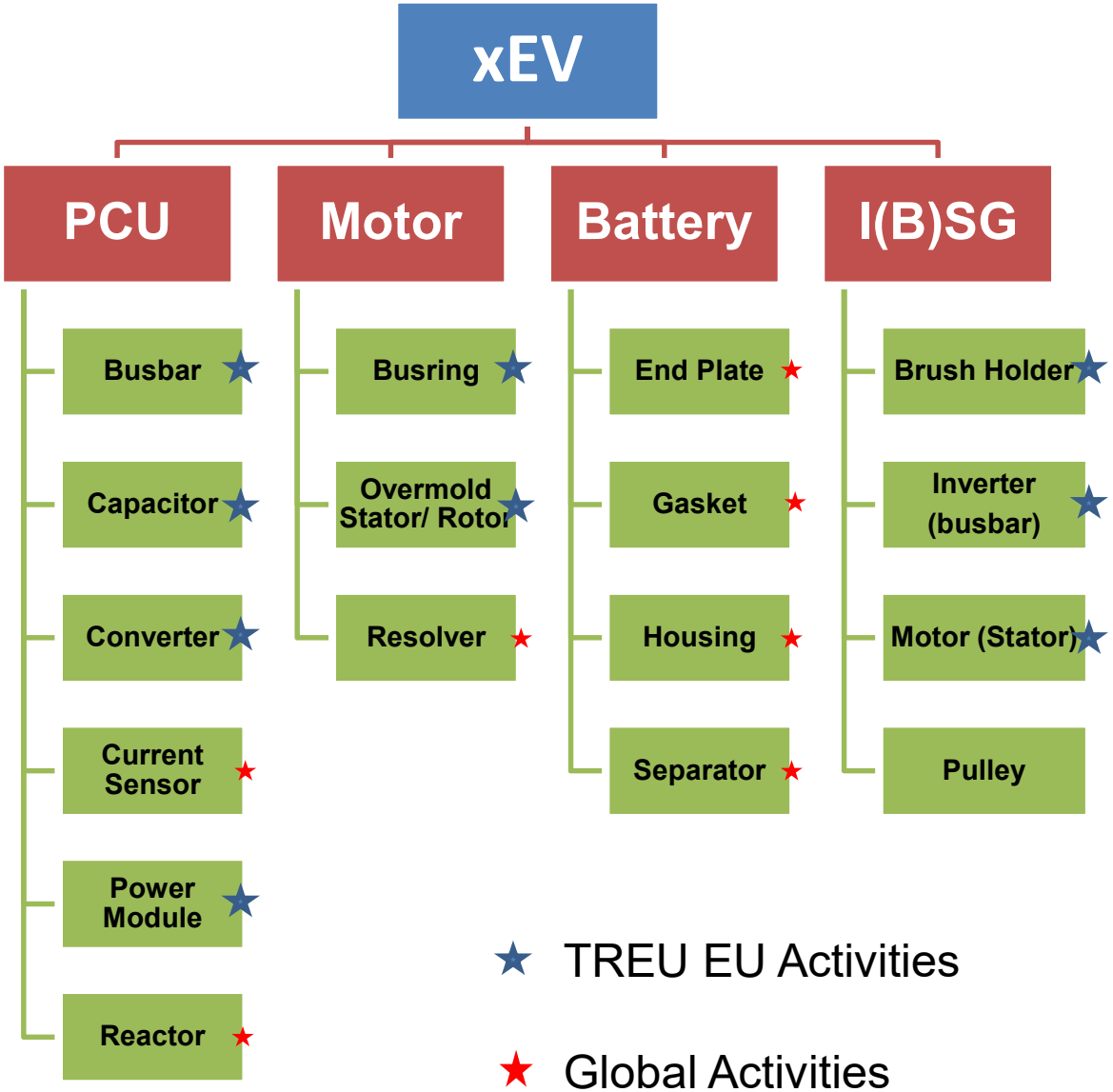
Impact Analysis

'TORAY'

Innovation by Chemistry

E-Mobility

xEV - Segmentation



Source: BMW, Valeo

TORAY

Target Application and Case study

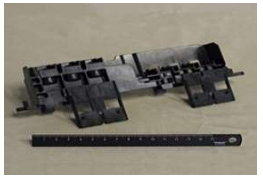
Coil case

Coil Bobbin

HC/
Low Warpage

PM case

Resolver



Bus Bar

Thermal
conductivity

<PPS/GF40)>

Alternator

Insulator

HC

<A673MTB, A675GS1B>

Sensor Parts

HC/
Epoxy adhesion

CTI

<A495MA2B>

Condenser Case

<A660HVB>

PM case

HC/
Weld strength/
Low Warpage

<A675GS1B>

Current Sensor

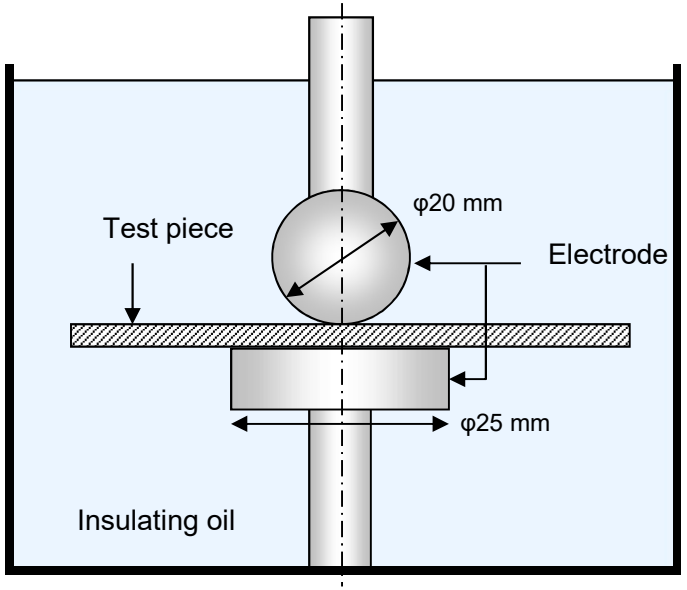
TORELINA PPS Line-up for xEV

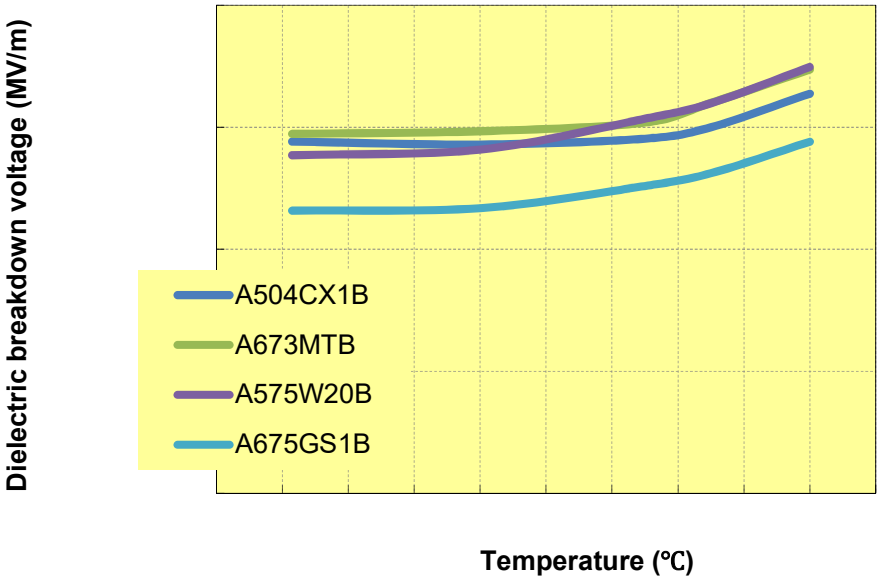
			High Strength		High Heat Cycle Resistance				CTI Performance	
Item	Unit	Test Method	A604CX1B Linear	A504CX1B Cross linked	A673MTB Heat cycle	A674MTB Heat cycle	A575W20B low warpage Heat cycle	A675GS1B Heat cycle	A610MVB Heat cycle CTI3	A660HVB CTI0
GF / Filler	-	-	GF40	GF40	GF30	GF40	(GF+MD)50	(GF+MD)50	(GF+MD)60	(GF+MD)65
Elastomer	-	-	-	-	Added	Added	Added	Added	Added	Added
Density	kg/m^3	ISO 1183	1670	1670	1520	1565	1700	1670	1814	1840
Tensile Strength	MPa	ISO 527-1,2	185	190	155	147	150	160	167	114
Tensile Elongation	%		1.8	1.7	2.2	2.4	1.5	2.0	1.4	0.7
Flexural Strength	MPa	ISO 178	275	290	230	237	230	235	258	190
Flexural Modulus	GPa		14.5	15.0	10.0	12.0	16.0	12.3	16.2	18.6
Comparative Tracking Index	V	IEC60112	150	150	150	150	150	150	200	600
Dielectric Strength at 180℃	MV/m	IEC60243	17	16	17	(15)	17	15	(20)	(21)
Volume resistivity at 180℃	Ω.m	IEC60093	10^{10}	10^{10}	10^{11}	(10^{10})	10^{10}	10^{10}	(10^{10})	(10^{10})
Flammability (equivalent)	-	UL94	(V-0) (0.2mmt)	(V-0) (0.28mmt)	V-0 1.5mmt	(V-0) (2.0mmt)	V-0 1.5mmt	V-0 2.0mmt	V-0 / equivalent	V-0 0.38mmt
Spiral Flow (320℃, 98MPa, 1mmt)	mm	Toray Method	100	130	135	125	200	160	109	100

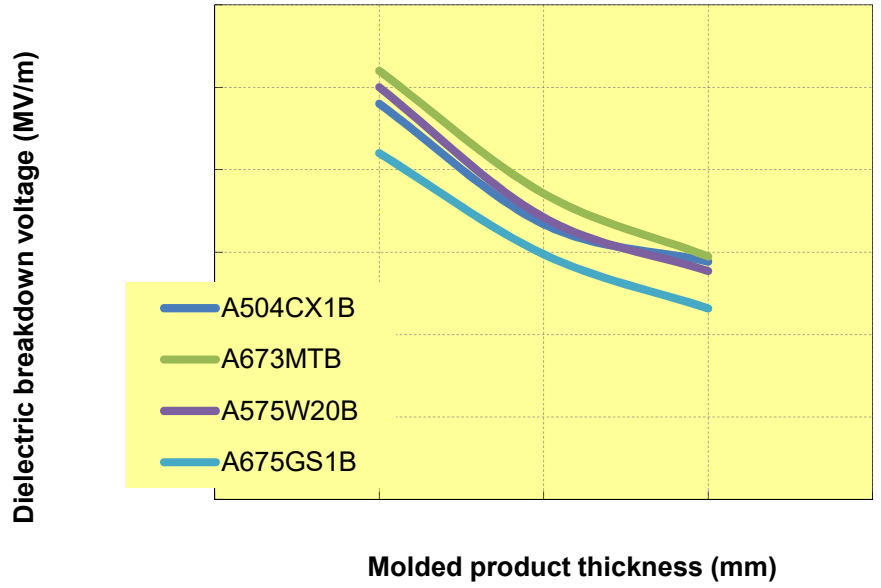
Dielectric Strength

Test Method;IEC60243-1

・The dielectric breakdown strength is expressed as the voltage endurance per unit thickness, obtained by dividing the voltage at which the test piece experiences dielectric breakdown by the electrode-to-electrode distance (test piece thickness).
・The dielectric breakdown strength of TORELINA is determined with a short-time breakdown test method (short-time method), in which the voltage is increased so that dielectric breakdown occurs after 10 to 20 seconds.







TORAY

Innovation by Chemistry

Coolant System

Reinforced PPS

Confidential

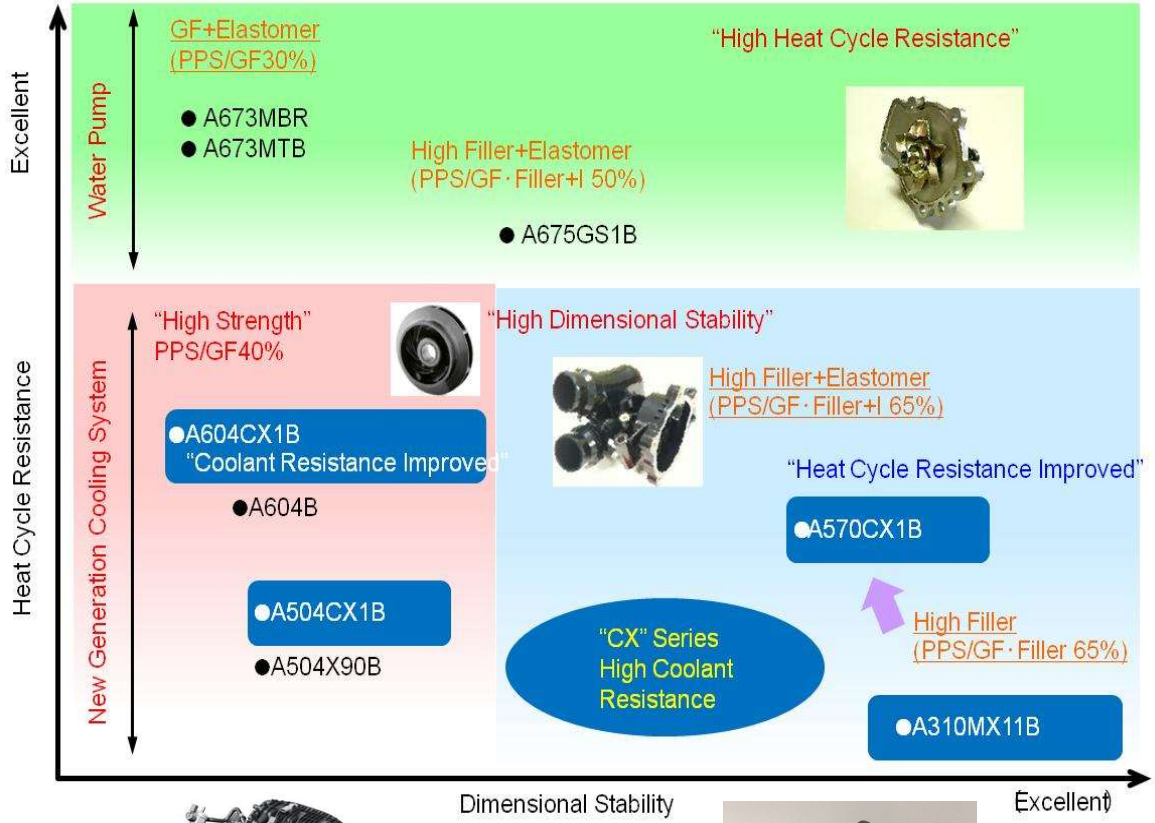
TORAY – Resins for Automotive Applications

Advantages

- Dimensional stability
- Long life coolant (LLC) resistance
- High mechanical properties
- Achievement of parts integration
- Metal replacement for weight reduction
- Design freedom

Torelina® PPS is currently used by European OEM

- Water Pump
- Water Pump Impeller
- Thermostat
- Thermostat Housing



TORAY – Resins for Automotive Applications

For Electric Water Pump Housing

Item

EWP Housing

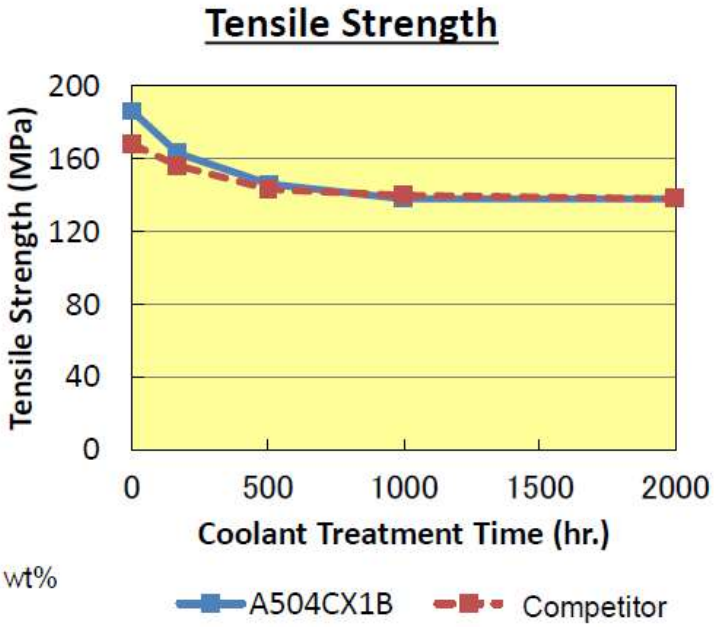
✓ Complex Shape

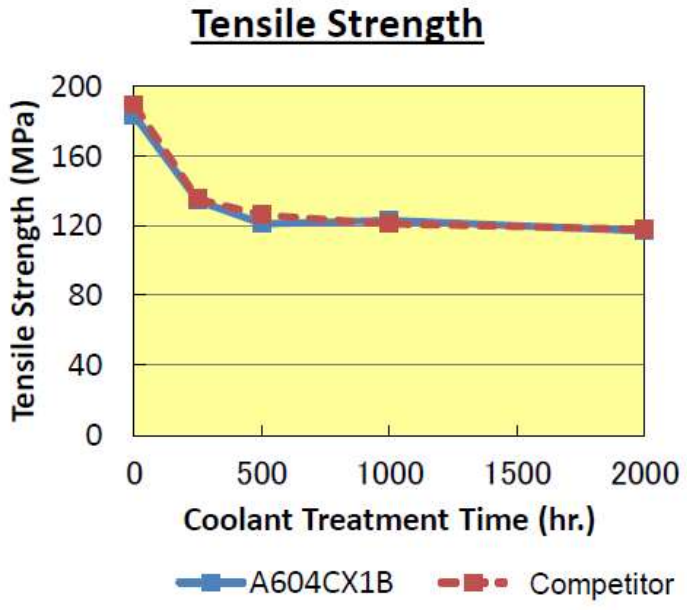
Requirement

- ➢ High LLC Resistance
- ➢ Dimensional Stability
- ➢ Thermal Cycle Resistance

TORAY's Solution

Suitable Formulation
+
Suitable PPS base polymer
+
=
A504CX1B, A604CX1B





(Testing Condition)
- Coolant Type: G13, G05
- Coolant Conc.:
  Coolant / Water = 40 / 60 wt%
- Temp.: 135˚C

TORAY

TORAY – Resins for Automotive Applications

For Electric Water Pump Housing

Item

EWP Housing

✓ Complex Shape

Requirement

- ➢ High LLC Resistance
- ➢ Dimensional Stability
- ➢ Thermal Cycle Resistance

TORAY's Solution

Suitable Formulation

+

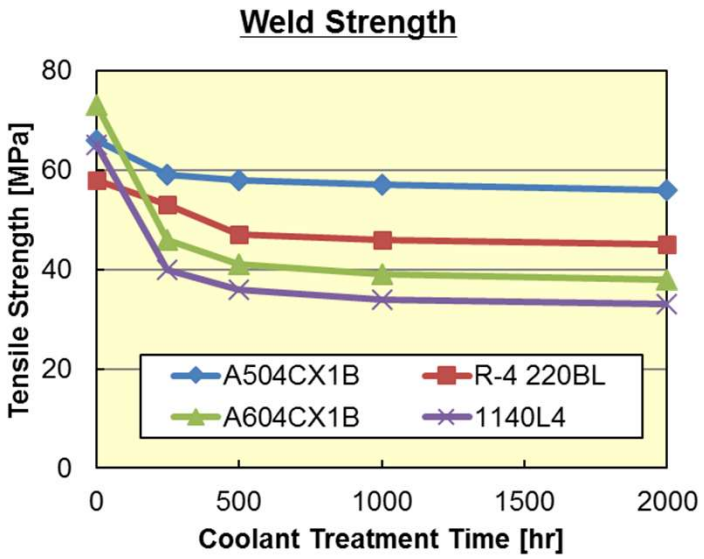
Suitable PPS base polymer

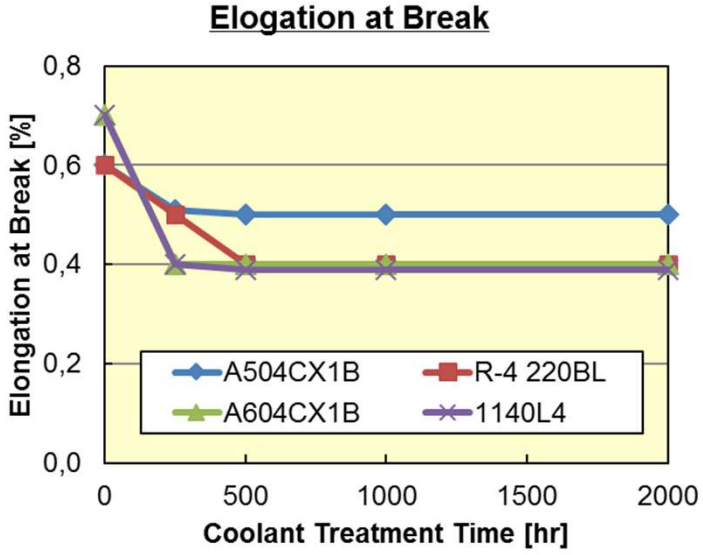
+

=

A504CX1B, A604CX1B

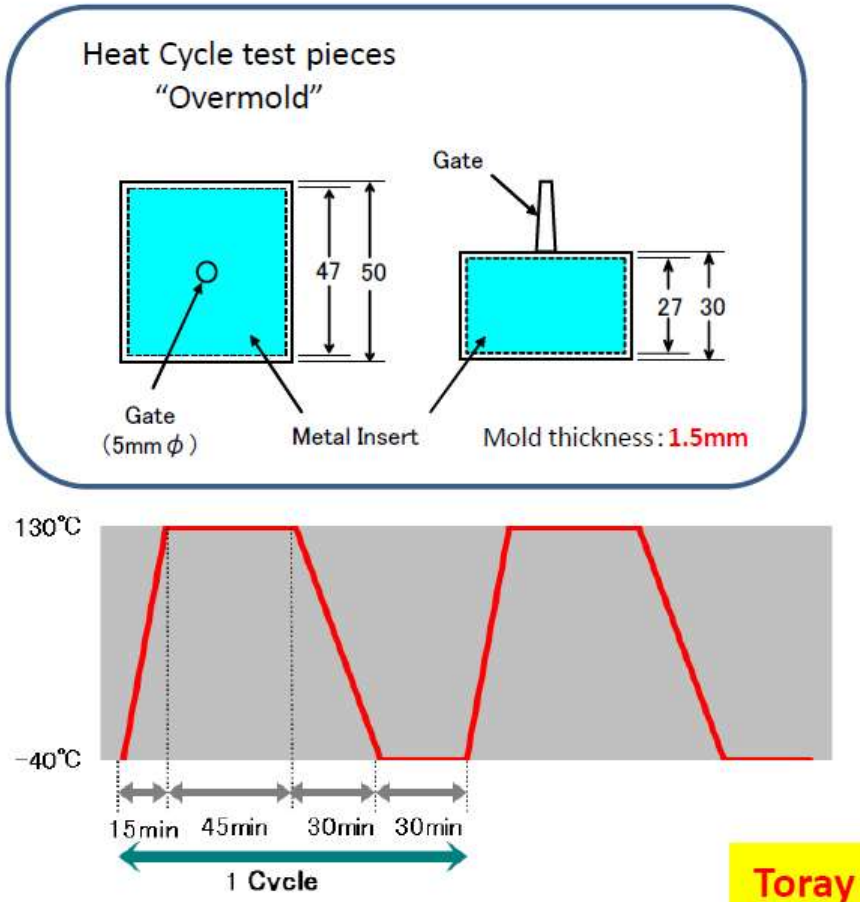
- Coolant Type: **G13**
- Coolant Conc.: Coolant / Water = 40 / 60 wt%
- Temp.: 135˚C

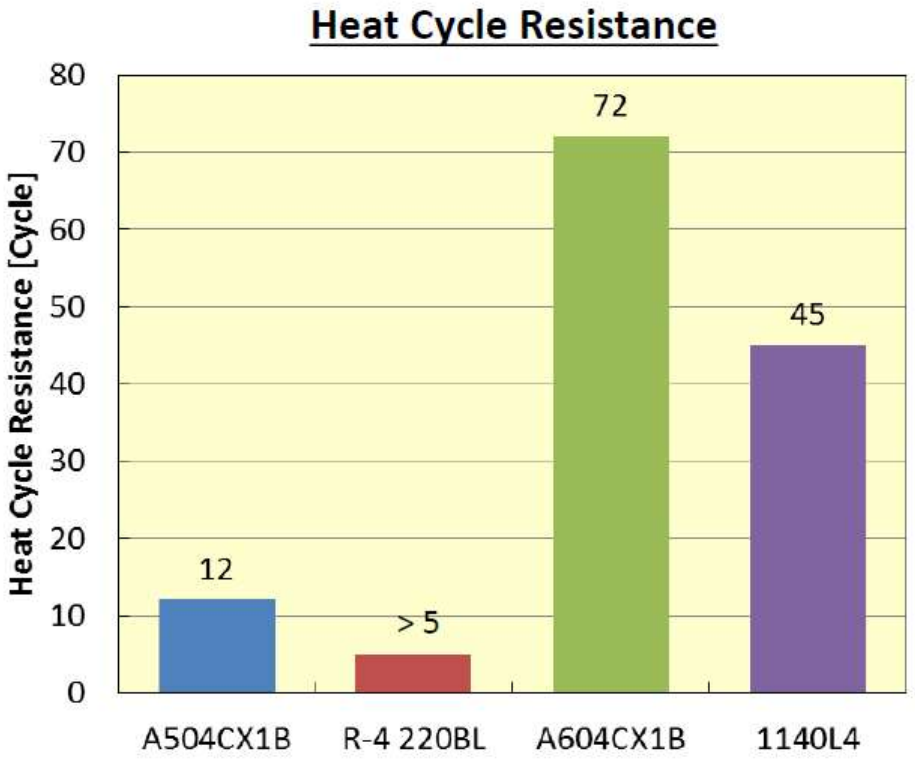




Heat Cycle Resistance Test

-Test method: -40 deg C ⇔ 130 deg C x 1hr





Toray has higher heat cycle resistance than competitors.

Measuring Method :
Check the samples (n=3) every 5 cycle whether clacking occurred or not.

TORAY

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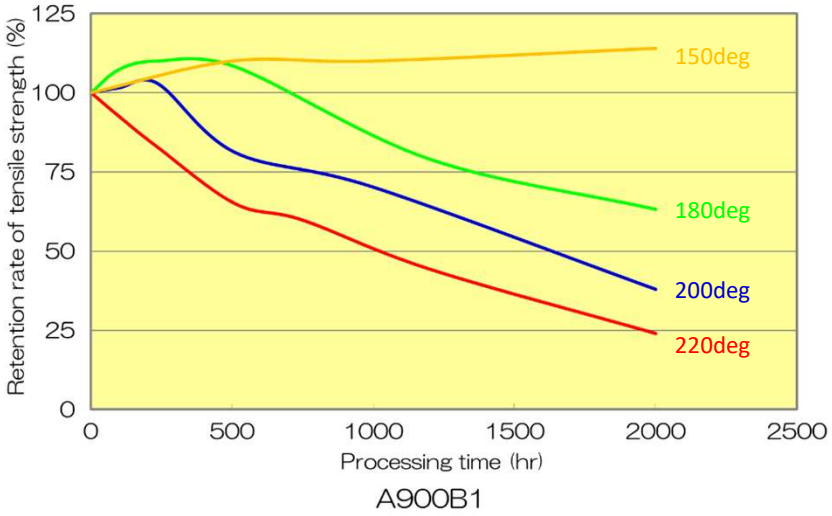
Coolant System

Unreinforced PPS

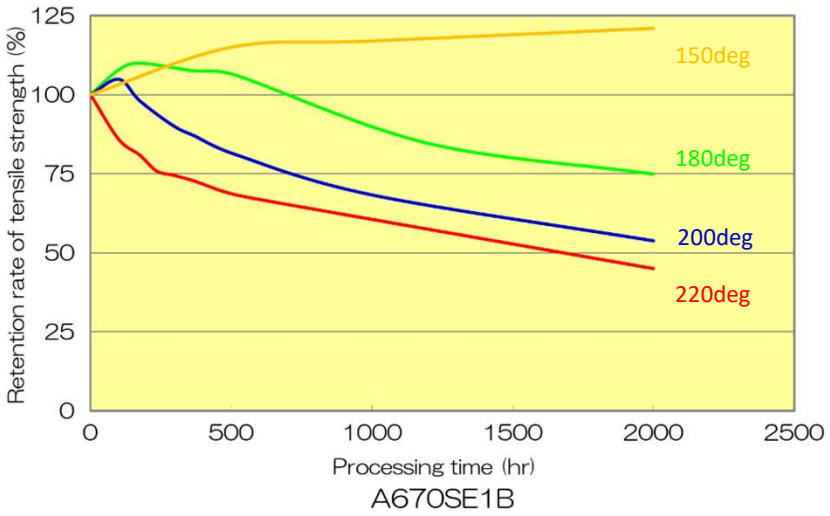
Overview of unreinforced PPS grades

Item	unit	Method (ISO)	A900	**A670R63**	A670T05	**A670MT1**	A670SE1
			NC/BK	**NC/BK**	NC	**BK**	BK
			Non-reinforced Standard	**Elastomer modified**	Elastomer modified	**Elastomer modified**	Elastomer modified
Density	kg/m^3	1183	1340	**1300**	1300	**1270**	1200
Tensile strength	MPa	527 -1,-2	85	**70**	70	**58**	45
Tensile strain at break	%		8	**10**	15	**26**	22
Flexural strength	MPa	178	140	**110**	115	**94**	67
Flexural modulus	MPa		3900	**2800**	3100	**2500**	1850
Charpy impact strength (V-noched)	kJ/m^2	179-1	4.0	**7.3**	6.4	**30**	55
HDT (at 1.8MPa)	℃	75	105	**100**	100	**100**	97
Mold shrinkage (80mm□×3mmt) MD/TD	%	TORAY method	1.4/1.9	-	1.5/1.9	-	2.3/2.3

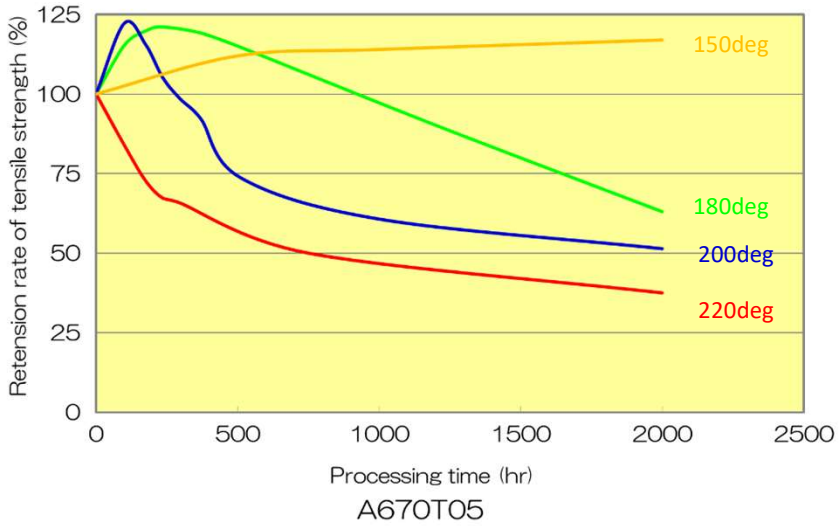
Heat-resistance of unreinforced PPS grades (tensile strength)



A900B1



A670SE1B



A670T05

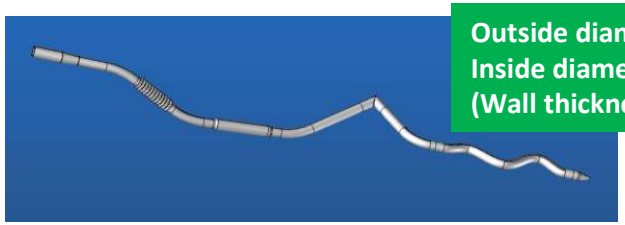
Production Method: Extrusion & Suction Blow Moulding

Extrusion @TORAY TPS Mishima

Outside diameter : ϕ9mm & φ7.5mm
Inside diameter : ϕ7mm & φ5.5mm
(Wall thickness: 1mmt)

Can change the pipe size

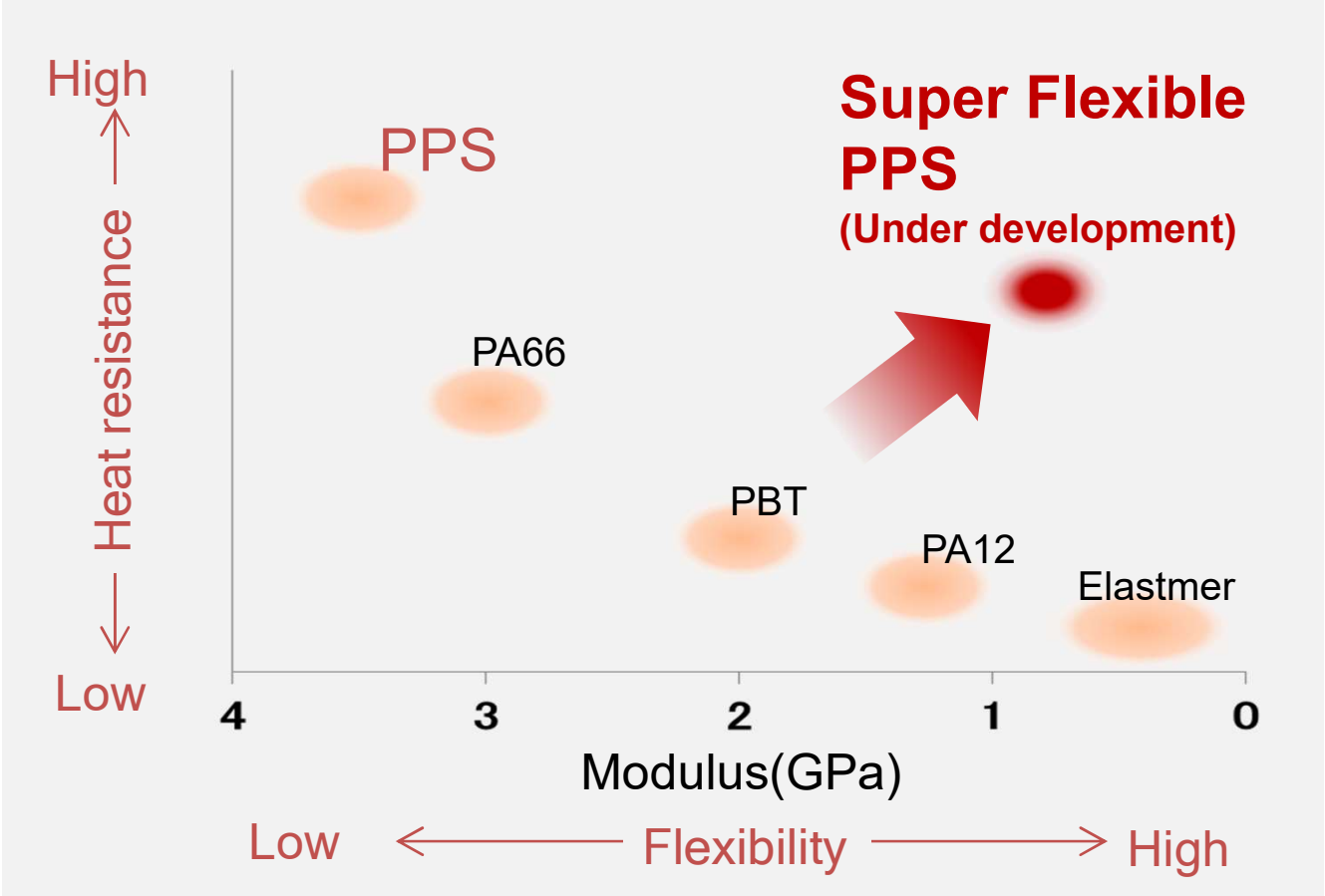
Suction blow @TORAY Nagoya



Outside diameter : ϕ17mm
Inside diameter : ϕ13mm
(Wall thickness: 2mmt)

Can change the design with insert mold

Super Flexible PPS ~ Concept ~ - OUTLOOK



Flexibility and Toughness was improved by NANOALLOY® technology.

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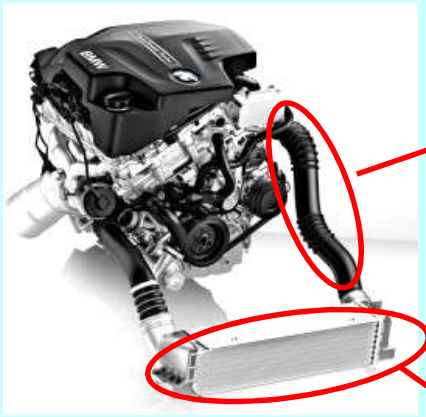
Turbo Duct

TORAY Development for Turbo Related Applications

High Heat solution with TORAY Resin for B/C duct etc.

Down Size Engine & Turbo System

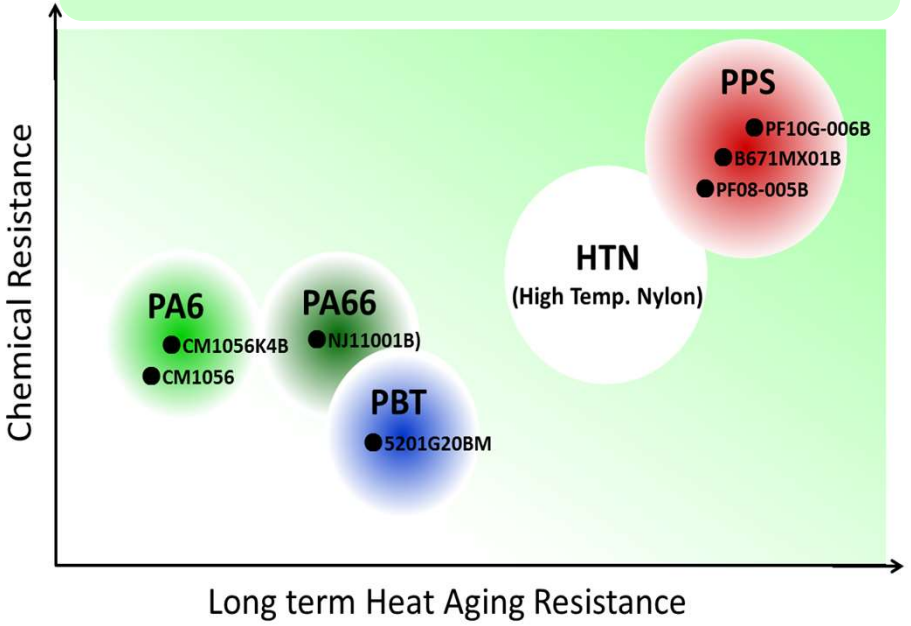


Turbo Duct

Turbo Housing

Intercooler

- Catch up the New trend of turbo charger system
- Bring High heat & Chemical resistance solutions



TORAY total solution & collaboration with KAUTEX

Parts design & concept by customers

Recommendation for suitable production process & material by TORAY

Initial trial & mass production support by TORAY

Mass production by customers

Collaboration with Kautex Maschinenbau Global No.1 3D suction blow machine maker

New instrument with Kautex machine To TORAY Japan R&D center (Since October 2016)

TORAY

Strong Focus on Automotive

Experience with Global Automotive Brand leaders.

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