

General

Confidential

Secret

Introduction of

**LG Chem**

**LUSEP (PPS Compound)**



# Contents

## ▶ LG CHEM ENGINEERING PLASTICS

- ▶ Global Network
- ▶ Technical Service
- ▶ EP Product Portfolio
- ▶ LUSEP Portfolio
- ▶ Applications of LUSEP
- ▶ Technical Datasheet

## ▶ CHARACTERISTICS OF LUSEP

- ▶ Long Term Heat Aging
- ▶ Chemicals and Hot Water Resistance
- ▶ Thermal Shock Resistance
- ▶ Abrasion Resistance
- ▶ Low Flash PPS
- ▶ Mold Releasing
- ▶ Thermally Conductive PPS (LUCON)

## ▶ INJECTION MOLDING GUIDE OF LUSEP

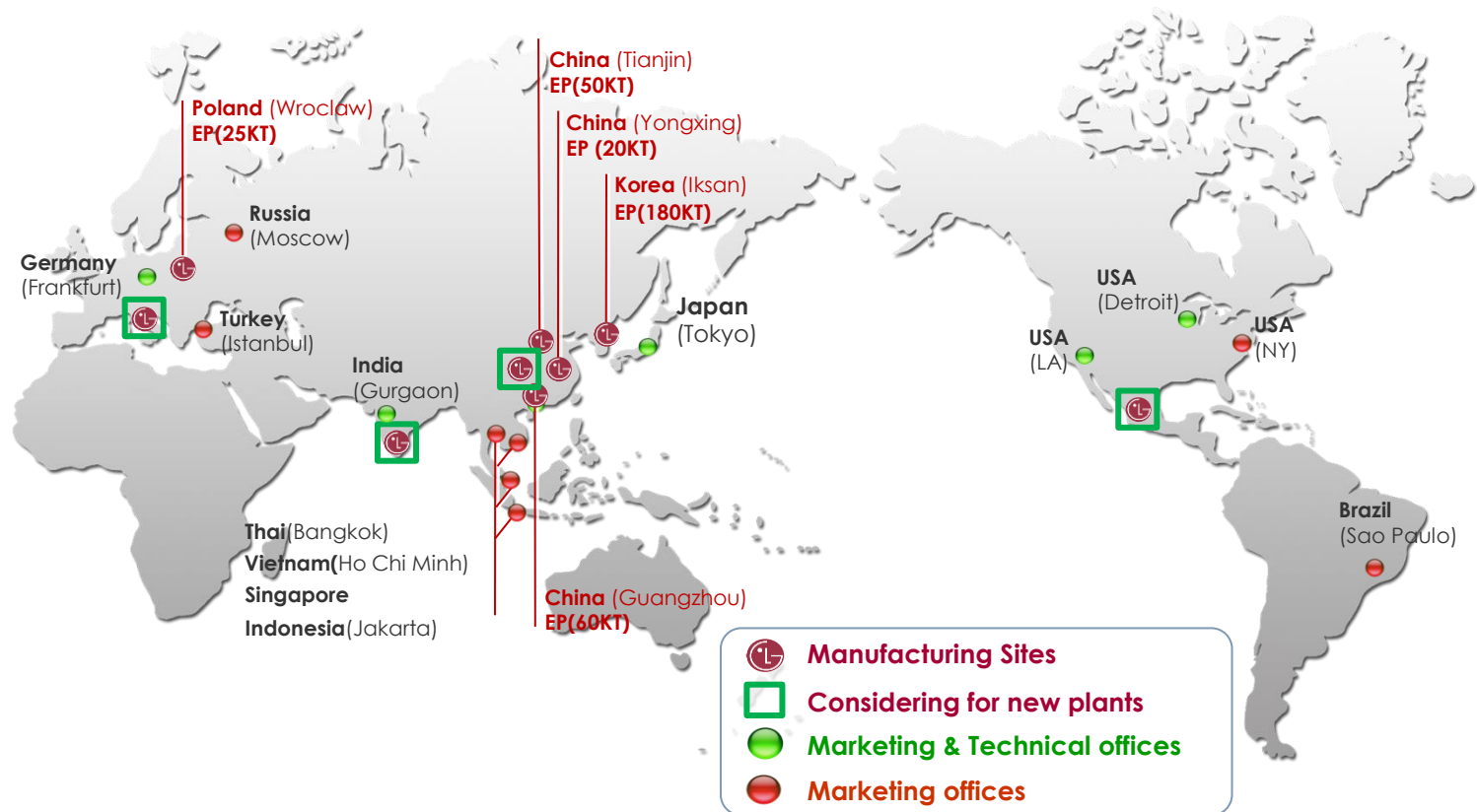
# LG Chem EP: Global Network

LG Chem's global presence can support customers by on-site supply & technical service.  
LG Chem EP will be a top supplier by continuous expansion in production sites & capacity.

**Global Network :**  
On-site Production,  
Technical Service

**Reliable Quality :**  
Total Technical Service

**Customer Oriented R&D :**  
Wide Range of Product  
Portfolio



# LG Chem EP: Technical Service

LG Chem's advanced analysis techniques and well-equipped devices enable full technical support for customers.

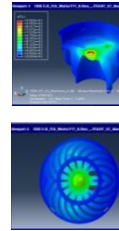
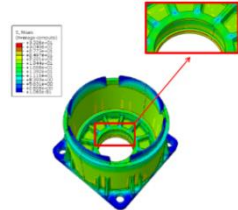
Global Network :  
On-site Production,  
Technical Service

Reliable Quality :  
Total Technical Service

Customer Oriented R&D :  
Wide Range of Product  
Portfolio

## Structural Analysis / Impact & Crash Design

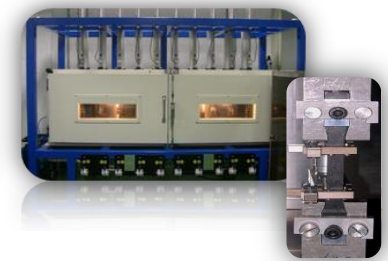
Thermal shock analysis of EGR motor      Thermal analysis of LED bulb



## Material Properties

Fatigue property

Creep resistance

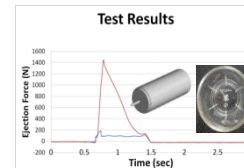
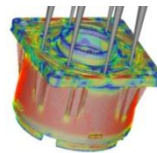
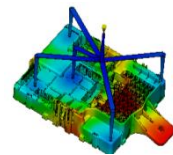


## Injection Molding Analysis

Optimization of gate & runner

Orientation of fiber

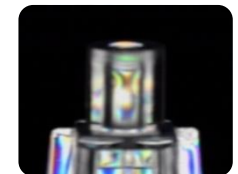
Evaluation of mold releasing property



## Product Reliability

Falling weight impact tester

Residual stress measurement

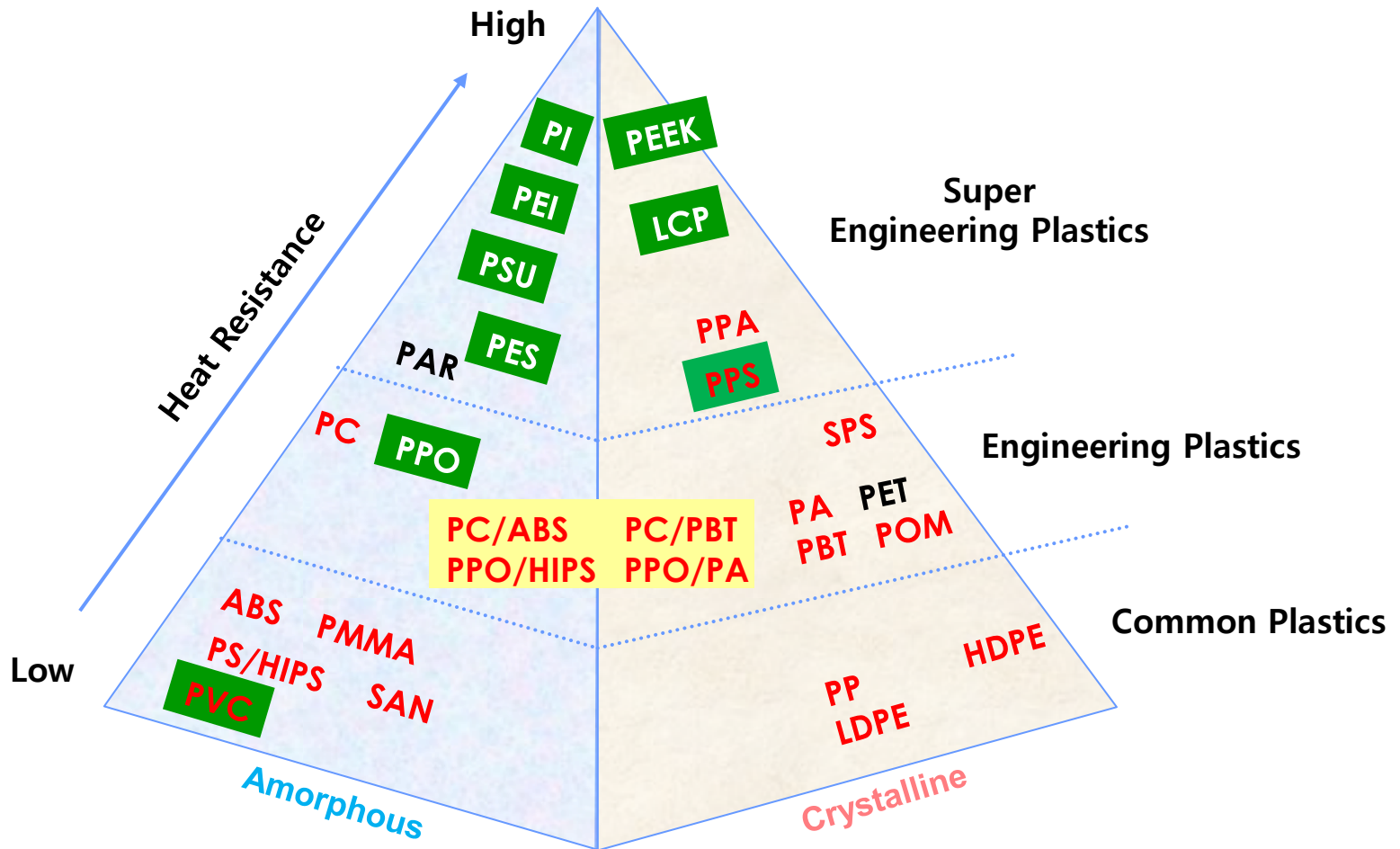


LG Chem

The information contained herein, including, but not limited to, data, statements, and typical values, are given in good faith. The information is valid for referential purpose only. LG Chem makes no warranty or guarantee, expressed or implied regarding to the above information.

# LG Chem LUSEP: Characteristics of PPS

 Inherently Flame Retardant





# LG Chem EP: Product Portfolio

LG Chem offers a wide range of EP products to meet customers' various needs.

Global Network :  
On-site Production,  
Technical Service

Reliable Quality :  
Total Technical Service

Customer Oriented R&D :  
Wide Range of Product  
Portfolio

Polycarbonate

Polyester

Polyamide

TPE

Olefin

mPPE

Styrenics

Acetal

Super EP

Conductive Resin

PC

PC Compound, PC Alloy

PBT, PBT Compound, PBT Alloy  
PBT/Styrenics Alloy

PA Compound, PA Alloy

TPEE (Ester Type Elastomer)  
TPO (Olefin Type Elastomer)

PP Compound

PPE/HIPS, PPE/PA Alloy

Reinforced ABS & SAN

POM, POM Compound

PPS & PPA Compound

ABS, PS, PC, mPPE, PPS Compound

LUPOY

LUPOX  
LUMAX

LUMID

KEYFLEX BT  
KEYFLEX TO

LUPOL

LUMILOY

LUPOS

LUCEL

LUSEP

LUCON



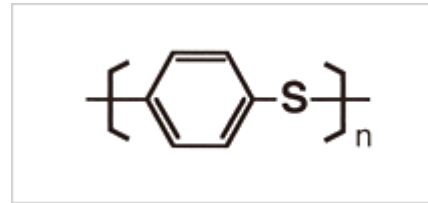
LG Chem

The information contained herein, including, but not limited to, data, statements, and typical values, are given in good faith. The information is valid for referential purpose only. LG Chem makes no warranty or guarantee, expressed or implied regarding to the above information.

# LG Chem PPS: What is PPS?

## ► Features of LUSEP

- Chemical Structure of Polyphenylene Sulfide



- ◆ LUSEP covers wide range of products to meet the various applications including automotives, electricals, electronics and industrials.
- ◆ LUSEP exhibits excellent heat resistance, chemical resistance, flame retardance and low moisture absorption.  
LUSEP also shows minimal decrease of mechanical strength and no dimensional change by absorption of moisture.
- ◆ Glass fiber reinforced LUSEP grades show superior mechanical strength and stiffness.
- ◆ Glass fiber and mineral filler reinforced LUSEP have many advantages including great dimensional stability, low coefficient of thermal expansion, low warpage and good electrical properties such as high CTI and arc resistance.
- ◆ LUSEP covers wide range of specialty grades including low flash characteristics, thermal shock resistance, abrasion resistance, and metal and epoxy adhesion properties.
- ◆ LUSEP has excellent melt flow, it is therefore suitable for injection molding of small precision parts with good surface finish.
- ◆ LUSEP releases small amount of outgas caused by volatile organic compounds during processing.



# LG Chem PPS: Opportunity of Metal and Thermoset Replacement

## ► Comparison with Competitive Materials

Criteria	Unit	PPS/GF 40%	Al-Die Casting	Phenolic Resin	Merits of PPS	
Specific Gravity	-	1.66	2.71	1.76	Lower weight	
Tensile Strength	MPa	180	240	70	Higher than Phenol	
Flexural Strength	MPa	260	-	140	Higher than Phenol	
Impact Strength	-	High	High	Low	Higher than Phenol	
High Temp. Performance	-	Good	Good	Annealing required	Better than Phenol	
Chemical Resistance	-	Excellent	Painting required for anti-corroison	Excellent	Painting for anti-corrosion unnecessary	
Design Freedom	-	High	Low	Low	Higher than Phenol	
Surface Finish Secondary Processing	-	Good Unnecessary	Trimming & machining required	Good Trimming required	Good Unnecessary	
Mold ing	Molding Time	Sec	20 ~ 25	10 ~ 60	30 ~ 40	Shorter than Phenol
	Defect Rate	-	Low	High	High	Low
	Mold Life	Shot	0.5 ~ 1 X 10 <sup>6</sup>	0.1 X 10 <sup>6</sup>	0.3 ~ 0.5 X 10 <sup>6</sup>	2-5 times than ALDC
	Recycle	-	Possible	Regrinding impossible	Impossible	Possible

\* PPS has advantages of lower weight and manufacturing cost than aluminum and higher productivity and recyclability compared with Phenolic resin.



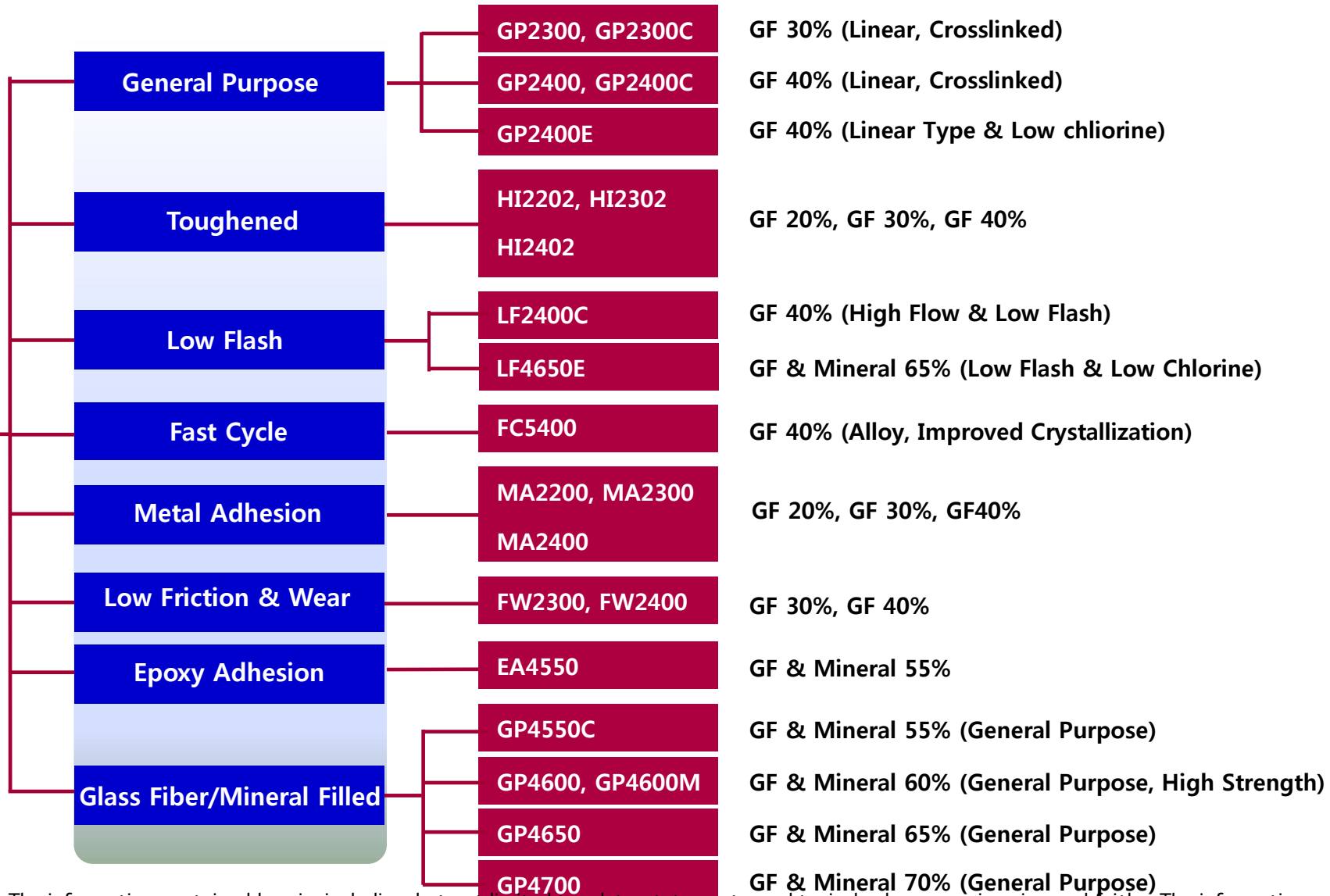
**LG Chem**

The information contained herein, including, but not limited to, data, statements, and typical values, are given in good faith. The information is valid for referential purpose only. LG Chem makes no warranty or guarantee, expressed or implied regarding to the above information.



# LG Chem PPS: Grade List

## LUSEP PPS



The information contained herein, including, but not limited to, data, statements, and typical values, are given in good faith. The information is valid for referential purpose only. LG Chem makes no warranty or guarantee, expressed or implied regarding to the above information.

# LG Chem PPS: Grade Recommendation

## ► Automotive Electric Parts

LUSEP has excellent mechanical strength, long term heat resistance, chemical resistance, dimensional stability and electrical properties to endure for automotive underhood applications which lie under harsh environments such as high temperature, vibrations and broad range of fluids such as fuels, oils and coolants.

- Brake System
- Cooling System
- Fuel System
- Electrical System
- Exhaust Gas Recirculation System
- Lighting
- Control System
  - Sensors, ECU, Valves

Water Pump Body/Impeller  
LUSEP GP2400, GP2400C  
FW2400



EGR Motor Housing  
LUSEP HI2402



EV/HEV Capacitor Case  
LUSEP EA4550



EV/HEV Converter Bobbin  
LUSEP HI2402



Ignition Coil  
LUSEP HI2202, HI2302



Power Window Switch Wafer  
LUSEP FC5400



Engine Control Sensors  
LUSEP HI2302, GP4650



Fuel Pump Brush Holder  
LUSEP GP2400



Head Lamp Reflector/Base Plate  
LUSEP GP4650, GP4600M/GP2400



Alternator Brush Holder  
LUSEP GP2400, GP4650



Fuel Pump Impeller  
LUSEP GP4650



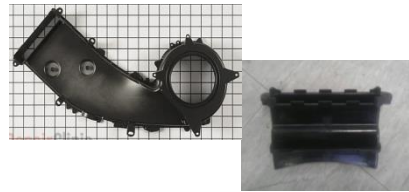
# LG Chem PPS: Grade Recommendation

## ► Electrics/Electronics and Home Appliance Parts

LUSEP has excellent properties to make it possible for weight and cost savings for E&E and home appliance products. It has superior melt flow, low mold shrinkage, high mechanical strength and excellent long term heat aging resistance in order to deal with various applications. It also has high thermal resistance and is suitable materials for SMT. Low flash grades have been developed for precision molding of sockets and connectors. Most of LUSEP grades exhibit UL94 V-0 flame retardance.

- Capacitor
- Connector / Socket
- Relay, Switch, Circuit Breaker
- Bobbin, Coil
- Gears
- Boiler Plumbing
- Consumer Electronics Parts

Washing Machine Connector Duct  
LUSEP GP4600M, GP4700C



Connectors  
LUSEP GP2400, LF2400C



Optical Pick-Up Base  
LUSEP GP4600M, LF4650E



Temperature Sensors for Washing Machine and Refrigerator  
LUSEP GP2400, HI2402



Fitting and Pipes for Boiler  
LUSEP HI2302, HI2202



Projector Lamp Housing  
LUSEP GP2400



Printer Gears  
LUSEP GP2400, FW2400



Micro Wave Oven Rotator Ring  
LUSEP GP2400, GP4550



Electronic Adaptor Transformer  
LUSEP GP2400E



# LG Chem LUSEP : Technical Data (1)

● Table 1. Standard and Toughened Grades

Property	Test Method	Unit	GP2300	GP2400	GP2400C	HI2202	HI2302	HI2402
<b>Physical Property</b>			GF 30% Linear ←	GF 40% Linear General Purpose	GF 40% Crosslinked →	GF 20% Toughened	GF 30% Toughened	GF 40% Toughened
Specific Gravity	ASTM D792	-	1.55	1.65	1.65	1.42	1.50	1.63
Mold Shrinkage 2.0mm, MD/TD	-	%	0.27/0.82	0.18/0.78	0.18/0.78	0.32/1.2	0.28/0.90	0.20/0.85
Water Absorption Ratio, 23°C, 24hrs	ASTM D570	%	0.02	0.02	0.02	0.02	0.02	0.02
<b>Mechanical Property</b>								
Tensile Strength	ASTM D638	MPa	150	190	180	135	155	170
Elongation	ASTM D638	%	1~2	1~2	1~2	2~3	2~3	2~3
Flexural Strength	ASTM D790	MPa	250	275	255	200	230	250
Flexural Modulus	ASTM D790	MPa	12,700	13,500	13,500	7,400	9,600	12,500
Notched Izod Impact Strength	ASTM D256	J/m	70	90	80	82	120	110
Rockwell Hardness	ASTM D785	-	121	121	121	112	118	120
<b>Thermal Property</b>								
Heat Deflection Temp. @1.82MPa	ASTM D648	°C	263	267	268	260	260	265
<b>Electrical Property</b>								
Comparative Tracking Index	IEC112	Volt	170	170	170	180	180	180
Dielectric Strength, 2mm thick	IEC60243-1	KV/mm	20	19	19	21	20	20
<b>Flame Retardant Property</b>								
Flammability	UL 94	-	V-0 @0.4mm	V-0 @0.4mm	V-0 @0.4mm	-	-	-



**LG Chem**

The information contained herein, including, but not limited to, data, statements, and typical values, are given in good faith. The information is valid for referential purpose only. LG Chem makes no warranty or guarantee, expressed or implied regarding to the above information.

# LG Chem LUSEP : Technical Data (2)

● Table 2. Highly Glass Fiber and Mineral Filled Grades

Property	Test Method	Unit	GP2500	GP4550	GP4600M	GP4650	GP4700	
			GF 50%	GF & MF 55%	GF & MF 60%	GF & MF 65%	GF & MF 70%	
<b>Physical Property</b>			←————— General Purpose —————→					
Specific Gravity	ASTM D792	-	1.75	1.83	1.87	1.96	2.04	
Mold Shrinkage 2.0mm, MD/TD	-	%	0.15/0.71	0.17/0.55	0.16/0.38	0.16/0.33	0.16/0.33	
Water Absorption Ratio, 23°C, 24hrs	ASTM D570	%	0.02	0.02	0.02	0.02	0.02	
<b>Mechanical Property</b>								
Tensile Strength	ASTM D638	MPa	200	140	155	155	135	
Elongation	ASTM D638	%	1~2	1~2	1~2	1~2	1~2	
Flexural Strength	ASTM D790	MPa	290	190	205	220	190	
Flexural Modulus	ASTM D790	MPa	15,000	15,200	16,600	19,000	18,000	
Notched Izod Impact Strength	ASTM D256	J/m	85	60	55	55	50	
Rockwell Hardness	ASTM D785	-	121	121	122	122	121	
<b>Thermal Property</b>								
Heat Deflection Temp. @1.82MPa	ASTM D648	°C	267	267	267	268	268	
<b>Electrical Property</b>								
Comparative Tracking Index	IEC112	Volt	170	170	180	200	250	
Dielectric Strength, 2mm thick	IEC60243-1	KV/mm	-	-	19	19	-	
<b>Flame Retardant Property</b>								
Flammability	UL 94	-	V-0 @0.4mm	V-0 @0.4mm	V-0 @0.4mm	V-0 @0.4mm	V-0 @0.4mm	

# LG Chem LUSEP : Technical Data (3)

● Table 3. Low Flash, Metal Adhesion, Wear Resistant, Epoxy Adhesion Grades

Property	Test Method	Unit	LF2400C	MA2200	MA2400	FW2300	FW2400	EA4550
<b>Physical Property</b>			GF 40% Low Flash	GF 20% Metal Adhesion	GF 40% Metal Adhesion	GF 30% Wear Resistance	GF 40% Wear Resistance	GF & MF 55% Epoxy Adhesion
Specific Gravity	ASTM D792	-	1.64	1.44	1.60	1.62	1.72	1.80
Mold Shrinkage 1.5mm, MD/TD	-	%	0.19/0.80	0.31/1.02	0.19/0.78	0.25/0.89	0.16/0.78	0.16/0.52
Water Absorption Ratio, 23°C, 24hrs	ASTM D570	%	0.02	0.02	0.02	0.02	0.02	0.02
<b>Mechanical Property</b>								
Tensile Strength	ASTM D638	MPa	160	110	170	155	150	150
Elongation	ASTM D638	%	1~2	1~2	1~2	1~2	1~2	1~2
Flexural Strength	ASTM D790	MPa	220	150	240	210	220	215
Flexural Modulus	ASTM D790	MPa	13,500	6,300	11,000	11,000	15,000	15,500
Notched Izod Impact Strength	ASTM D256	J/m	65	50	85	70	60	60
Rockwell Hardness	ASTM D785	-	121	112	118	119	120	120
<b>Thermal Property</b>								
Heat Deflection Temp. @1.82MPa	ASTM D648	°C	265	253	260	262	265	263
<b>Electrical Property</b>								
Comparative Tracking Index	IEC112	Volt	170	180	180	-	-	-
Dielectric Strength, 2mm thick	IEC60243-1	KV/mm	21	21	20	-	-	-
<b>Flame Retardant Property</b>								
Flammability	UL 94	-	-	-	-	-	-	-





# LG Chem LUCON : Technical Data (4)

● Table 3. Thermally Conductive PPS Grades

Property	Test Method	Unit	PN9025	PN9055	PN9031	PN9051	PN9101
<b>Physical Property</b>							
Specific Gravity	ASTM D792	-	1.80	1.85	1.65	1.55	1.85
Mold Shrinkage 2.0mm, MD/TD	-	%	0.15/ 0.40	0.11 / 0.32	0.23 / 0.59	0.31 / 0.60	0.26 / 0.37
Water Absorption Ratio, 23°C, 24hrs	ASTM D570	%	0.02	0.02	0.02	0.02	0.02
<b>Mechanical Property</b>							
Tensile Strength	ASTM D638	MPa	80	65	100	60	60
Elongation	ASTM D638	%	1~2	1~2	1~2	3~4	2~3
Flexural Strength	ASTM D790	MPa	90	90	140	85	90
Flexural Modulus	ASTM D790	MPa	10,100	15,600	11,500	11,000	12,000
Notched Izod Impact Strength	ASTM D256	J/m	30	20	35	30	20
<b>Thermal Property</b>							
Heat Deflection Temp. @1.82MPa	ASTM D648	°C	260	265	265	265	265
Thermal Conductivity	ASTM E1461	W/m·K	2	5	3	5	10
<b>Electrical Property</b>							
Surface Resistivity	IEC 60093	Ohm	10 <sup>14~16</sup>	10 <sup>14~16</sup>	10 <sup>7~9</sup>	<10 <sup>7</sup>	<10 <sup>7</sup>
<b>Flame Retardant Property</b>							
Flammability	UL 94	-	V-0 @0.95mm	V-0 @1.0mm	V-0 @0.8mm	V-0 @0.8mm	V-0 @0.8mm



# Features of LUSEP

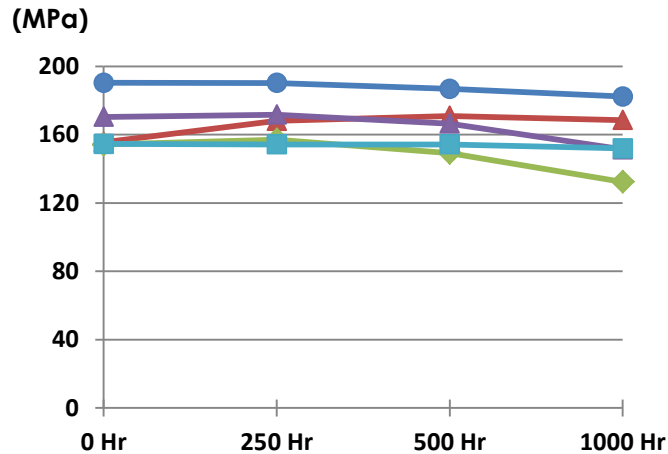
- ▶ Heat Aging Properties
- ▶ Chemicals and Hot Water Resistance
- ▶ Thermal Shock Resistance
- ▶ Metal & Epoxy Adhesions
- ▶ Abrasion Resistance
- ▶ Low Flash PPS
- ▶ Mold Release Characteristics
- ▶ Thermally Conductive PPS

# LG Chem PPS: Heat Aging Property

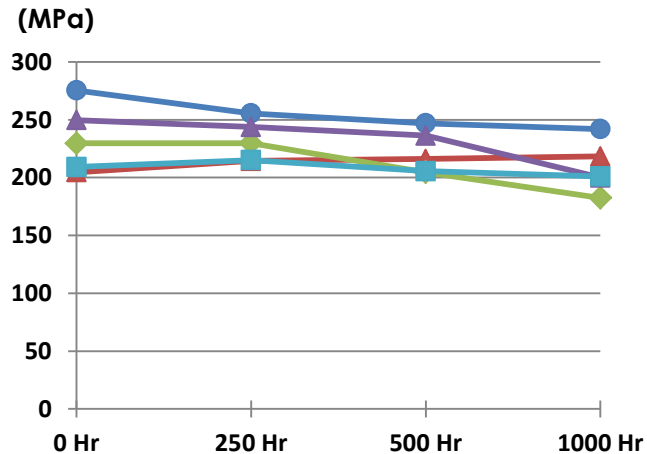
## ▶ Long Term Heat Aging Resistance (180°C, 1,000hrs)

LUSEP PPS shows excellent retention of mechanical properties after prolonged exposure at elevated temperature. For most LUSEP grades, mechanical strengths are remained stable up to 1,000 hours at 180°C.

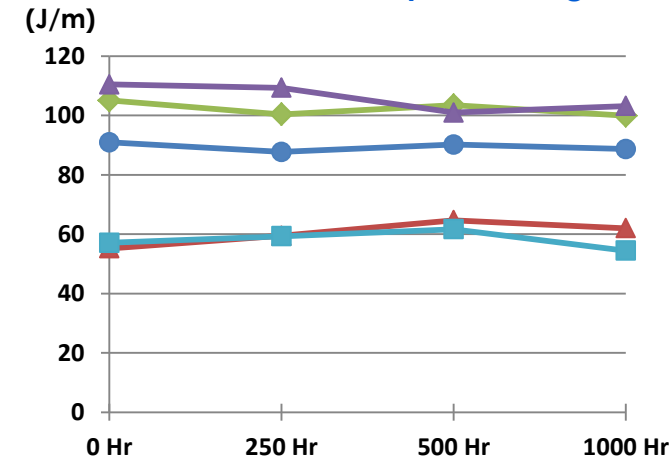
### Tensile Strength



### Flexural Strength



### Notched Izod Impact Strength

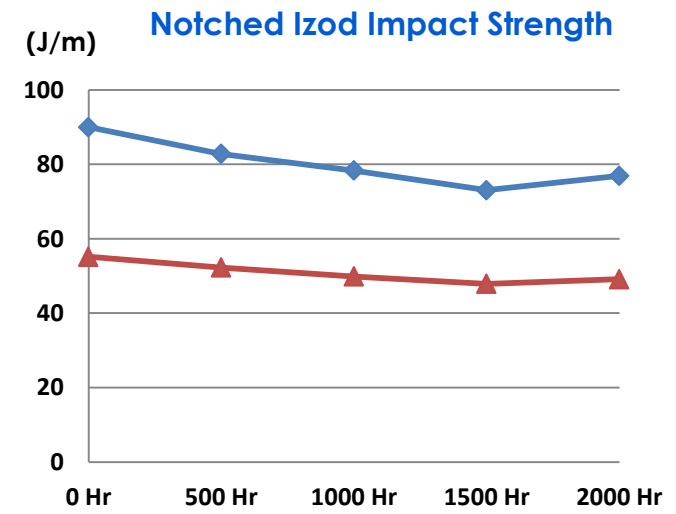
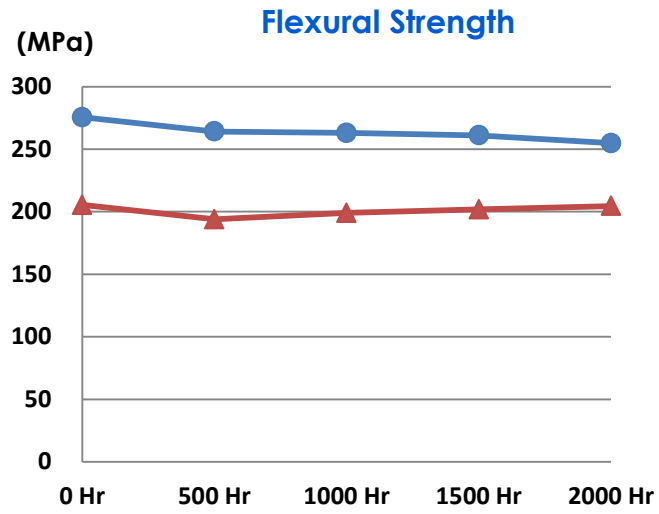
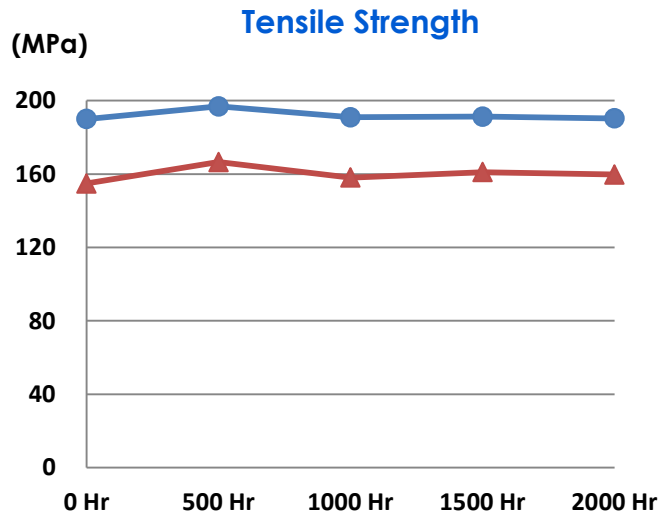


● GP2400    ▲ GP4600M    ◆ HI2302    ▲ HI2402    ■ FW2300

# LG Chem PPS: Heat Aging Property

## ▶ Long Term Heat Aging Resistance (200°C, 2,000hrs) : GP2400, GP4600M

Mechanical properties of LUSEP GP2400 and GP4600M change very little for up to 2,000 hours of heat exposure at 200°C. Mechanical strengths are retained more than 90%, and impact strengths are maintained more than 80%.



● GP2400    ▲ GP4600M

# LG Chem LUSEP: Chemicals and Hot Water Resistance

## ► Chemical Resistance of LUSEP

LUSEP PPS is crystalline thermoplastic and has superior chemical resistance for wide range of chemicals including acids, bases, hydrocarbons and organic solvents even at elevated temperatures and is not chemically dissolved below 200°C.

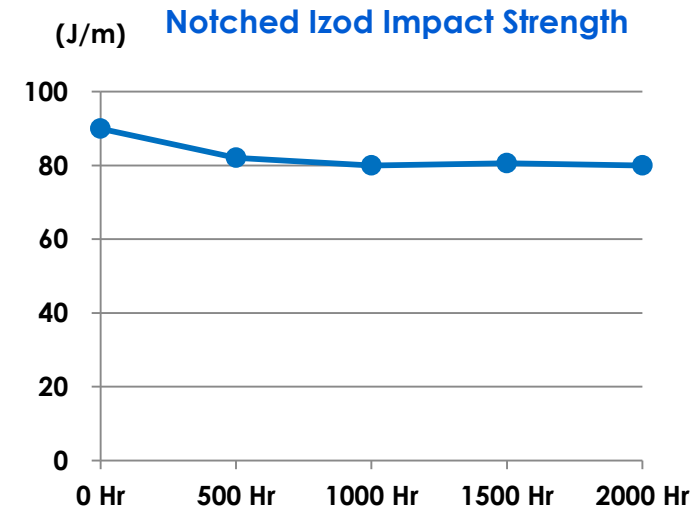
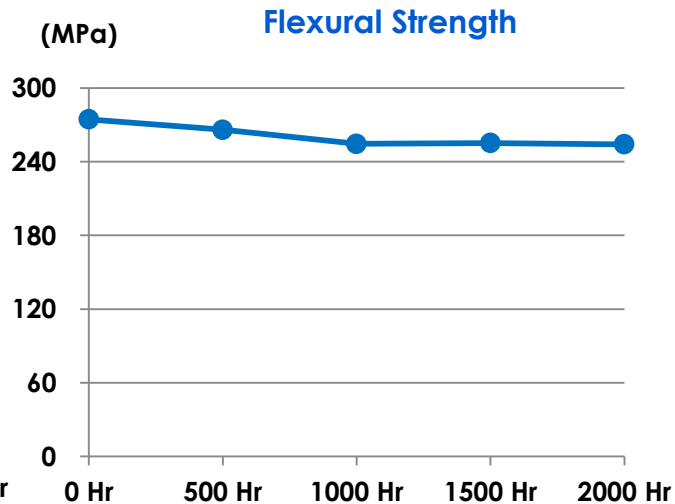
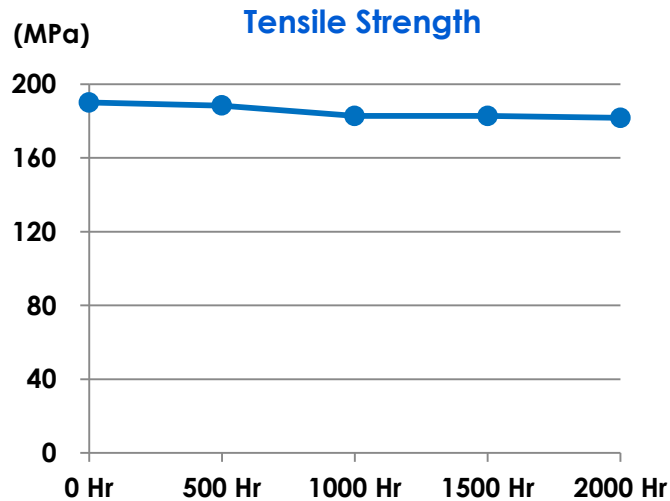
Solvent Resin	AROMATIC HYDRO-CARBONS		ALPHATIC HYDRO-CARBONS		HALOGEN-ATED SOLVENTS		ESTERS AND KETONES		ALCOHOLS		AMINES		STRONG ACIDS		STRONG BASES	
	25°C	93°C	25°C	93°C	25°C	93°C	25°C	93°C	25°C	93°C	25°C	93°C	25°C	93°C	25°C	93°C
Nylon	1	1	1	1	1	2	1	1	1	2	-	2	5	5	2	3
PC	5	5	1	1	5	5	5	5	-	2~5	-	5	1	1	5	5
PBT	2	5	1	3~5	3	5	2	3~4	1	1	1	1	1	1	1	1
PTFE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PPO	4	5	2	3	4	5	2	3	-	2~5	-	5	1	2	1	1
<b>LUSEP (PPS)</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>1~3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
POLYSULFONE	4	4	1	1	5	5	3	4	1	1	-	5	1	2	1	1

1: Very Bad Solubility, 5: Very Good Solubility

# LG Chem LUSEP: Chemicals and Hot Water Resistance

## ► Coolant Test (120°C, 2,000hrs) : GP2400

LUSEP GP2400 retains tensile and flexural strength more than 90% after 2,000 hours immersion in coolant at 120°C. The impact strength is decreased about 10% up to 500 hours and after then remained constantly.

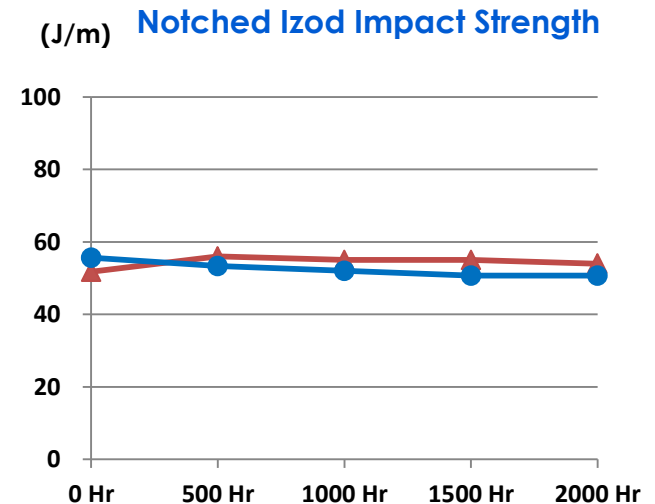
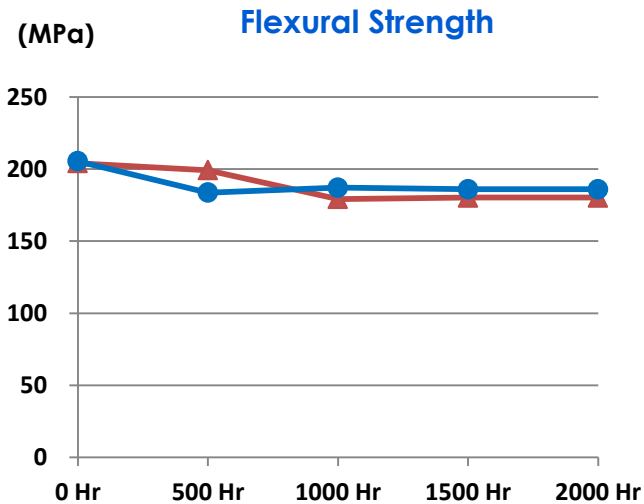
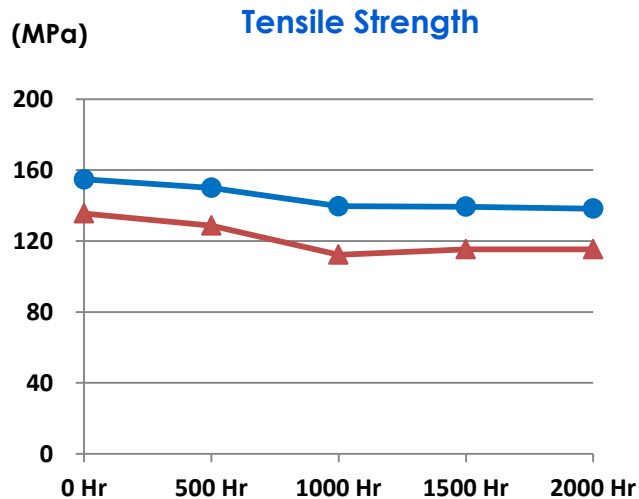




# LG Chem LUSEP: Chemicals and Hot Water Resistance

## ► Coolant Test (120°C, 2,000hrs) : GP4600M

LUSEP GP4600M shows equal and better property retention compared with competitor's equivalent product for soaking in coolant at 120°C.

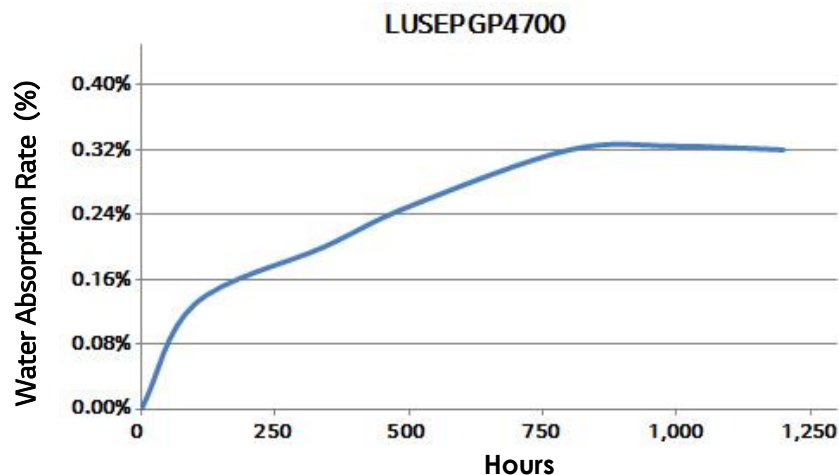
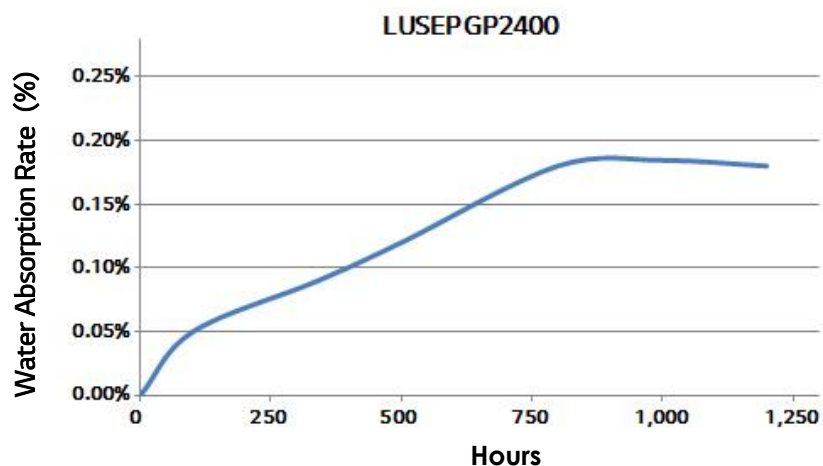


● GP4600M    ▲ Competitor's PPS/GF+MF 60%

# LG Chem LUSEP: Chemicals and Hot Water Resistance

## ► Hot Water Resistance

LUSEP GP2400 and GP4700 exhibit very little moisture absorption rate and tend to show saturated water absorption after 875 hours of 85°C hot water treatment. Reductions in the mechanical properties are small.



• Test condition : Water absorption rate with immersion time in 85°C water

## ► Property Change before and after water immersion

Property	Test Method	Unit	LUSEP GP2400			LUSEP GP4700		
			Before immersion	23°C	85°C	Before immersion	23°C	85°C
Tensile Strength	ASTM D638	MPa	190	187	163	135	125	100
Tensile Modulus			1,450	1,410	1,320	2,250	2,200	2,040

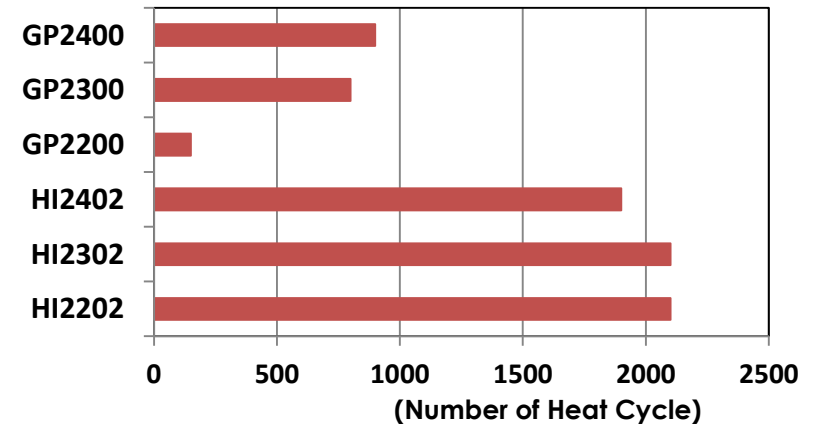
# LG Chem LUSEP: Thermal Shock Property

## ► Thermal Shock Resistance

Heat cycle tests are carried out by using small metal block inserted specimen. Thermal shock resistance of LUSEP HI2000 series show much better performance than those of standard glass fiber reinforced PPS.



\* Heat Cycle Condition : -40℃, 30min ↔ 140℃, 30min



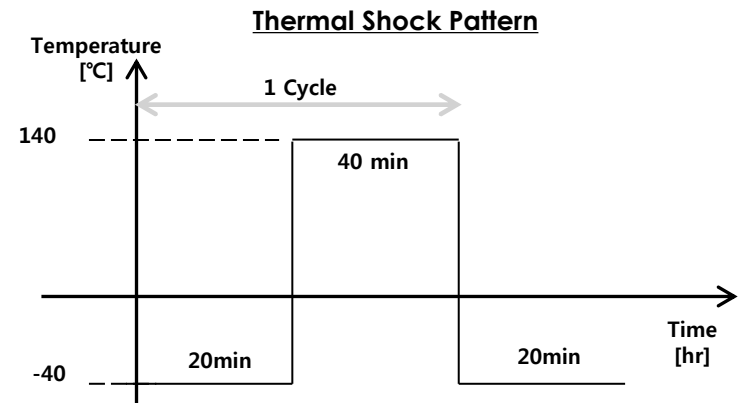
## ► Thermal Shock Evaluation of Automotive EGR\* Motor



LUSEP HI2402

Standard PPS/GF40%  
(Crack detected at 90 cycles)

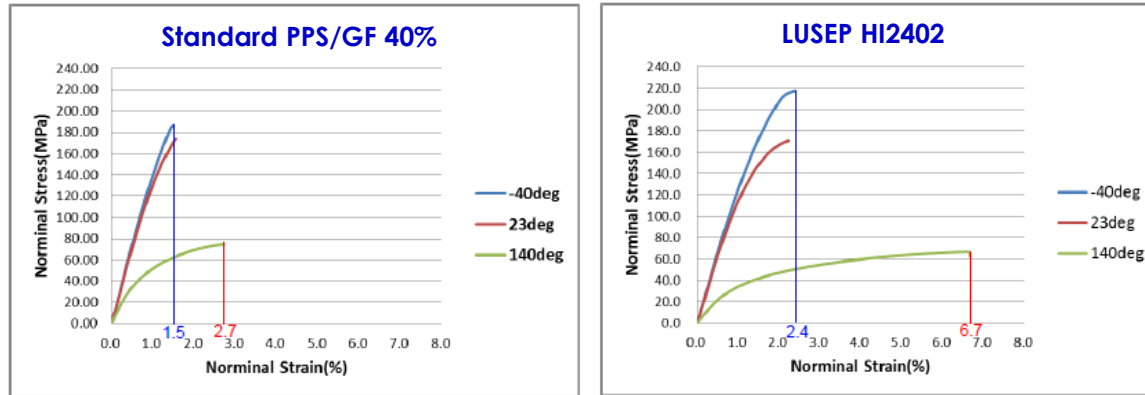
\* EGR : Exhaust Gas Recirculation



# LG Chem LUSEP: Thermal Shock Property

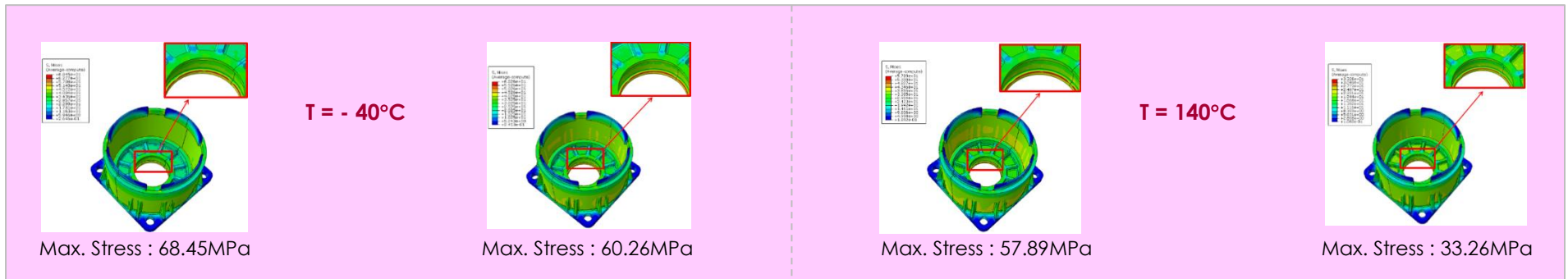
## ► Stress vs. Deformation

LUSEP HI2402 exhibits higher elongation than standard PPS+GF40% at low and elevated temperatures.



## ► Thermal Shock Analysis

LUSEP HI2402 undergoes lower stress than standard PPS+GF40% at low and elevated temperatures.



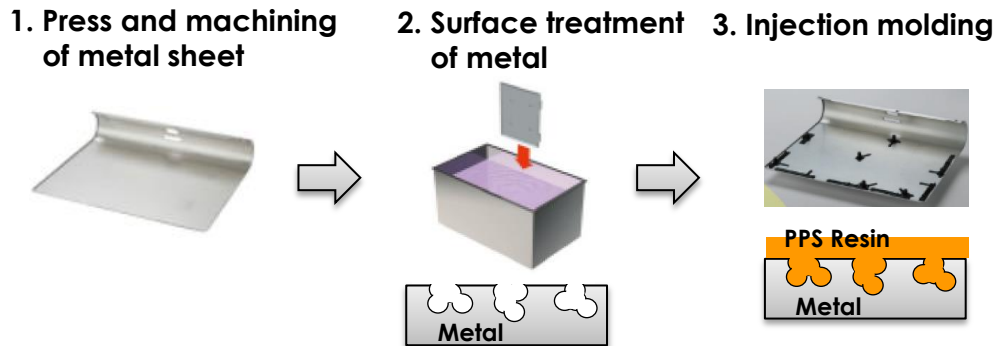
# LG Chem LUSEP: Metal & Epoxy Adhesion



## ▶ Integration Technology of Metal and Plastic

Integration technology between metal and plastic resin is the best way to produce key parts. It offers many advantages such as thickness and weight reduction of product, increased design freedom and reduction of assembly works. LUSEP MA series for metal bonding applications shows excellent bonding properties to various types of aluminum and stainless steel.

## ▶ Process

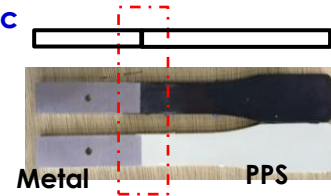


## ▶ Testing of Tensile & Shear Bonding Strength

[ Specimen and Test Condition ]

- Testing speed = 5 mm/min
- Grip to grip distance = 80 mm

• TRI & Polymetac

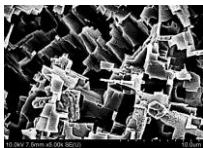
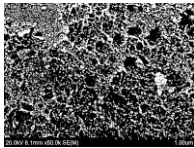
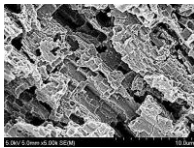


• BMPT



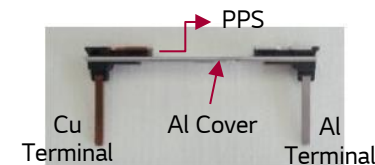
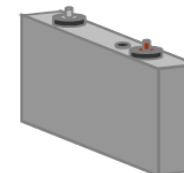
Al 3003+PPS

## ▶ Various Types of Metal-Polymer Bonding Technology

Classification	Polymetac	TRI 1)	BMPT 2)
Company	Mitsui Chemical	Toadenka	Taesung Politech
Al surface			
Hole size	10 $\mu\text{m}$ ↓	100nm ↓	10 $\mu\text{m}$ ↓

Metal Bonding Technology	LUSEP MA2200	LUSEP MA2400
TRI (Al6061)	52 MPa	55 MPa
Polymetac (Al5052)	50 MPa	52 MPa
BMPT (Al3003)	-	53 MPa

## ▶ Applications



[ Automotive Rechargeable Battery Cap Assy ]



[ M/P Battery Cover ]

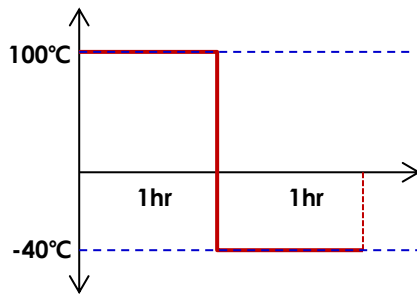
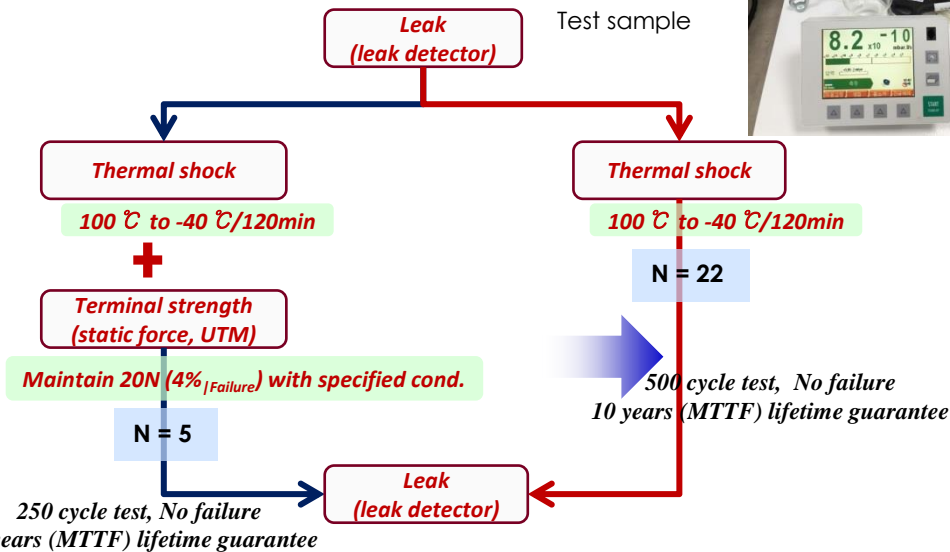
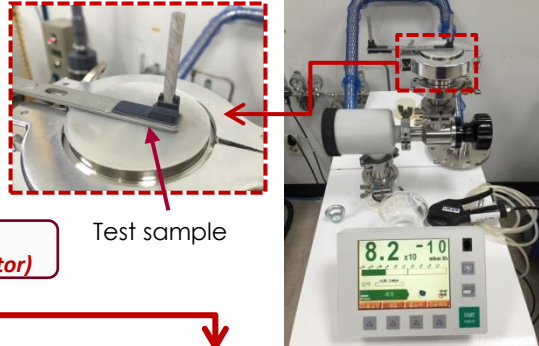
1) TRI : Technologies Rise from Iwate, 2) BMPT : Bonding of metal-polymer technology



# LG Chem LUSEP: Battery Cap Plate Acceleration Test

## ▶ Sealing (He Leakage Test)

## ▶ Thermal Shock Test - Flow Chart



## ▶ GMW3172- (Random) Vibration Test - Leakage Test after Vibration

### 9.3.1.2 Random Vibration – Mounting Location Sprung Masses(Passenger car)

**Purpose:** This test shall verify that the component is immune from the effects of vibration when it is located on a sprung mass.

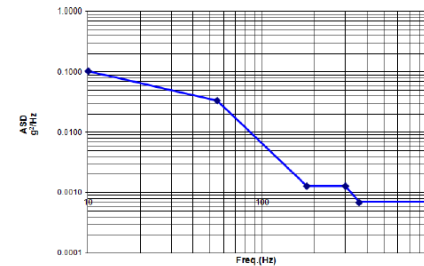
**Applicability:** All components attached to the body, frame, or sub-frame of a car or truck.

**Operating Type:** 3.2

**Monitoring:** Continuous Monitoring.

**Procedure:** Use the test methods according to IEC 60068-2-64, Test Fh, Vibration, broad-band random (digital control) and guidance.

Figure 29: Random Vibration Profile for Sprung Masses



Effective Acceleration = 19.6 m/s<sup>2</sup> = 2.0 G<sub>rms</sub>

Table 28: Random Vibration Profile for Sprung Masses

Frequency	Power Spectral Density
10 Hz	9.9248 (m/s <sup>2</sup> ) <sup>2</sup> /Hz = 0.1032 g <sup>2</sup> /Hz
55 Hz	3.2313 (m/s <sup>2</sup> ) <sup>2</sup> /Hz = 0.0336 g <sup>2</sup> /Hz
180 Hz	0.1250 (m/s <sup>2</sup> ) <sup>2</sup> /Hz = 0.0013 g <sup>2</sup> /Hz
300 Hz	0.1250 (m/s <sup>2</sup> ) <sup>2</sup> /Hz = 0.0013 g <sup>2</sup> /Hz
360 Hz	0.0673 (m/s <sup>2</sup> ) <sup>2</sup> /Hz = 0.0007 g <sup>2</sup> /Hz
1000 Hz	0.0673 (m/s <sup>2</sup> ) <sup>2</sup> /Hz = 0.0007 g <sup>2</sup> /Hz

- ▶ No leakage of bonded part after random vibration
- ▶ No failure is confirmed for 10 test samples

	Electrode 1 (mbar.l/sec)		Electrode 2 (mbar.l/sec)	
	Before Vibration	After Vibration	Before Vibration	After Vibration
B1-1	1.7 × 10 <sup>-8</sup> (NDL)	2.5 × 10 <sup>-8</sup> (NDL)	1.3 × 10 <sup>-8</sup>	3.0 × 10 <sup>-9</sup> (NDL)
B1-2	4.4 × 10 <sup>-8</sup>	1.7 × 10 <sup>-6</sup>	1.8 × 10 <sup>-7</sup>	1.2 × 10 <sup>-7</sup>
B1-3	3.7 × 10 <sup>-8</sup>	1.4 × 10 <sup>-8</sup>	1.3 × 10 <sup>-6</sup>	1.3 × 10 <sup>-7</sup>
B1-4	1.6 × 10 <sup>-7</sup>	1.4 × 10 <sup>-7</sup>	2.0 × 10 <sup>-7</sup>	2.2 × 10 <sup>-8</sup>
B1-5	1.4 × 10 <sup>-7</sup>	6.1 × 10 <sup>-7</sup>	1.8 × 10 <sup>-7</sup>	7.2 × 10 <sup>-8</sup>
B1-6	2.8 × 10 <sup>-7</sup>	3.4 × 10 <sup>-6</sup>	1.5 × 10 <sup>-7</sup>	2.4 × 10 <sup>-8</sup>
B1-7	2.5 × 10 <sup>-8</sup>	2.4 × 10 <sup>-6</sup>	3.8 × 10 <sup>-8</sup> (NDL)	9.7 × 10 <sup>-7</sup>
B1-8	3.4 × 10 <sup>-8</sup>	1.7 × 10 <sup>-6</sup>	2.1 × 10 <sup>-8</sup>	6.3 × 10 <sup>-8</sup>
B1-9	9.2 × 10 <sup>-9</sup>	2.2 × 10 <sup>-6</sup>	2.2 × 10 <sup>-8</sup>	1.8 × 10 <sup>-9</sup> (NDL)
B1-10	1.6 × 10 <sup>-8</sup> (NDL)	2.7 × 10 <sup>-8</sup>	8.0 × 10 <sup>-9</sup> (NDL)	1.7 × 10 <sup>-9</sup> (NDL)

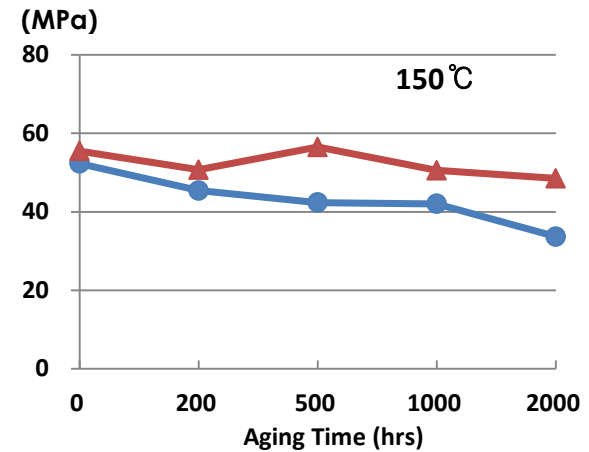
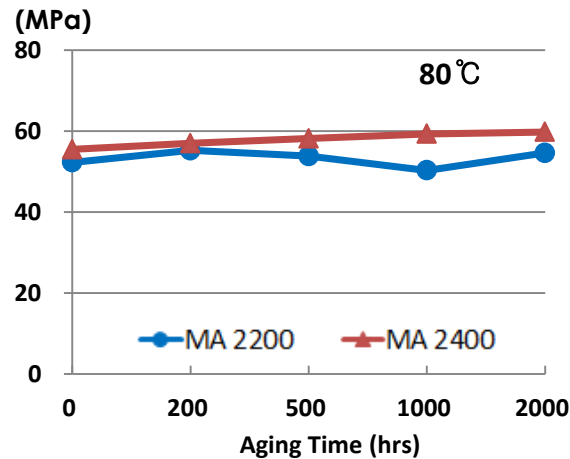


# LG Chem LUSEP : Metal Adhesion

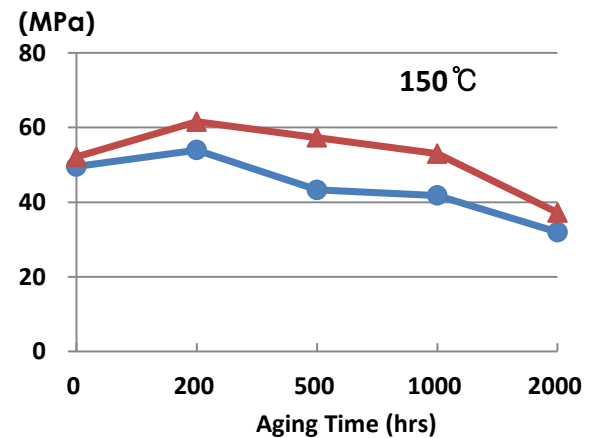
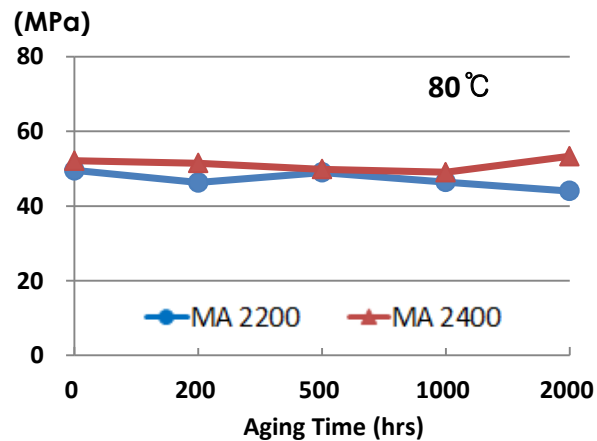


## ► Variation of Bonding Strength of LUSEP MA2200 & MA2400 with Time at Elevated Temperature Conditions

### ◆ TRI Process



### ◆ Polymetac Process

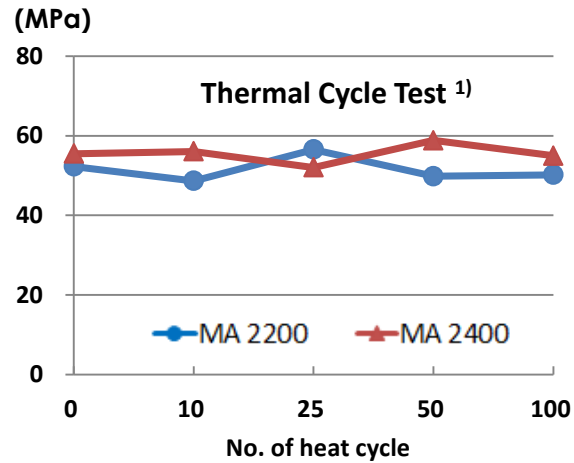


# LG Chem LUSEP : Metal Adhesion

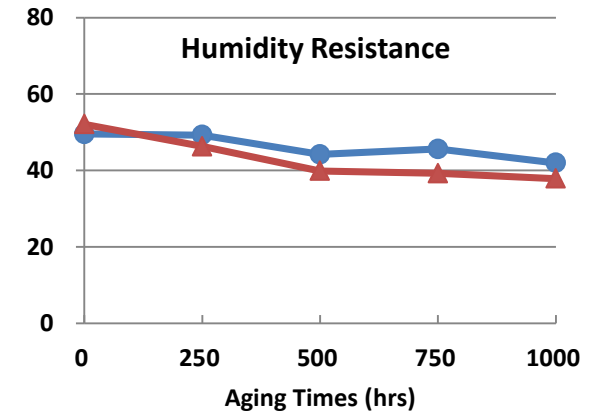
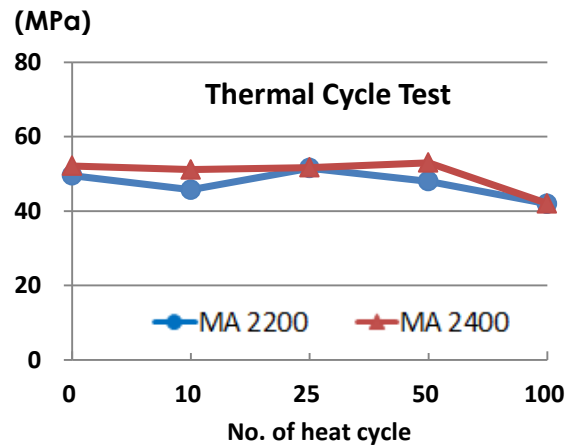


## ► Variation of Bonding Strength of LUSEP MA2200 & MA2400 after Thermal Cycles and Humid Condition

### ◆ TRI Process



### ◆ Polymetac Process



1) Thermal Cycle Condition : -40°C, 7.5hr → 5°C/min heating → 110°C, 15.5hr → 5°C/min cooling to -40 °C (1 cycle)

2) Humidity Resistance Condition : 80 RH%, 80°C

# LG Chem LUSEP: Abrasion Resistance

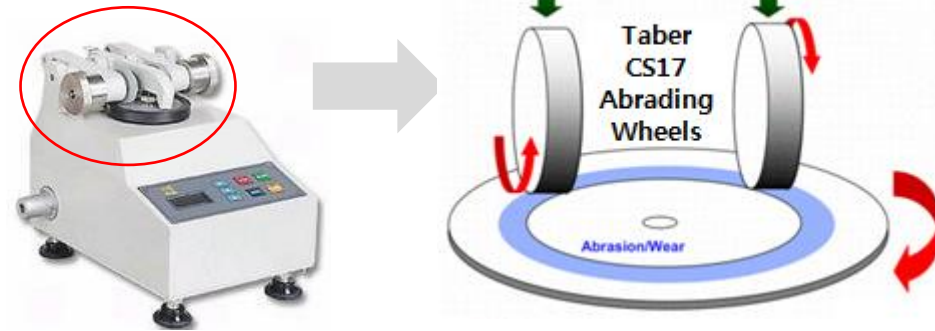
## ▶ Taber Abrasion Test Results

LUSEP FW series have superior wear resistance than standard glass fiber reinforced PPS.

Grade	Abrasion (mg)	Feature
LUSEP GP2300	130	Standard, G/F 30%
LUSEP GP2400	150	Standard, G/F 40%
LUSEP FW2300	80	Wear resistance, G/F 30%
LUSEP FW2400	95	Wear resistance, G/F 40%

\* Test Condition: 1kg Load, 3,000 Cycles

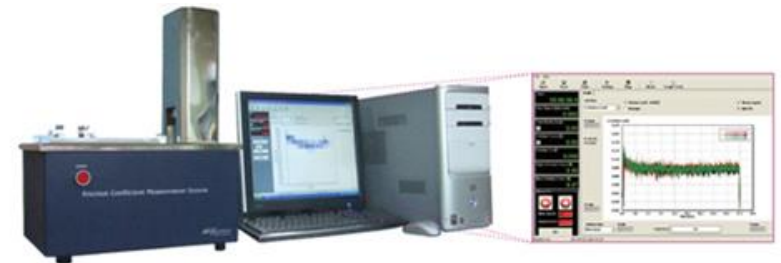
### ◆ Taber Abrasion Tester



## ▶ Coefficient of Friction (vs. Steel, 1kg Load)

Grade	Coefficient of Friction	Feature
LUSEP GP2300	0.08	Standard, G/F 30%
LUSEP GP2400	0.09	Standard, G/F 40%
LUSEP FW2300	0.04	Wear resistance, G/F 30%
LUSEP FW2400	0.05	Wear resistance, G/F 40%

### ◆ Coefficient of Friction Measuring Equipment

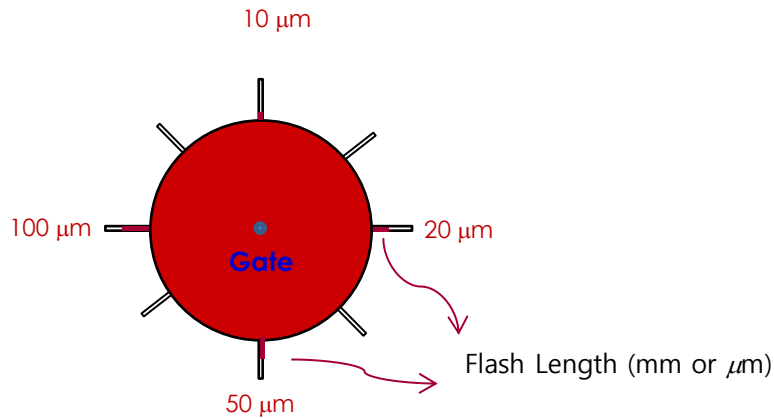


# LG Chem LUSEP: Flash Formation

## ► Evaluation of Flash Length

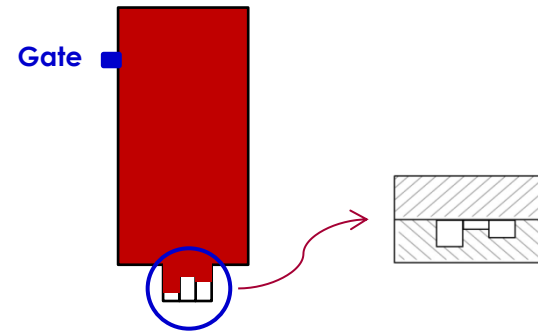
### 1) Disk mold with center pin gate

- Gas vents with different clearance are installed radially in the mold



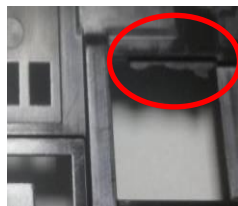
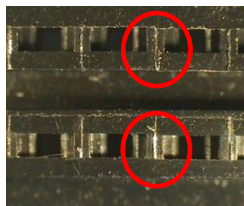
### 2) Bar type mold with side pin gate

- Gas vents with different clearance are installed at the opposite side of gate

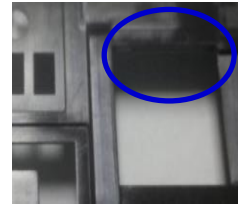
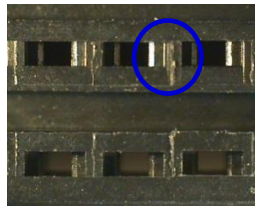


## ► Visual Examination of Microflash

Standard PPS/GF 40%



LUSEP LF2400C



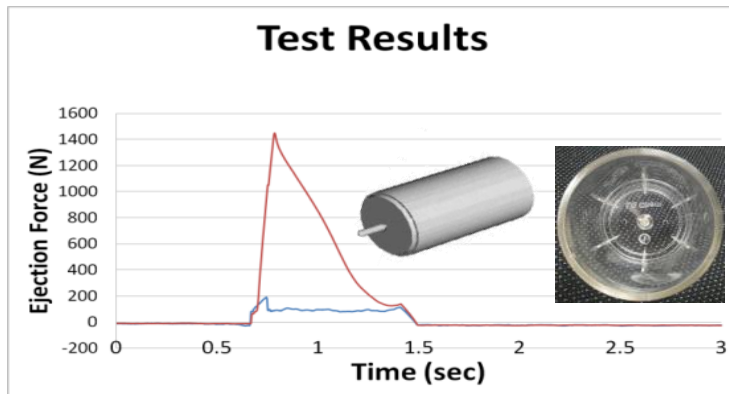
○ Microflash

○ No microflash

# LG Chem LUSEP: Mold Release Property

## ► Evaluation of Ejection Force

- Ejection force is measured in real time through pressure sensors inserted in the ejection pins using a cup shaped mold.



## ● Result

Ejection Force (N)	LUSEP LF2400C	Competitor's PPS+GF40%
Average	500	1,600
Maximum value	710	1,650
Minimum value	430	1,575

• Injection molding conditions : Temperature = 295°C, Mold temperature = 130°C, Cooling time = 20 sec

# LG Chem LUCON: Thermally Conductive PPS

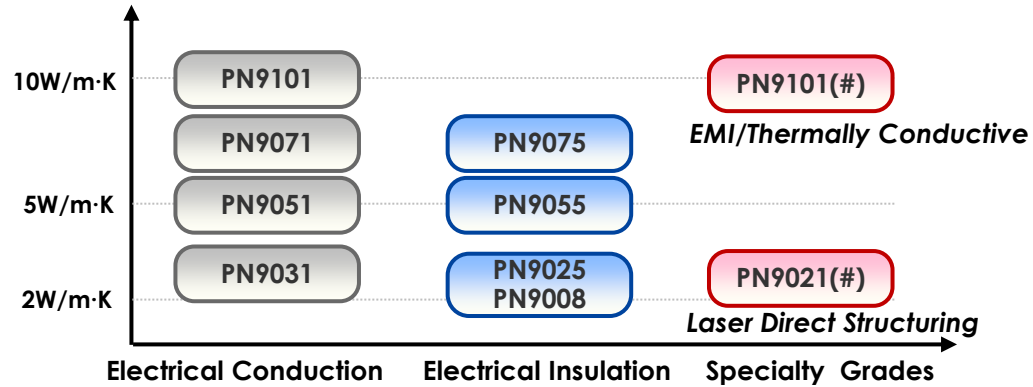
► **LUCON PN9000 Series** are thermally conductive PPS compounds and the thermal conductivity range from 2 to 10W/m.K. They have good melt flow, high heat resistance and flame retardant characteristics.

## ● Applications

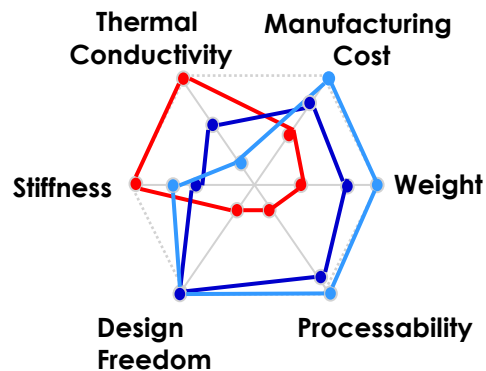
- LED Lamp Heat Sink, Housing, and Reflector
- Thermal Resistor, Heat Exchanger, Industrial Parts



## ● Product Portfolio

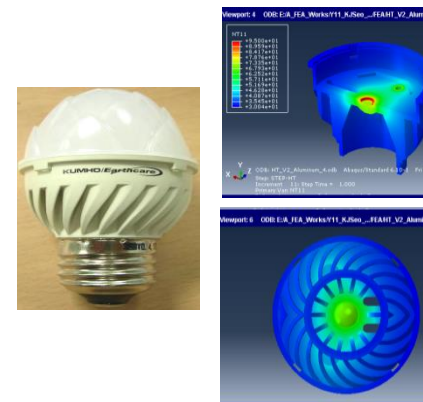


## ● Features

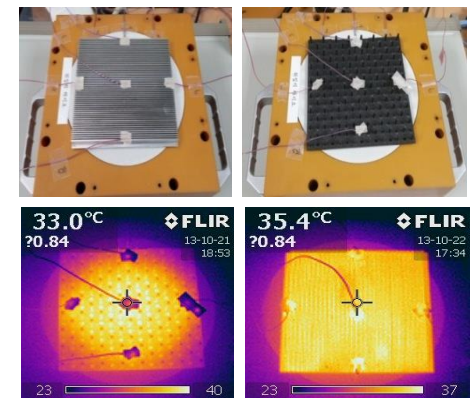


## ● Thermal Analysis

### Thermal Analysis of LED Heat Sink



### Experimental Validation (AI & LUCON)





# LG Chem LUCON: Thermally Conductive PPS

## ► Application

: Replacement of Aluminium to LUCON → Weight Reduction 30%, Cost Saving 20% ↑

Grade	PN9008, PN9075	PN9025	PN9031	PN9051
Product	 <p><u>LED Lamp Heat Sink</u></p> <p><u>LED Module Heat Sink</u></p>	 <p><u>Relay Case &amp; Socket</u></p>	 <p><u>LED Security Lamp H/Sink</u></p>	 <p><u>LED Lamp Heat Sink</u></p>
Thermal Conductivity*	2, 7 W/m K	2 W/m K	3 W/m K	5 W/m K
Features	Electric Insulation, $10^{14}\Omega$ UL94 V-0 (@0.8mm) RTI 130°C	Electric Insulation, $10^{14}\Omega$ UL94 V-0 (@0.95mm) High Impact, 70J/m	Surface Resistance, $10^{7-9}\Omega$ UL94 V-0 (@0.8mm) High Strength	Surface Resistance, $10^6\Omega$ UL94 V-0 (@0.8mm)

\* Thermal Conductivity (ASTM E1461, Laser Flash Method)

**LUSEP**

# Injection Molding Guide

► **Injection Molding Guide**

# LG Chem LUSEP: Injection Molding Guide

## ► Injection Molding

### ● Pre-drying

- 3 ~ 5 hours drying at 120 ~140 °C is recommended.  
Color may be changed by excessive drying temperature and/or time.

### ● Cylinder Temperature

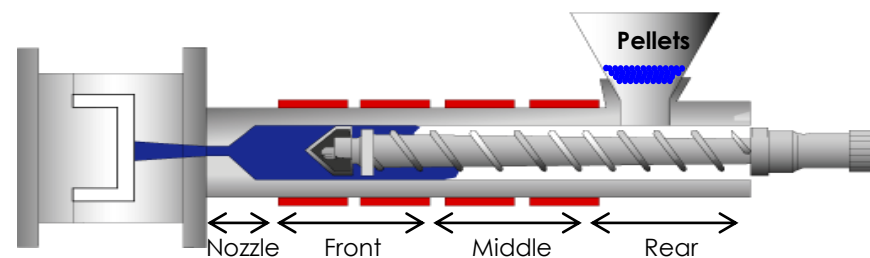
- 290 ~ 330 °C is normally recommended.

### ● Mold Temperature

- Mold temperature affects the crystallinity, surface finish and dimensional accuracy of the molded product.
- To obtain high levels of crystallinity in PPS parts, it's recommended to utilize hot mold conditions, greater than 125°C or higher up to 150°C. The advantages of high crystallinity include improved dimensional stability, increased heat deflection temperature and improved mechanical properties at elevated temperatures.

Parts molded at mold temperatures below 120 °C achieve low levels of crystallinity. If the mold temperature is near the glass transition temperature, 80°C to 100 °C, of PPS, undesirable appearance quality and mold release failure are likely to occur.

Processing Parameter		Unit	Range
Cylinder Temperature	Nozzle	°C	300 ~ 330
	Front	°C	290 ~ 320
	Middle	°C	290 ~ 320
	Rear	°C	280 ~ 300
Pressure Condition	Injection Pressure	MPa	70 ~ 150
	Holding Pressure	MPa	30 ~ 70
	Back Pressure	MPa	1 ~ 10
Mold Temperature		°C	120 ~ 150
Drying Condition		°C Hr	120 ~ 140 3 ~ 5



# LG Chem LUSEP: Injection Molding Guide

## ► Mold Design and Materials

- Recommendations for mold design
  - Gas vent should be installed at the flow ends.
  - Valve gates are recommended to reduce drool.
  - Sufficient draft angle is required to eject the part without bending or failure.
  - Due to the high mold temperature of LUSEP, tolerance by thermal expansion should be considered.
- Recommendations for mold material
  - It is recommended to use corrosion-resistant material for LUSEP mold.
  - Because of the abrasive nature of the glass fiber and mineral fillers incorporated in LUSEP PPS compounds, hard tool steels with good wear resistance are required for mold cores and cavities.
- Table : Features of recommended mold materials

Mold Material (Hard Tool Steel)	Hardness (HRC)	Wear Resistance	Surface roughness	Strength	Machinability
KP4M	34	B	C	C	C
NAK80	40	B	A	B	D
ASSAB718	33	C	A	C	C
STAVAX	45	B	A	B	C
SKD11	55	C	C	A	C

\* A : Excellent, B : Good, C : Poor



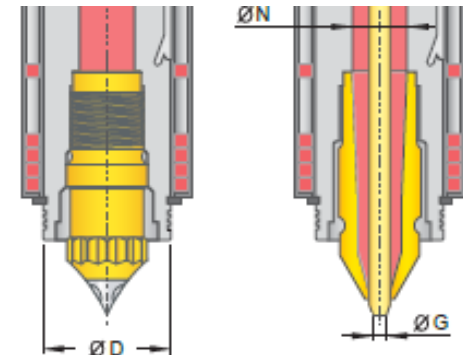
# LG Chem LUSEP: Injection Molding Guide

## ► Hot Runner Guide

- In the case of using hot runner for injection molding of LUSEP PPS, temperature of hot runner should be set to the front zone cylinder temperature of injection molding machine. Gate depends on the type, specifications and locations of heaters and sensors. In general, gate temperature should be set 10 ~ 20°C higher (320 ~ 350°C) than those of hot runner to prevent solidification of PPS resin at the nozzle tip.
- ※ Since set temperature depends on the injection molding machine, mold and gate type, it is also important to confirm the solidification temperature of resin under real environment.
- For highly filled LUSEP grades, proper selection of hot runner and size and material of gate is important above all. In the case of nozzle tip, metals with higher thermal conductivity and hardness (ex: Aluminum-Bronze) than those of general Beryllium-Copper are recommended to prevent solidification and improvement of durability.

◆ Table : Recommended Specifications for Hot Runner and Gate

Category	Recommended Specification
<b>Nozzle Outer-diameter (ΦD)</b>	<ul style="list-style-type: none"> <li>• Below 70g/gate : Φ25mm or smaller</li> <li>• Above 300g/gate : bigger than Φ35 mm</li> </ul>
<b>Nozzle Inner-diameter (ΦN)</b>	<ul style="list-style-type: none"> <li>• 20% or less reinforced : bigger than Φ10 mm</li> <li>• 30% or higher reinforced : bigger than Φ15 mm</li> </ul>
<b>Gate Size (ΦG)</b>	<ul style="list-style-type: none"> <li>• 20% or less reinforced : bigger than Φ2.0 mm</li> <li>• 30% or higher reinforced : bigger than Φ1.5 mm</li> </ul>
<b>Nozzle Tip Material</b>	<ul style="list-style-type: none"> <li>• Thermal conductivity : higher than 70~80% conductivity of Copper</li> <li>• Hardness : higher than 30HRC</li> </ul>



- ※ It is recommended to determine proper specifications for hot runner and nozzle considering the characteristics of molded part and filler content of PPS resin.





An electric scooter that a 22-year-old wishes to have

A smartphone that a 15-year-old covets

A toy that a 7-year-old wants to have

An EV that a 30-year-old desires

An eco house that a 46-year-old seeks to have

**Chemicals make up  
everything you can dream of**

Behind every product, there is LG Chem  
LG Chem will be your partner in advanced life  
with our differentiated solutions

**Thank You !**