



Toray Resins

Torelina PPS

March 28th 2019

Toray Resins Europe GmbH

Jonas Ehinger



Facts & Figures



President:
Akihiro Nikkaku

Employees

46,248

(Toray Group in fiscal year 2017)



Consolidated operating income

1,1
billion euros

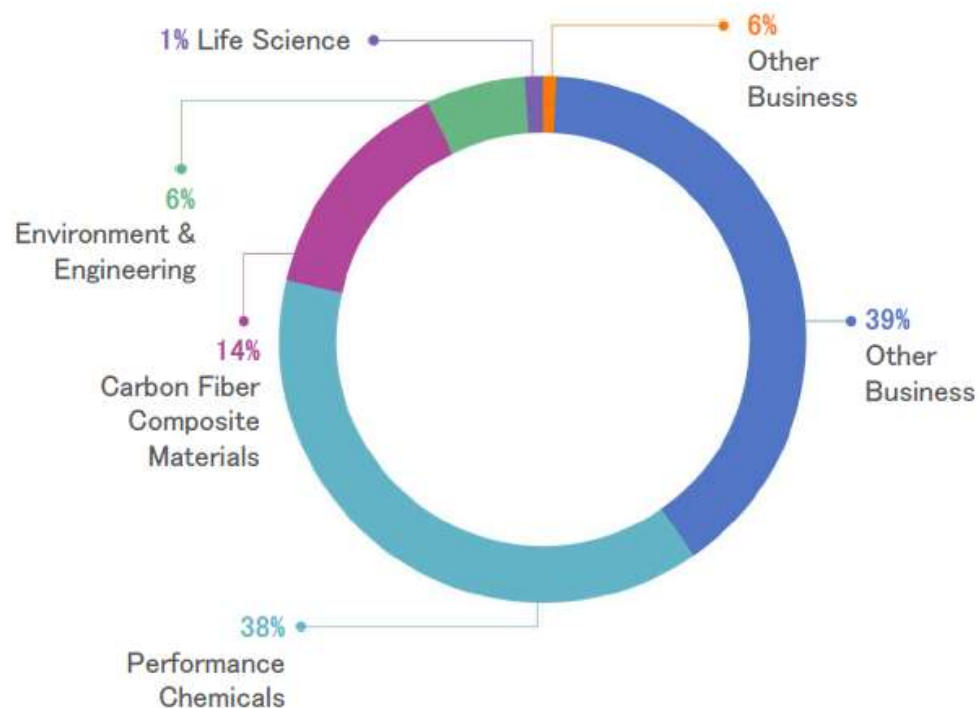
Subsidiaries/Affiliates:

255 in **26**

countries worldwide



Operating Income by Segment (2017):



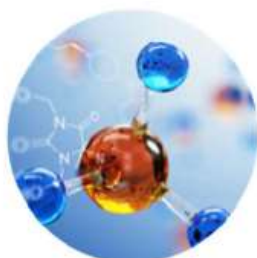
Extensive Competence in Material Technologies

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



Fibers & Textiles:

all three major 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

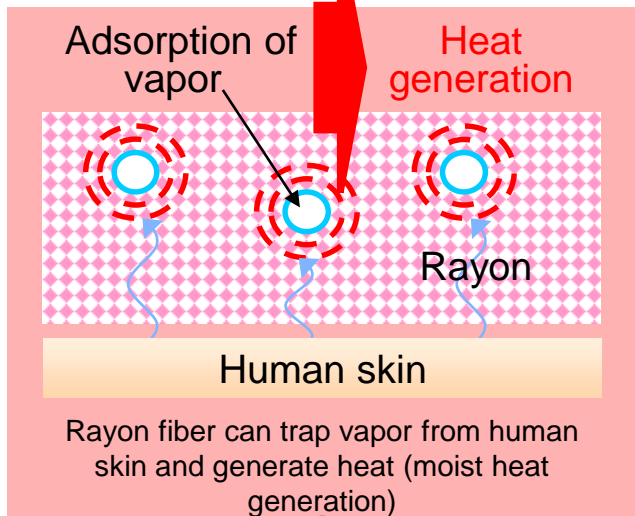


Life Science:

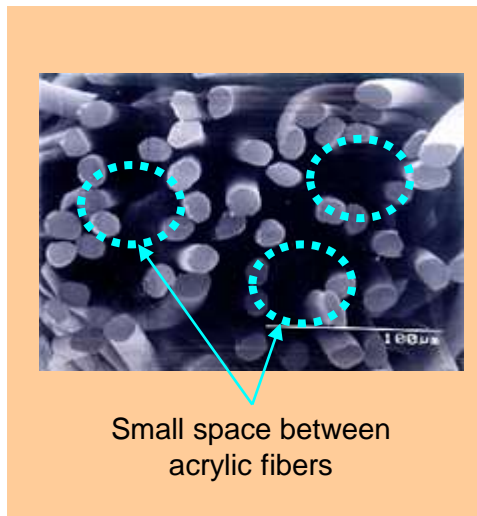
medical products, pharmaceuticals and bio-tool products

Challenge to ultimate : Comfortability

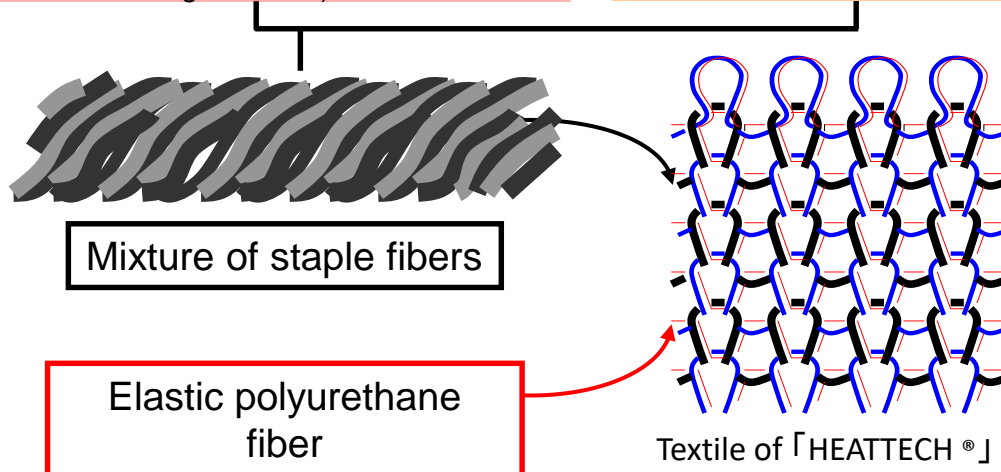
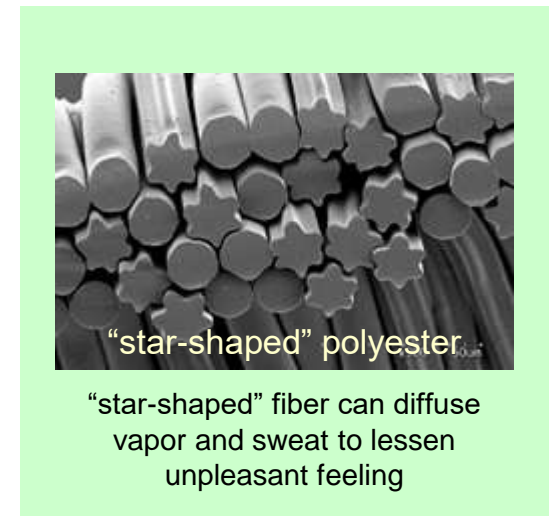
Moisturization / Heat generation



Thermal insulation



Easy to dry

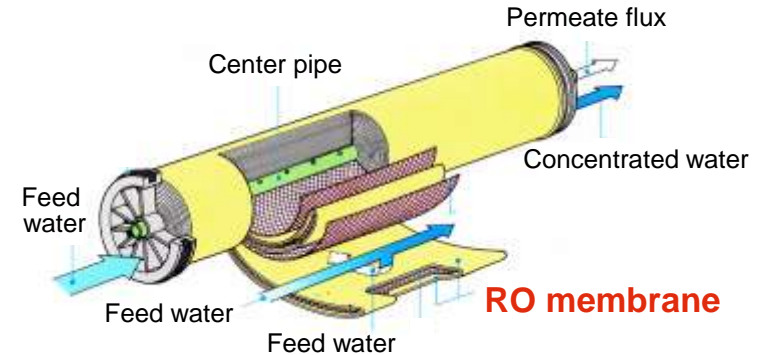


「HEATTECH®」 is trade mark of First Retailing company







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)
	<p>Ladder/Spoiler</p> 	<p>Stabilizer Floor Beam</p> 	<p>Main Wing/Fuselage/ Stabilizer</p> 
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

Performance Chemicals



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

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

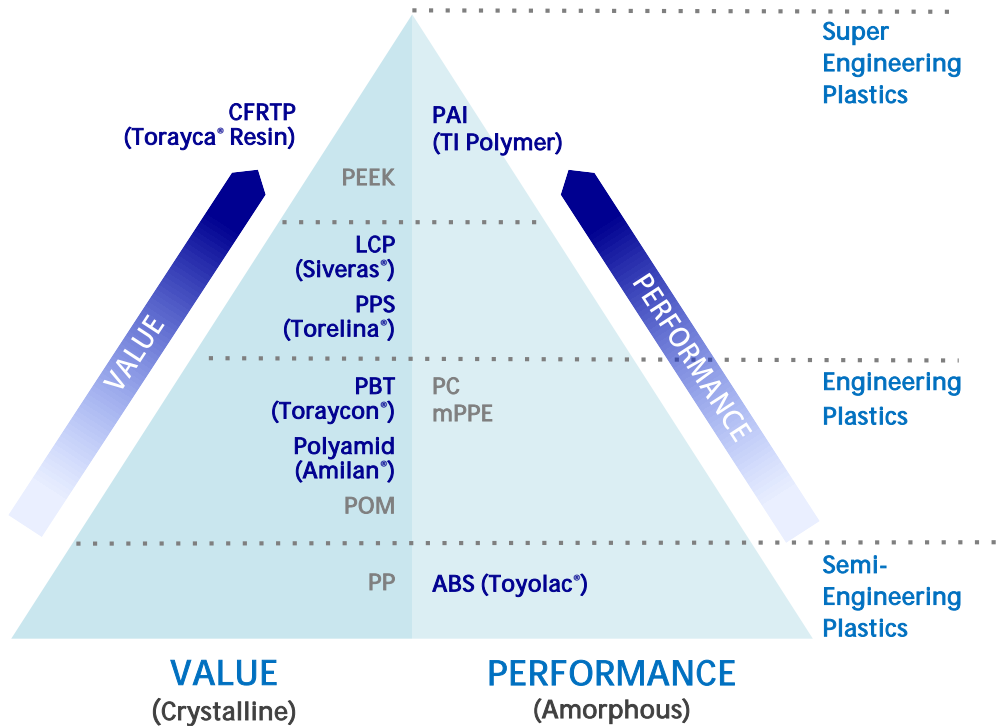


Electric and Information Material



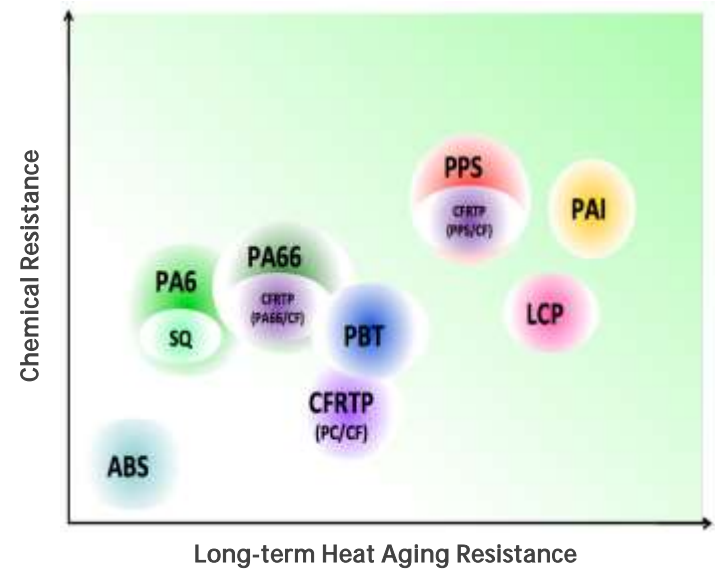
TORAY Resin Company

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

ecodear

PLA Resin

TORAYCA

Carbon Fiber Reinforced
Thermo Plastics

TORAYCON

PBT Resin

TORELINA

PPS Resin

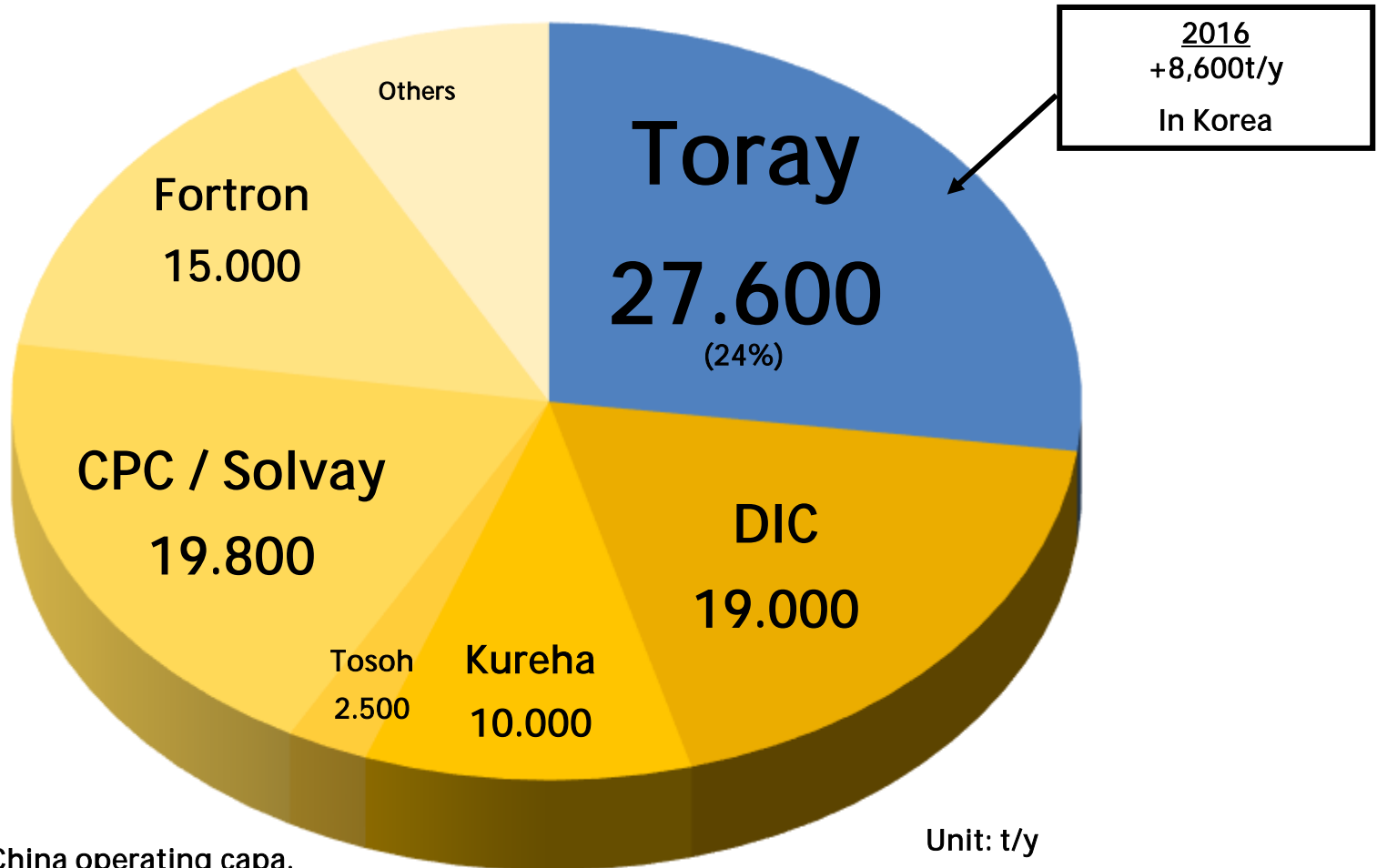
Polymer Production Capacity

Confidential

Polymer	Brand	Polymer Capacity	
ABS	TOYOLAC™	402.000	t/a
PA	Amilan™	54.000	t/a
PBT	TORAYCON®	54.000	t/a
PPS	TORELINA	19.000	t/a
		(2016) → <u>27.600</u>	t/a
		(201X) → <u>36.600</u>	t/a
LCP	SIVERAS	2.000	t/a
Polyolefin Foam	TORAYPEF	7.000	t/a

Global No. 1 supplier

2016 TTL cap. : 114kt/y (estimate)



Others: including China operating capa.

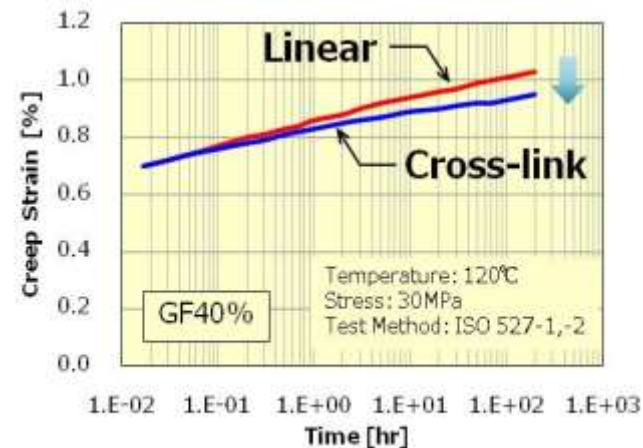
General PPS – Torelina®



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



	Unreinforced	GF30	GF40	GF+MD	
Cross-Linked		<i>Standard</i>	<i>Standard</i>	<i>High Flow</i>	<i>Standard</i>
		A503X05	A504X90	A504FG1	A310MX04
		<i>High Flow</i>	<i>Low Flash</i>	<i>High Rigidity</i>	<i>High Flow</i>
		A503F1	A504X95	A505D7	A400MX01
Linear	<i>Unreinforced</i>		<i>Standard</i>	<i>Low Chlorine, High Toughness</i>	<i>Standard</i>
	A900		A604	A604L02	A610MX03
			<i>Low Flash</i>		<i>Low Chlorine</i>
			A604X95		A625HL01
Tough	<i>Unreinforced</i>	<i>High Impact</i>	<i>High Impact, Heat Cycle Resistance</i>	<i>Heat Cycle Resistance, High Flow</i>	
	A670X01	A673M	A674M2	A675GS1	A575W20
	<i>Unreinforced</i>				
	A670T05				
Specialized		<i>High Tribological Property</i>	<i>Antistatic High Heat Dissipation, Insulated</i>		<i>CTI Rank 0</i>
		A514 A515	A756MX02	H718L	A660HVB
		<i>CF30 % Reinforced</i>	<i>High Heat Dissipation, Conductive</i>		<i>Good Epoxy Adhesion</i>
		A630T30		H501	A610EA1
Extrusion Grades (unreinforced)	<i>High Flow</i>	<i>HR & V0</i>	<i>low viscosity / stiffness</i>	<i>super-soft grade</i>	
	A670SE1B	A900B1	A670SE2BH	A670FX1B	

Toray's Global Resins Footprint

Polymerization

Compound

● Sales Office

■ Injection, Assembly

<Germany>

◆ Toray Resin Company Europe
(Germany/Toll compound)

PA PBT

<Hungary>

◆ Zoltek

PPS
Mar, 2018~

<Korea>

◆ Toray Advanced Korea (Korea)
C) Oct, 2015 Start
P) Apr, 2016 Start

PPS PPS

<JAPAN>

◆ TORAY (Japan)

PA PBT PPS LCP ABS
PA PBT PPS LCP ABS

■ Toray Plastics Precision

<U.S.A>

◆ Toray Resin Company

PA PBT PPS
Oct, 2017~

<THAILAND>

◆ Thai Toray Synthetics

PA PA PBT PPS
Oct, 2016~
■ Toray Plastics Precision
(Thailand)

<MALAYSIA>

◆ Toray Plastics (Malaysia)

ABS ABS

◆ Toray BASF PBT Resin

PBT

<INDONESIA>

◆ P.T. Indonesia Toray Synthetics

PA PA PBT

<CHINA>

◆ Tianjin Pigment Engineering Plastics

PA PBT ABS

◆ Toray Plastics (Suzhou)

PA PBT PPS ABS

◆ Toray Plastics (Chengdu)

PA PBT PPS ABS

◆ Toray Plastics (Shenzhen)

PA PBT PPS LCP ABS

■ Shanghai TPS Precision (Shanghai)

■ Toray Plastics Precision (Zhongshan)

<MEXICO>

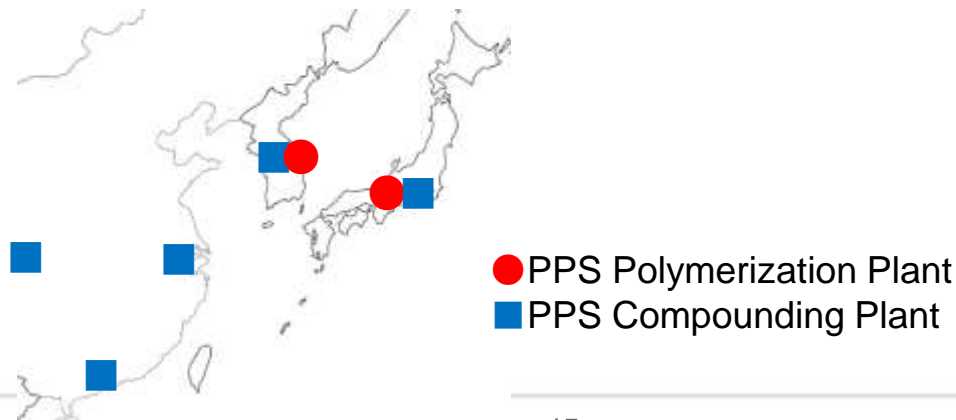
◆ Toray Resin Mexico
Feb, 2015 Start

PA PBT

TORAY

1. Only Toray has fully Integrated PPS Production
→ from Raw material (in Korea) to Polymer to Compounding.
2. Only TORAY has 2 polymerization plants
3. Largest PPS Polymerization capacity in the world in 2016

TORAY PPS Plant Locations in East Asia



TORAY in EUROPE

- All divisions

Subsidiaries (Polymer) in EUROPE

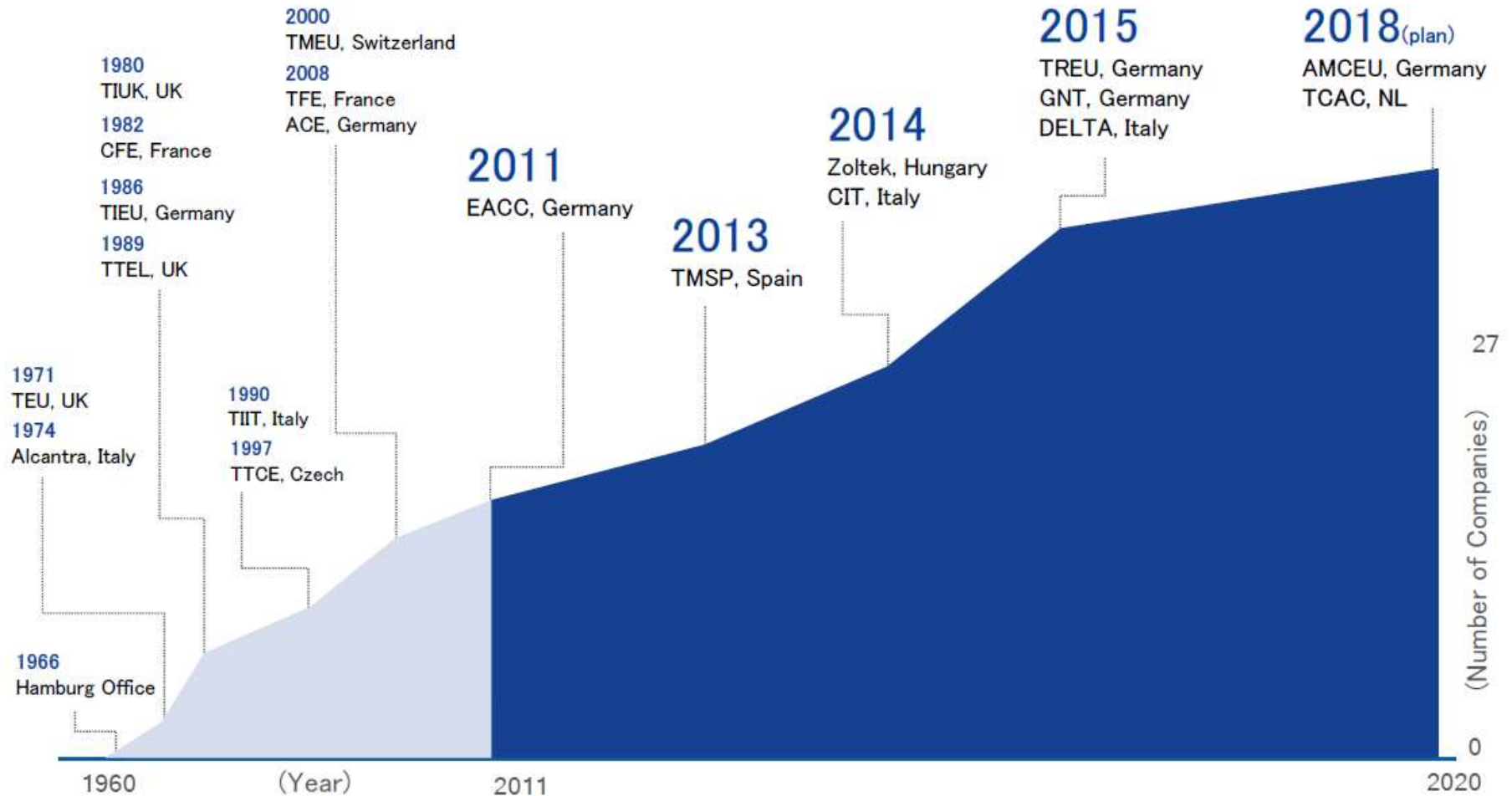
- Neu-Isenburg: Resins-department HQ (Sales & Marketing)
- Zoltek Hungary: Compounding (Production)
- Neufahrn: Automotive Center EU (Development)

Toray's Presence in Europe

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



Toray in Europe: A History of Growth



TORAY in EUROPE

- All divisions

Subsidiaries (Polymer) in EUROPE

- Neu-Isenburg: Resins-department HQ (Sales & Marketing)
- Zoltek Hungary: Compounding (Production)
- Neufahrn: Automotive Center EU (Development)

TREU - Toray Resins Europe GmbH (01.08.2015)

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	2,0 Million €
Shareholder	TORAY 100%
Business	Sale and Marketing, Developmental support

Technical Center

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



1.CAE Analysis



② DSC



③FT-IR & ④TGA



①REM



AMCEU

Automotive Center Europe (AMCEU)

Important facts:

Location: Munich area

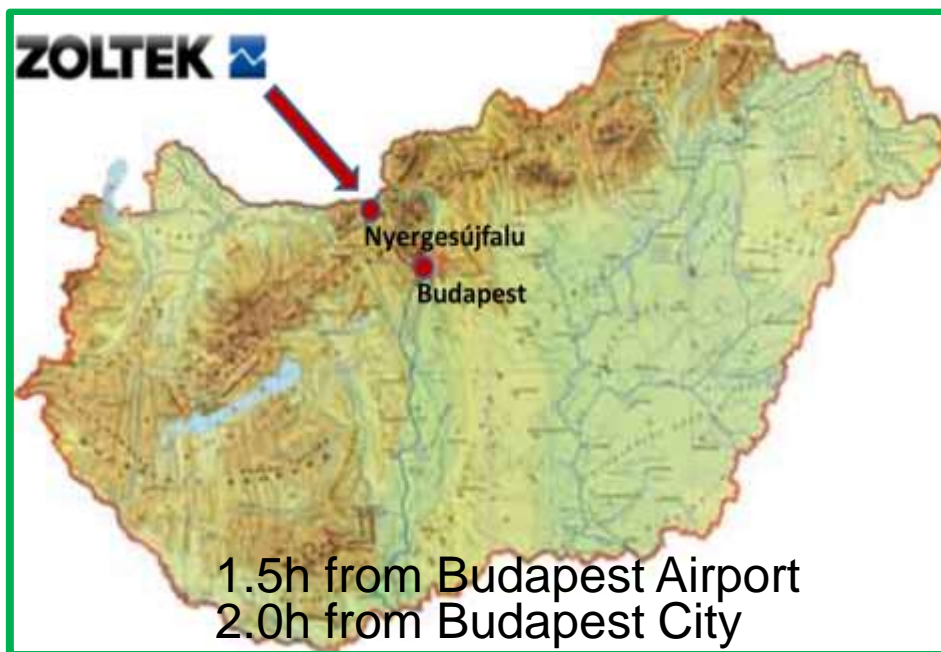
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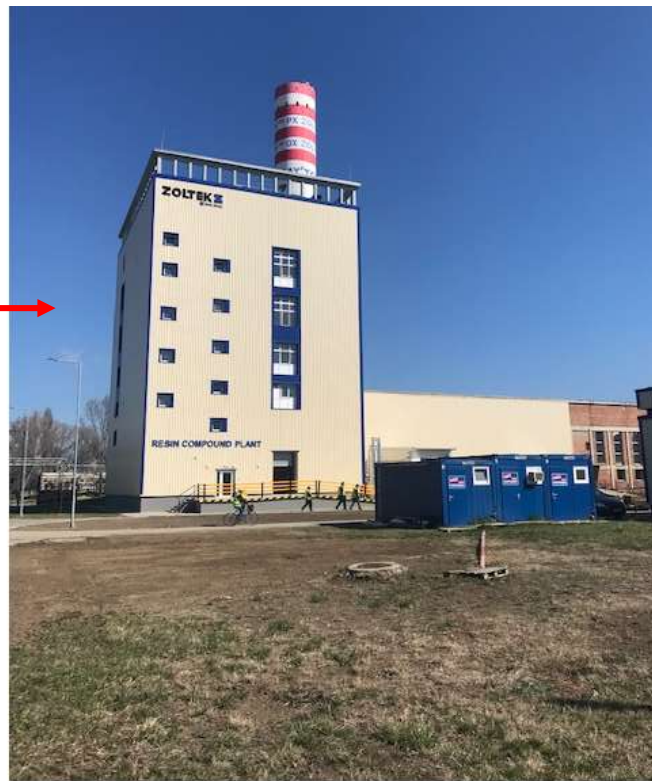
- Coordinate research and developments efforts across Europe
- conduct experiments, evaluations and technological support
- focus areas: lightweight construction, e-mobility, innovative materials



New PPS Production site in EU - Zoltek Hungary -

Company	Zoltek
Location	Varga József Tér 1., Nyergesújfalu, Hungary H-2537
Start	March 2018
Compounding	PPS Resin(Capacity : 3,000t/y)





Zoltek

About



No.1 Large tow carbon fiber supplier (Share 63%)

No.1 CF supplier for Wind power market (Share 70%)

No.1 CF supplier for Termoplastic market (Share 53%)

A horizontal banner featuring a close-up, high-contrast image of carbon fiber strands. A blue rounded rectangle is overlaid on the left side, containing the text "Carbon Fiber" in white.

Carbon Fiber

A horizontal banner featuring a photograph of a wind farm at sunset. The sky is a vibrant orange and yellow. A blue rounded rectangle is overlaid on the left side, containing the text "Composite Intermediates" in white.

Composite
Intermediates

A horizontal banner featuring a photograph of several large, black aircraft tires mounted on a metal frame. A blue rounded rectangle is overlaid on the left side, containing the text "Zoltek OX" in white.

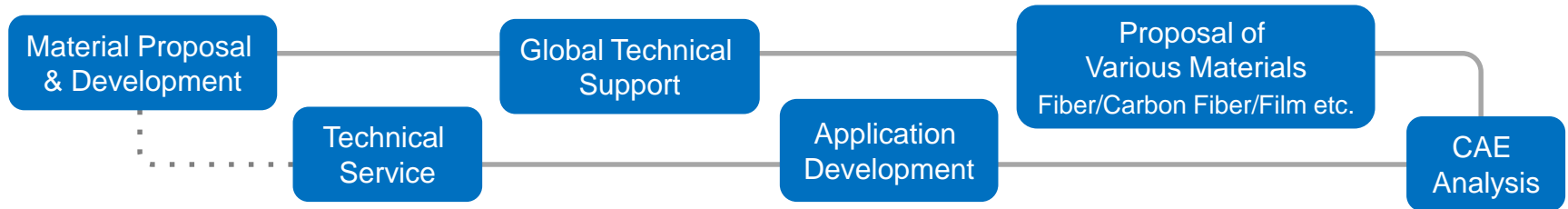
Zoltek OX

[Zoltek starts PPS compounding in their new Division](#)

Service TORAY

- CAE: 3D TIMON
- Testing / Analyze
- Processing

Development Support with TORAY CAE



- 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

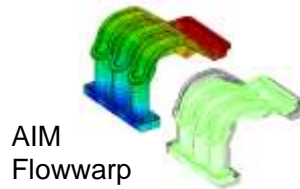
TORAY Plastics CAE



AIM
Vibration

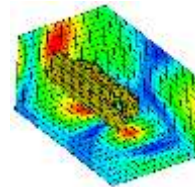
Structural Analysis

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

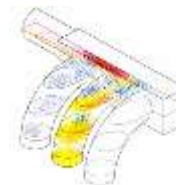


AIM
Flowwarp

Injection Molding CAE ("3D TIMON")



Acoustic Analysis



Flow Analysis

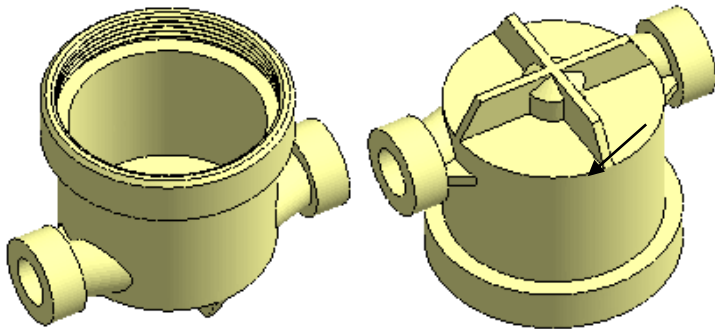


Impact Analysis

Part Design Case Study

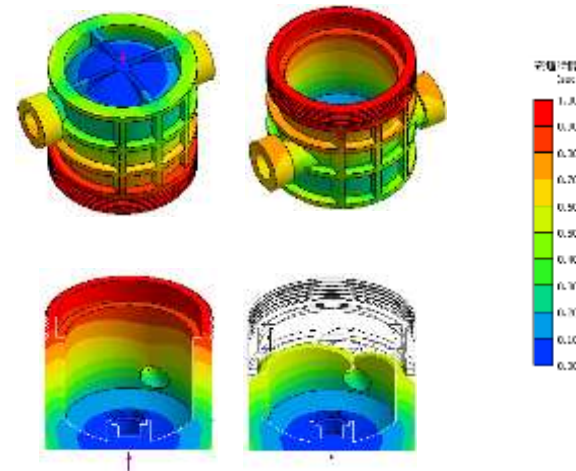
- When making Water Meter Housing by PPS polymer, a part design must take the strength difference between Brass and PPS into consideration in order to achieve a required pressure strength.

Brass Design

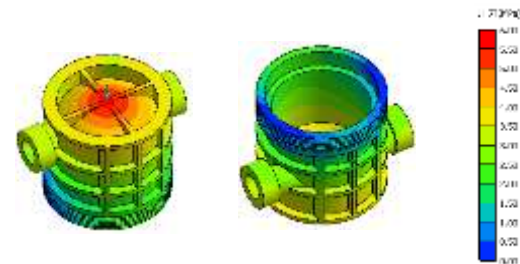


General Thickness : 3mmt
Volume : 65.1cm³
Weight : 574.8g (Brass)

Filling



Pressure distribution at cavity filled



Flow length

Test Method

Test Piece:

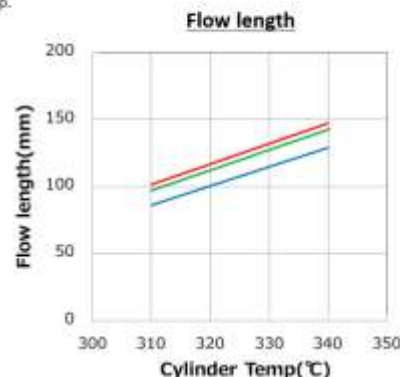
Shown below in the picture (5mm width*1mm thickness)
Measure the dependence between the length & cylinder temp.
*The length: From Start to end shown below



Test Piece
For flow length evaluation

Molding condition

*Molding Machine : 30t Electric Molding machine
(Sumitomo)
*Cylinder temp. : 310, 320, 330, 340°C
*Mold temp. : 130°C
*Injection / Cooling : 10sec/15sec
*Injection pressure : 90MPa
*Injection speed : 250mm/s



Mold Release

Test Method

Measure the resistance value when it is ejected from the mold for the test piece shown in right picture. The value is smaller, it is easier to be released.

Molding Condition

*Molding Machine : 30t Electric Injection Machine(Sumitomo)
*Cylinder Temp. : 310, 320, 330°C
*Molding Temp. : 130°C
*Injection / Cooling : 5sec/25sec
*Injection Pressure : Minimum filling pressure + 5MPa
*Injection Speed : 100mm/s

Test Piece for Mold Release



Test result

Item	Test Method	A604WRB	A604B	C's
Mold Release	Toray	30N	30N	30N

Flash

Test Method

Test piece is shown right. Injection is the condition of injection pressure (1.2 multiple of the minimum pressure to fill 0.7mm clearance (A)). Measure the length of the part of 10micron(B) & 20micron(C) thickness clearance with microscope.

Machine

KEYENCE DIGITAL MICROSCOPE VHX-500P

Molding Condition

*Molding Machine : 30t Electric Injection Machine(Sumitomo)
*Cylinder Temp. : 310, 320, 330°C
*Molding Temp. : 130°C
*Injection / Cooling : 10sec/15sec
*Injection Pressure : 0.7mm thickness(A)
Minimum filling pressure x 1.2(MPa)

Flash Evaluation Test Piece & Clearance Thickness

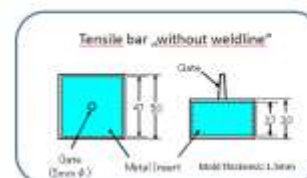
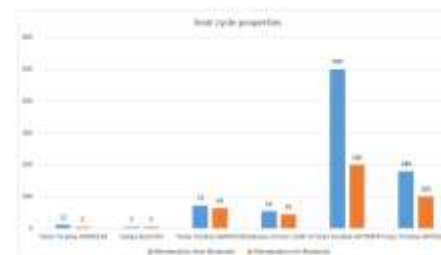


Test Result

Cylinder Temp	Thickness	Method	Unit	A604WRB	A604B	C's
310°C	10µm	Toray	µm	80	90	80
	20µm			110	120	100
320°C	10µm	Toray	µm	75	80	75
	20µm			100	110	105
330°C	10µm	Toray	µm	80	—	—
	20µm			105	—	—

Heatcycle-properties

Confidential



		Wärmeszyklen ohne Bindenaht / mit Bindenaht	
PPS-GF40	Toray Torayline AG604B	12	>6
(cross-linked)	Solvay Ryton A4	>6	>6
PPS-GF40	Toray Torayline AG604WRB	12	>6
(linear)	Celanese Furrtron 1140 LR	24	>40
PPS-GF20-I	Toray Torayline AG73M1B	200	>200
PPS-SP/MP10-I	Toray Torayline AG75G53B	>180	>200

Water Pressure Cracking Test

■ Test Method

1. Use the T shape test piece shown in the right picture.
2. Connect it to the hand pump with special tool to fix it firmly.
3. Put water inside the test piece and eliminate air inside.
4. Put water pressure gradually by the pump
5. Measure the water pressure when the test piece breaks (n=3)

* Hand Pump: Kyowa Inc. 30MPa Test Pump shown in right below.

■ Molding Condition

- *Molding Machine: 100t Electric Injection molding Machine (Sumitomo)
- *Cylinder Temp: 305 / 305 / 305 / 285 °C
- *Mold Temp: 130 °C
- *Injection / Cooling time: 5sec / 20sec
- *Injection pressure: Set the injection pressure at a number which has a filling time of 1sec.
- *Injection time: 1sec(actual)
- *Holding pressure: 50% of injection pressure
- *Holding time: 3sec

■ Test Result

Item	Test Method	A604WRB	A604B	C's
Water Pressure Cracking Test	Toray	8 MPa	7 MPa	7 MPa



Test Piece (HS G3452)
Outside Diameter: 21.7mm(15A)
Thickness: 2.8mm
※ A&B has same diameter

Toray T shape test piece



Hand Pump

Water Hammer resistance

■ Test method

1. Using Toray T shape test piece
 2. Connect it and conduct the test under the following condition
- *Maximum Water hammer pressure: 2MPa
 - *Cycle: 0.1million cycle
 - *Water temp: Tap water temp
3. Crack check after the above treatment

Water Hammer Test Equipment



Toray T shape Test piece



Test Piece (HS G3452)
Outside Diameter: 21.7mm(15A)
Thickness: 2.8mm
※ A,A'&B have same diameter

■ Test result

Item	A604WRB	C's
0.1mil cycle	No Crack	No Crack

Hot internal pressure creep test

■ Test Method

1. Prepare 95°C hot water in the test bath
2. Connect and fix T-shape test pieces with special tool and dip it in the bath with hot water.
3. Connect the test pieces to the pump and fill water in the test pieces, eliminate air inside and put 1.2MPa water pressure.
4. After 1,000hrs treatment, check the change on the measuring point on the test pieces (A, A' & B inside diameter/ 16points) by Mitsutoyo 3D size measuring instrument.
5. If required, we can continue to do testing till the time desired.

Toray T-Shape Test Piece



Test Piece (HS G3452)
Outside Diameter: 21.7mm(15A)
Thickness: 2.8mm
※ A,A'&B have same diameter

■ Test Result

1. Dimensional stability

Please refer to Page 33. A' & A didn't have any difference. All samples didn't have any water leak.

2. Water pressure strength

Please refer to the Page 34.



Test piece setting

Tooling die for screw bolt part & Torque testing

■ Tooling die for screw/bolt



■ Gauge for screw/bolt



■ mold parts of R 1/2 Taper pipe screw



	φ9	φ11	φ13
a (mm)	8.0000	11.000	13.000
b (mm)※	10.793	8.793	8.793

※ The thickness b is calculated with the pitch diameter of R 1/2 taper pipe screw.

R 1/2 Taper pipe screw		
Pitch diameter (mm)	Outer diameter (mm)	Root diameter (mm)
10.793	20.975	18.623

Extrusion @TORAY TPS Mishima



Outside diameter : $\phi 9\text{mm}$ & $\phi 7.5\text{mm}$
Inside diameter : $\phi 7\text{mm}$ & $\phi 5.5\text{mm}$
(Wall thickness: 1mmt)



Can change the pipe size

Suction blow @TORAY Nagoya



Outside diameter : $\phi 17\text{mm}$
Inside diameter : $\phi 13\text{mm}$
(Wall thickness: 2mmt)



Can change the design with insert mold

PPS APPLICATIONS

- Automotive Application
- Non-Automotive Application



Target Applications for PPS in Automotive

1 Thermal Management System

- impeller housing
- valve housing
- water pump
- thermostat

2 Turbo

- pumps
- coolant pipe
- turbo duct
- intercooler

3 Pumps

- pumps
- coolant pipe
- turbo duct
- intercooler

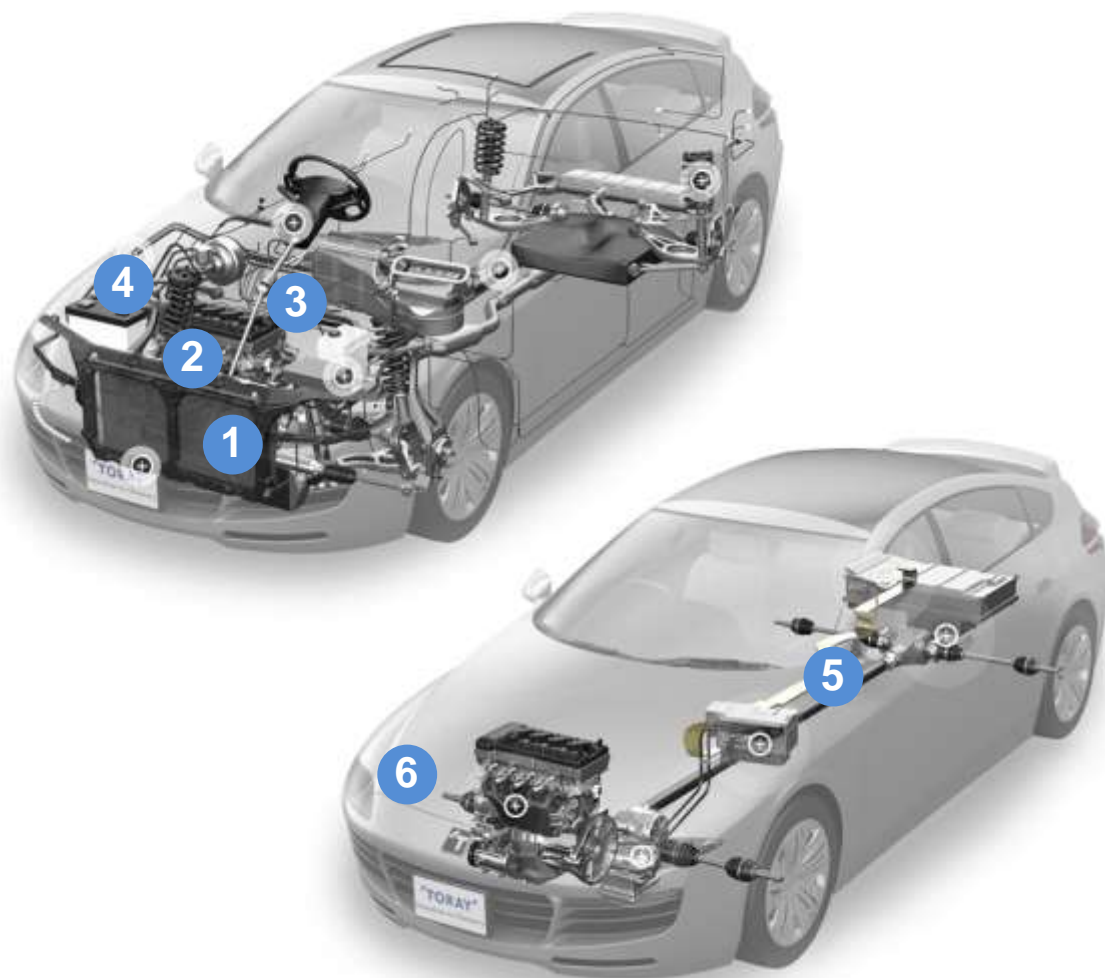
4 Auto Electrical

- busbar
- ignition coil
- coolant pipe
- connectors

5 Hybrid Electrical Vehicles

- Inverter
- power module
- capacitor frame

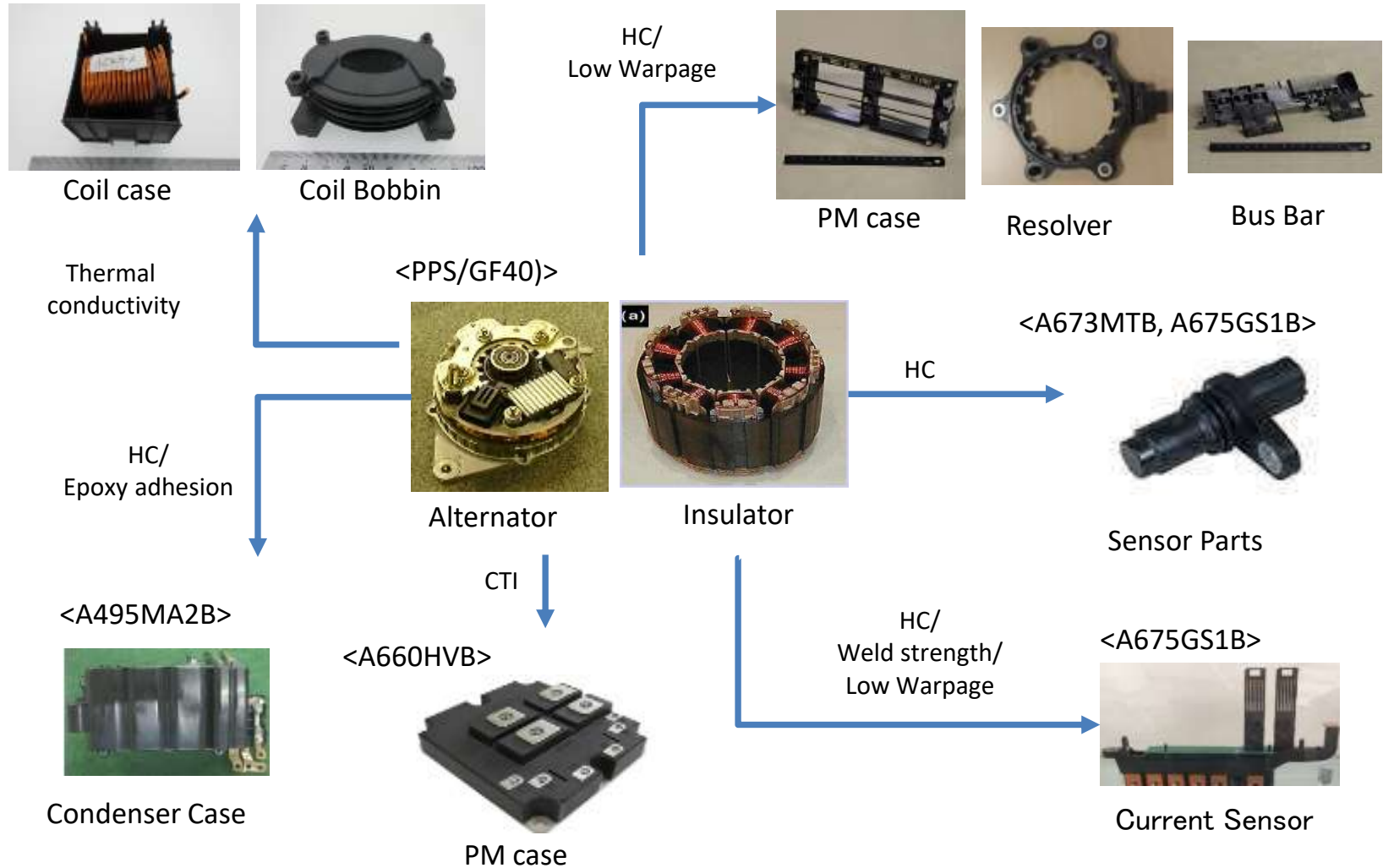
6 Others (brush holder, cover, lamp reflector)





E-Mobility

Target Application and Case study



OEM FCV sales and development situation

TOYOTA MIRAI(2014-)



HONDA CLARITY(2016-)



GM FCV



DAIMLER FCV(2017)



HKMC Tucson FCV(2013-)



Collaboration: TOYOTA&BMW、GM&HONDA、NISSAN-RENAULT&DAIMLER+FORD

Applications for Reciprocating Engine vehicle

Power train & Engine Parts

Intake manifold, Engine cover,
Turbo duct, Ignition coil



Electric Parts

Lever combination switch, ECU case,
Wire harness connector



Cooling Parts

Radiator tank, Cooling fan,
Water treatment module

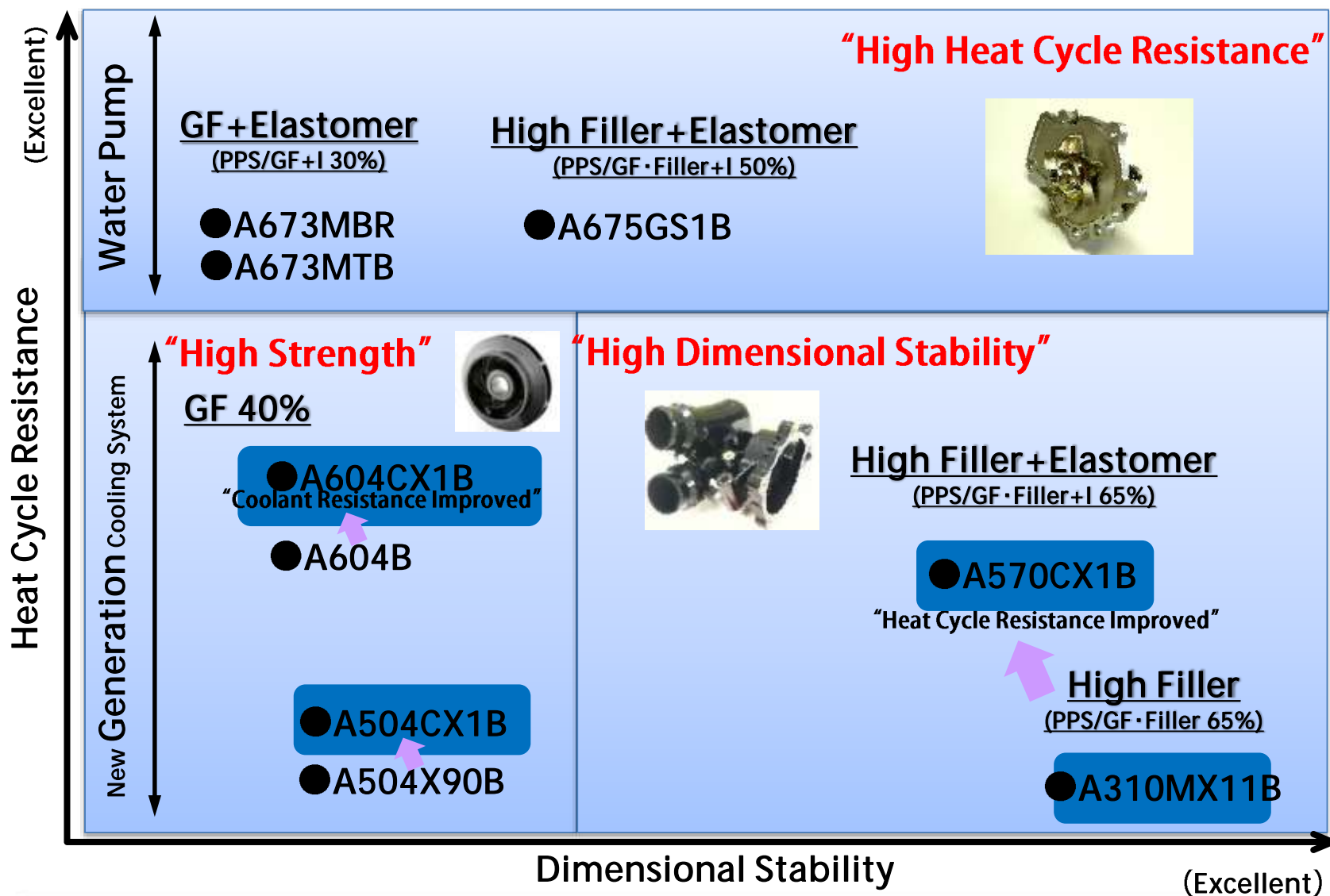


Interior & Exterior Parts

Head lamp, Door lock, Power window



Material Line-Up for Water Treatment Modules



TORAY PPS Solutions for Engine Cooling Systems

The Challenge

Rapid Heating
&
Optimized
Thermal Management

Integrated Modular Solutions

- Long Life Coolant Resistance
- New coolants
- Hydrolysis Resistance
- Heat Shock Resistance



Pumps



Impellers

Covers and Housings

Tube-extrusion-PJ (global)



PPS APPLICATIONS

- Automotive Application
- Non-Automotive Application



Regulatory approval of Torelina PPS grades

Grade /color			A673MWR B/NC	A604WR B/G/NC	A670R63 B/NC
Filler rate			GF30+elastomer	GF40	Unreinforced +elastomer
Features			High impact resistance moist and heat resistance	Toughness	High toughness
W A T E R	NSF ANSI61	USA	○	○	Apr. 2019
	KTW	Germany	○	○	Jun. 2019
	W270		○	○	Jun. 2019
	WRAS	UK	○	○	Apr. 2019
	ACS	France	○	○	Jun. 2019
F O O D	FDA	USA	-	○	-
	EU10/2011	EU	-	○	○
Long term	ISO9080		-	○	Sept. / 2019

Weight Reduction by PPS Replacement

<PPS replacement of drain part>



<PPS replacement heating manifold>



<PPS replacement of joint part>



<hot water tank: joint & valve>



【Advantage of PPS】

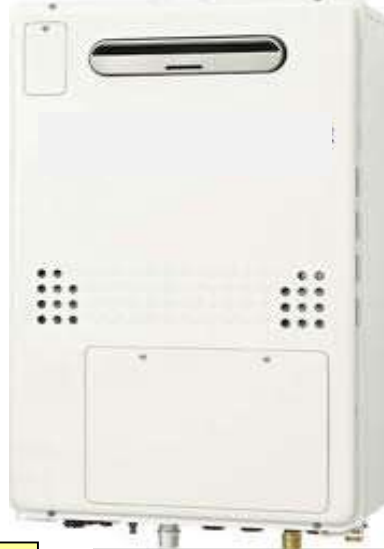
①Reduce weight ②Reduce parts ③Shape flexibility ④Slim shape

Water Appliance Application

①Faucet



②Gas Water Heater



③Electric Water Heater (EcoCute)



④Water Joint (household pipeline)



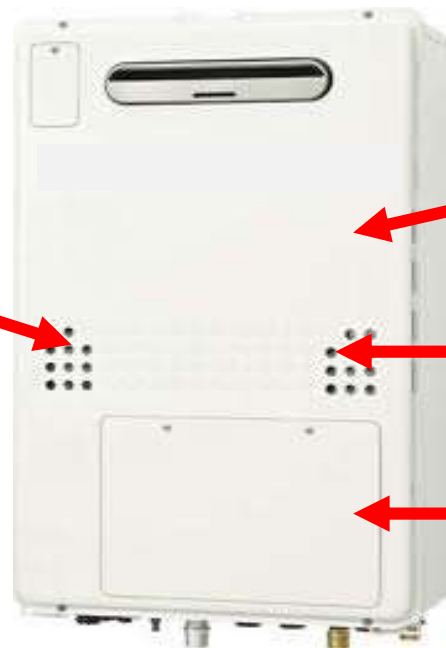
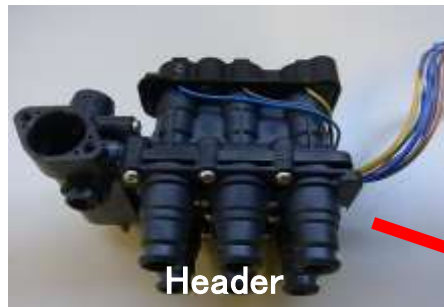
⑤Commercial Water Filter



⑥water meter



Gas Water Heater (multi-unit with floor heating system and hot-water heater)

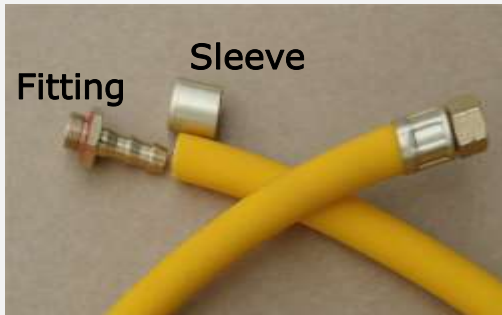


: Toray A673MB2 items

~1kg/unit of PPS is used.

Fitting Business

<BEFORE : Metal>



Cost Down
(Low Density &
Processing Cost)



<Current : PPSU>



Replacing from PPSU to PPS can be more cost down

*Estimated Market Price of PPSU: over 15-25 €/kg > PPS unfilled

*Mechanical Properties: PPSU \approx PPS

⊖ Water appliance application



Item

Water Joint
(For household pipeline)

Grade

A670MT1B
(Quench (Unfilled) and Elastomer)

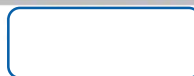
Quantity

36 MT /year

Start

Feb. 2017 ~

User



Requirement properties :

- 1) High toughness
- 2) High impact resistance
- 3) Chemical resistance

Handpresso



Molder: Simatelex
OEM: KEURIG
Nespresso
Issue: Replace Solvay PPS R4-232
application: steam Nozzle / VALVE COVER /
VENTURI BODY / VENTURI OUTLET



Home appliance application



Item

Induction cooking plate

Grade

A310MX04B

Requirement :

1) thermal resistance



Home appliance application



Item

Auto-dishwasher (steam BOX)

Grade

A504X90B



Requirement :

- 1) thermal resistance
- 2) Hot water resistance

Home appliance application



Item

Micro wave oven
(Turn table)

Grade

A310MB7

Requirement :

1) thermal resistance



Torelina Neat Resin for compounding



compounding

Toray offers Torelina Neat Resin for compounding (flakes, granules, powder).
A NDA is needed (in advance) for exchange of any information.





General information

KEYWORDS

Thermal management (automotive)

FDA-compliance

Hydrolysis resistance

Metal-overmolding

Coolant tubes & systems

Fortron / DIC / Ryton / TEDUR / Xytron / ...

High heat resistance

UL94: V0 flammability

Tracking Index CTI

Electric vehicle

chemical resistance

No water-uptake

Dimensional stability

Yellow Card (RTI)

Potable water-approvals (KTW, WRAS, NCS; ANSI, ...)

Flowability / thin-wall

Heat-cycle properties

Extrusion: compounding

APPROACH

Search PPS-customers in your region → substitution of running grades

- shortage (for example Ryton)

Toray offers: stable supply

- price increase (for example Fortron)

Toray offers: frame-contracts (binding prices)

News Release



Celanese Corporation
222 West Las Colinas Blvd.
Suite 900N
Irving, Texas 75039

Celanese Announces Price Increases for Engineered Material Fortron® PPS Polymer

DALLAS, AMSTERDAM & SHANGHAI (Nov. 20, 2018) – Celanese Corporation (NYSE: CE), a global specialty materials company, today announced price increases for its Fortron® polyphenylene sulfide (PPS) grades.

The price increases below will be effective for orders shipped on or after January 1, 2019, or as contracts otherwise allow.

Product	Americas (\$/kg)	Europe (€/kg)	Asia (\$/kg)
Fortron® (PPS)	\$0.85	€0.70	\$0.65

Individual grades may be subject to a higher increase than specified above.



September 28, 2018

RE: Notice of Force Majeure for Polyphenylene Sulfide Products

Dear Valued Customer:

As a result of Hurricane Florence's impact on Fortron's operations, suppliers, and service providers in and around the Wilmington, North Carolina area, beginning on September 11, 2018, Fortron is temporarily unable to supply the full polyphenylene sulfide (PPS) needs of our customers.

Fortron is in the process of assessing the effects of this force majeure event which has arisen from circumstances beyond Fortron's reasonable control. Given that this is a developing situation, Fortron cannot provide any specific details or timing of the full impact to all customers. Fortron will stay in close communication with you and will work with you to minimize the impact of this event.

If you have questions regarding your orders, please feel free to contact customer service or your designated sales representative.

Sincerely,

Scott Sutton
President

'TORAY'

Innovation by Chemistry

