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KEPITAL®

for a better future

KEP

KEP Vision

Through continuous innovation and new value creation, KEP will be the premier chemical company providing humanity with solutions for a better future.

1. General Information

KEPITAL® is the trade name for the polyacetal copolymer and homopolymer products of Korea Engineering Plastics Co., Ltd. (KEP).
KEPITAL® offers well-balanced physical and mechanical properties with a powerful combination of highly crystalline and thermally stable structures. KEPITAL® provides excellent resistance to various chemicals and a wide processing window.

The characteristics of KEPITAL® are as follows:

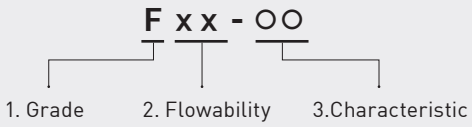
- High mechanical properties
- High fatigue resistance
- Long-term dimensional stability
- Excellent fuel resistance
- Excellent creep resistance
- Superior friction resistance and wear resistance characteristics
- Superior chemical resistance and alkali resistance

KEPITAL®'s products range, from standard unfilled grades to high performance specialties, is well-balanced with inherent properties in order to meet both general purpose applications and specific engineering requirements.

KEPITAL® is easily processed to manufacture the finished product through the typical processes of both injection molding and extrusion. Therefore, KEPITAL® has been widely used in products such as automotive, electronics, consumer goods, etc.

This brochure provides insight into the physical and chemical properties of KEPITAL®, processing information and the diverse applications to help select the correct KEPITAL® grade for your application.

1-1. KEPITAL Nomenclature



1-1-1. Grade

(1) Standard unfilled grades : F

(2) Reinforced & filled grades

- FG : Glass fiber reinforced
- MF : Milled glass fiber filled
- FB : Glass bead filled
- FT : Whisker filled
- TC : Talcum filled

(3) Impact modified grades : TE(FU)

(4) Low friction and wear grades

- FL : PTFE modified
- TS : Silicone modified
- FM : MoS2 filled
- NX, TX : Special lubricant package formulated

1-1-2. Flowability

x x	Melt Flow Rate (g/10 min)
10	3
15	6
20	9
25	13
30	27
40	48

1-1-3. Characteristics

O O	Characteristic
03/33	Mold released / moderate toughness
03H	Higher stiffness and strength than standard unfilled grade
51	UV-stabilized, Black color, outdoor
52	UV-stabilized, Natural color, indoor

1-2. Characteristic of KEPITAL

Description	Classification	Name	Characteristics
General	High viscosity	F10-01 F10-02	- Toughness - Rod, Sheet, Tube, Plate, Pipe - Reduced porosity and white marks
	Medium viscosity	F15-33	- Medium melt flow rate between F10 and F20 - High toughness - Proper for thick parts
		F20-03	- Standard type - Standard and balanced property - General injection molded parts
		F25-03	- Medium melt flow rate between F20 and F30 - General injection molded parts
	Low viscosity	F30-03 F30-34	- High melt flow rate - Multi-cavities parts - Proper for thin and small shape parts
	Extra low viscosity	F40-03 F40-34	- Short cycle time - Ultra high melt flow rate - Proper for thin and small shape parts
High rigidity	High viscosity	F10-03H	- Toughness and stiffness - Thick part
	Medium viscosity	F25-03H	- Medium melt flow rate between F20 and F30 - High stiffness
		F25-03HT	- Medium melt flow rate between F20 and F30 - Improved Toughness and friction property
Low VOC	High viscosity, rigidity	F10-03H LOF	- High viscosity - Low formaldehyde(HCHO) emission
	Medium viscosity	F20-03 LOF	- Medium viscosity - Low formaldehyde(HCHO) emission
	UV & Weather resistance	F20-52 LOF	- Medium viscosity - Low formaldehyde(HCHO) emission - UV/Light resistance *
	Low viscosity	F30-03LOF	- Low viscosity - Low formaldehyde(HCHO) emission
Reinforced & filled	Glass Fiber	FG2025K	- Low content of glass fiber - High rigidity and hardness
		FG2015	- Medium content of glass fiber - High stiffness and hardness
		FG2025	- High content of glass fiber - Maximum (Highest) stiffness, hardness and HDT - Reduced thermal expansion and shrinkage
	Glass Bead	FB2030	- Dimensional stability - Low warpage
	Talcum filled	TC3020	- Dimensional stability
	Whisker filled	FT2020	- Improved stiffness - Dimensional stability

Description	Classification	Name	Characteristics
Friction & Wear resistance	Silicone modified	TS-22H	- Low contents - High friction & wear resistance - High PV limit
		TS-25H	- High contents - Highest friction & wear resistance - Highest PV limit value
		TS-25A	- High contents - Highest friction & wear resistance - Delamination reduction
	PTFE modified	FL2020	- High friction & wear resistance - Low specific wear rate
	MoS_2 filled	FM2020 FM2520S	- Medium viscosity - Low specific wear rate in condition of high load, low speed and against metal - For bearing, bush parts
	Special lubricant package	TX-11H TX-21 TX-31	- High friction and wear resistance - Reduced noise
		NX-20	- High friction and wear resistance - Reduced noise - Silicone free
Impact modified	High toughness	TE-21 TE-22 TE-23	- Low contents of impact modifier - Impact modified grade for General purpose - Noise reduction
		TE-23S	- Low contents of impact modifier - High impact modified grade - Improved weld characteristics
		TE-24	- Medium contents of impact modifier - High impact modified grade
		TE-24S	- High contents of impact modifier - Super-toughened grade (Ultra high)
		TE-25	- Medium contents of impact modifier - High impact modified grade
		ST-50	- High contents of impact modifier - Improved impact-resistance and flexibility
UV & Weather resistance grade	General	F20-52	- Medium viscosity - UV/Light resistance * - For interior parts
		F30-52	- Low viscosity - UV/Light resistance * - For interior parts
	Low gloss	F20-52G	- Medium viscosity - UV/Light resistance * - For low gloss interior parts
		F30-52G	- Low viscosity - UV/Light resistance * - For low gloss interior parts

Description	Classification	Name	Characteristics
UV & Weather resistance grade	Black	F20-51	- Medium viscosity - Weather and UV/Light resistance - For interior and exterior parts
		F30-51	- Low viscosity - Weather and UV/Light resistance - For interior and exterior parts
	Impact resistance	F20-51U	- Medium viscosity - Weather and UV/Light resistance (Black colored) - For interior and exterior parts with improved impact strength
Medical	Medium viscosity	MX20BT01 MX25BT01	- Healthcare and medical application - Compliance to USP class6, ISO 10993-5 - Filed on DMF(Drug Master File)
	Low viscosity	MX30BT01	
Conductive	General	ET-20S	- Conductive carbon black filled - Conductivity - General purpose Type
		ET-20A	- Conductive carbon black filled - Conductivity - Improved fuel resistance
	High stiffness	FA-20	- Carbon black and carbon fiber reinforced - Conductive - High stiffness and high creep strength
		FC2010	- Carbon fiber reinforced - High stiffness
Anti-static	Specialty	ED-12	- Rod, Sheet, Plate - Static dissipation

* Can be matched with various colors

1-3. Typical properties of KEPITAL®

Description				General									High rigidity			Low VOC
				High viscosity		Medium viscosity			Low viscosity		Extra low viscosity		High viscosity	Medium viscosity		High viscosity, rigidity
Property		Test method	Unit	F10-01	F10-02	F15-33	F20-03	F25-03	F30-03	F30-34	F40-03	F40-34	F10-03H	F25-03H	F25-03HT	F10-03H LOF
Physical properties	Density	ISO 1183	g/cm^3	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
	Water absorption	ISO 62	%	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mechanical properties	Tensile modulus	ISO 527	MPa	2,500	2,600	2,600	2,750	2,750	2,850	2,850	2,900	2,900	2,800	2,850	2,700	2,800
	Tensile strength	ISO 527	MPa	63	63	64	65	65	65	65	65	65	67	68	64	67
	Elongation at yield	ISO 527	%	10	10	10	10	9	8	8	7	-	12	10	9	12
	Nominal strain at break	ISO 527	%	32	32	34	32	31	25	23	20	13	35	31	30	35
	Flexural strength	ISO 178	MPa	83	84	85	87	90	90	93	93	93	90	94	90	90
	Flexural modulus	ISO 178	MPa	2,350	2,400	2,450	2,550	2,650	2,700	2,700	2,750	2,700	2,600	2,800	2,600	2,600
	Charpy impact strength 23℃	ISO 179/1eA	kJ/m^2	8.0	8.0	7.0	6.5	6.0	5.5	5.5	5.0	3.5	8.5	6.5	6.0	8.5
	Charpy impact strength -30℃	ISO 179/1eA	kJ/m^2	6.5	6.5	6.0	5.5	5.5	5.0	4.5	4.0	2.2	6.5	6.0	5.0	6.5
Thermal properties	Melt index	ISO 1133	g/10min	3	3	6	9	13	27	36	45	75	3	13	13	3
	Melting point	ISO 11357	℃	165	165	165	165	165	165	165	165	165	170	170	170	170
	Heat deflection temperature(1.8MPa)	ISO 75	℃	96	96	96	100	100	101	101	101	101	100	101	100	100
	Coefficient of linear thermal expansion	ISO 11359	x10^{-5}/℃	12	12	12	12	12	12	12	12	12	12	12	12	12
Electrucal properties	Surface resistivity	IEC 60093	Ω	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}
	Volume resistivity	IEC 60093	Ω · cm	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}
	Dielectric strength	IEC 60243	kV/mm	19	19	19	19	19	19	19	19	19	19	19	19	19
Other	Mold shrinkage (Flow direction)	ISO 294-4	%	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

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Low VOC			Reinforced & filled						Friction & Wear resistance					
Medium viscosity	UV& Weather resistance	Low viscosity	Glass Fiber			Glass Bead	Talcum filled	Whisker filled	Silicone modified			PTFE modified	MoS_2 filled	
F20-03 LOF	F20-52 LOF	F30-03LOF	FG2025K	FG2015	FG2025	FB2030	TC3020	FT2020	TS-22H	TS-25H	TS-25A	FL2020	FM2020	FM2520S
1.41	1.41	1.41	1.47	1.50	1.59	1.64	1.56	1.59	1.40	1.39	1.39	1.51	1.43	1.38
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.23	0.2	0.2	0.2	0.18	0.2	0.2
2,750	2,600	2,850	4,900	5,400	9,000	4,000	4,850	7,300	2,600	2,650	2,450	2,250	2,600	2,300
65	62	63	100	105	150	53	58	84	62	59	57	45	65	58
10	10	8	-	-	-	-	-	-	10	9	12	10	9.5	10
32	34	25	3.4	2.7	2.4	2.9	5.0	2.7	22	23	30	14.5	20	33
87	83	90	160	175	220	97	112	146	85	83	80	70	90	80
2,550	2,350	2,600	4,750	5,200	8,250	4,050	5,290	6,800	2,500	2,550	2,500	2,150	2,690	2,400
6.5	6.0	5.5	6.5	7.0	8.0	2.5	3.8	3.6	7.0	5.5	7.0	3.0	5.5	5.5
5.5	5.5	4.5	6.5	7.0	8.0	2.0	2.5	2.5	6.0	4.5	6.0	2.5	4.0	4.0
9	10	27	13	11.5	7	19	5	15	13	24	15	5	11	10.5
165	165	165	165	165	165	165	165	165	168	168	165	165	165	165
100	92	101	160	161	162	117	122	152	90	98	90	87	105	89
12	13	12	6	5	3	8	8	10	11	11	11	10	11	11
$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$
$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$
19	19	19	-	-	23	20	21	-	-	-	-	16	-	-
2.0	2.0	2.0	1.0	0.9	0.7	1.4	1.4	0.9	2.1	2.1	2.1	2.0	2.1	2.1

Caution

※ Tensile properties except for modulus of reinforced and filled products and conductive high stiffness products were measured at 5 mm/min speed, and other products were measured at 50 mm/min.

※ Electrical properties of conductive and anti-static products are measured with KEP standard specimens.

※ Electrical properties, such as surface resistivity or volumetric resistivity, are variable depending on injection molding machine, extruder structure, die design, pressure and speed. Before use, sufficient verification are needed. In addition, color shade will change with product thickness, residence time in barrel, and annealing conditions.

Description				Friction & Wear resistance				Impact modified							
				Special lubricant package				High toughness							
Property		Test method	Unit	TX-11H	TX-21	TX-31	NX-20	TE-21	TE-22	TE-23	TE-23S	TE-24	TE-24S	TE-25	ST-50
Physical properties	Density	ISO 1183	g/cm^3	1.40	1.39	1.39	1.38	1.39	1.37	1.36	1.36	1.35	1.32	1.34	1.28
	Water absorption	ISO 62	%	0.2	0.2	0.2	0.2	0.22	0.23	0.24	0.24	0.24	0.25	-	-
Mechanical properties	Tensile modulus	ISO 527	MPa	2,600	2,500	2,550	2,400	2,300	2,100	1,800	1,750	1,700	1,400	1,500	800
	Tensile strength	ISO 527	MPa	64	57	56	53	57	51	45	45	41	38	39	25
	Elongation at yield	ISO 527	%	10	10	8	10	9	11	12	12	13	23	14	22
	Nominal strain at break	ISO 527	%	40	33	32	25	40	〉50	〉50	65	〉60	〉100	〉60	300
	Flexural strength	ISO 178	MPa	86	79	81	75	76	68	60	60	53	46	46	26
	Flexural modulus	ISO 178	MPa	2,550	2,350	2,450	2,100	2,150	1,900	1,650	1,750	1,450	1,300	1,250	800
	Charpy impact strength 23℃	ISO 179/1eA	kJ/m^2	9.5	7.5	6.5	4.5	8.0	11	13	18	18	28	21	N.B
	Charpy impact strength -30℃	ISO 179/1eA	kJ/m^2	7.0	5.0	4.5	3.5	6.0	6.5	6.5	7.0	7.0	9.0	7.0	7.0
Thermal properties	Melt index	ISO 1133	g/10min	5.0	16	30	12	11	8.5	8	3	6	2	6	4
	Melting point	ISO 11357	℃	170	165	165	165	165	165	165	165	165	168	165	165
	Heat deflection temperature(1.8MPa)	ISO 75	℃	97	90	89	90	84	76	76	75	71	61	65	58
	Coefficient of linear thermal expansion	ISO 11359	x10^{-5}/℃	13	13	13	8	13	13	13	13	13	13	13	12
Electrucal properties	Surface resistivity	IEC 60093	Ω	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}	1x10^{16}
	Volume resistivity	IEC 60093	Ω · cm	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}	1x10^{14}
	Dielectric strength	IEC 60243	kV/mm	19	19	19	-	-	-	-	-	21	-	21	-
Other	Mold shrinkage (Flow direction)	ISO 294-4	%	2.0	2.0	2.0	2.1	1.7	1.7	1.7	1.7	1.7	1.7	1.7	-

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UV & Weather resistance grade							Medical			Conductive				Anti-static
General		Low gloss		Black		Impact resistance	Medium viscosity		Low viscosity	General		High stiffness		Specialty
F20-52	F30-52	F20-52G	F30-52G	F20-51	F30-51	F20-51U	MX20 BT01	MX25 BT01	MX30 BT01	ET-20S	ET-20A	FA-20	FC2010	ED-12
1.41	1.41	1.39	1.39	1.41	1.41	1.39	1.41	1.41	1.41	1.38	1.39	1.43	1.43	1.32
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-	-	-	0.2	-
2,600	2,650	2,400	2,200	2,600	2,450	2,300	2,700	2,750	2,850	2,650	2,450	7,500	10,000	1,500
62	62	57	57	62	59	55	64	65	63	40	52	95	125	43
10	9	11	9	9	8	10	10	9	8	4	8	-	-	18
34	30	30	25	25	35	40	32	30	25	12	8	1.5	1.2	90
83	83	77	79	86	88	75	87	90	90	67	76	135	200	50
2,350	2,450	2,350	2,450	2,550	2,650	2,250	2,550	2,600	2,600	2,650	2,450	7,150	8,500	1,350
6.0	5.0	6.0	4.0	7.0	7.0	8.5	6.5	6.0	5.0	4.0	5.5	4.0	4.0	16
5.5	4.5	4.0	3.5	5.0	4.0	5.5	5.5	5.0	4.0	2.0	4.0	4.0	4.0	8.0
10	27	10	23	10	25	10.5	9	13	27	11.5	〈 1	3	9.5	〈1
165	165	165	165	165	165	165	165	165	165	165	165	165	165	165
92	90	88	88	92	92	89	100	100	98	88	92	160	160	70
13	13	11	11	11	11	11	12	12	12	12	11	4	2	12
$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{16}$	$1x10^{3}$	$1x10^{3}$	$1x10^{3}$	$1x10^{5}$	$1x10^{8}$
$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	$1x10^{14}$	-	-	-	-	-
19	19	-	-	19	19	19	19	19	19	-	-	-	-	-
2.0	2.0	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	1.9	2.0	0.9	0.7	1.6

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2. Processing of KEPITAL®

2-1. Equipment

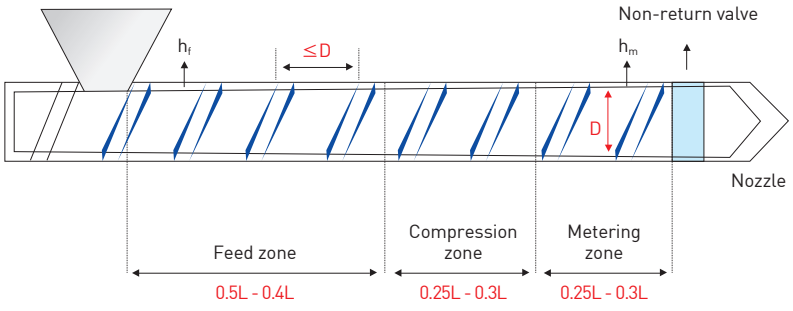
Injection molding is one of the common manufacturing methods for thermoplastics including KEPITAL® as it allows for designs of high complexity and cost-effective manufacturing methods. Therefore, understanding the process of injection molding for KEPITAL® is very important.
In order to obtain a high-quality product out of KEPITAL®, the recommendations or check-points on the injection molding machine are as following:

1) Open nozzle is recommended with a individual band heater on the nozzle itself. This type of nozzle has advantages over other nozzles when it comes to dealing with gaseous products that result from thermal decomposition without pressure building-up when the molding cycle is stopped or interrupted with melt left in the cylinder for over residence time.

2) The non-return valve (check ring) must be inspected to achieve holding pressure and cushion so as not to cause processed parts to experience sink marks, wide variations of weight or dimensions.

3) The compression zone of the screw is recommended at 25 to 30 % of screw length. Improper compression zone length may not only over-heat material but also cause a lack of pressure build-up in the plasticizing.

Fig 2-1. Typical injection molding screw for KEPITAL



[Recommendations on injection molding machine]
1) The one shot weight for KEPITAL® is 20-50 % of machine capacity
2) L/D: 20~23
3) Compression ratio: 2:1~3:1
4) When processing glass-fiber reinforced KEPITAL®, using a wear resistant plasticizing unit (screw and barrel) is advisable and regular inspection of screw for wear is recommended.

2-2. Injection molding

When designing injection molding tooling it is essential to review the dimensional requirements of the molded components (tolerances, capability), flow characteristics of the raw material, and cost-effectiveness to ensure operational goals can be accomplished.

2-2-1. Pre-drying

Being a non-hydroscopic material, KEPITAL® in its original packages can be processed without pre-drying unless it is exposed to a humid atmosphere for a prolonged periods of time. However, sometimes moisture that exists on the surface of pellet caused by improper handling or storage may result in a silver streak or nozzle drooling, so drying prior to molding may be necessary to prevent KEPITAL® from having these problems. In addition, in some cases, pre-drying is effective in reducing odor, mold deposits and in achieving improved surface appearance quality. Drying conditions are recommended at 80-90 ˚C for 3-4 hours.

2-2-2. Melt temperature

The melt temperature of KEPITAL® in general is from 180 to 210 ˚C, preferably 190~200˚C. It is common for the melt temperature rises above the temperature at metering zone by 10-20˚C, this results from mechanical shear heating during plasticizing. Barrel temperature set points do not equate to melt temperature as would be taken with a melt temperature pyrometer.

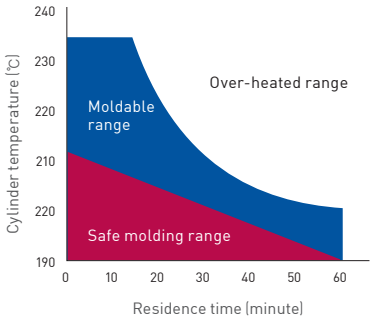
Table 2-1. Typical cylinder temperature for KEPITAL

Grade	Nozzle	Metering zone	Compression zone	Feed zone
General / UV & Weather resistance grade / Impact modified	180 ~ 210 ℃	190 ℃	180 ℃	170 ℃
Reinforced & filled		200 ℃	190 ℃	170 ℃
Low VOC	180 ~ 190 ℃	170 ℃	170 ℃	170 ℃

※ The above temperature is based on standard conditions and can be changed according to the size of injection molding machine and mold.
※ Refer to the separate materials for recommended injection molding conditions for low VOC product

When the melted improperly or exposed to long residence time in the plasticizing unit, over-heating causes thermal degradation, which results in discoloration, impairing mechanical properties, etc. The processing window; temperature versus melt residence time in the cylinder for standard unfilled grade is shown in Figure 2-2.

Fig 2-2. Cylinder temperature versus melt residence time in cylinder



2-2-3. Injection pressure

The injection pressure should be set high enough to achieve the set injection speed. The injection speed should not be reduced due to the low injection pressure. Typical injection pressures generally ranges 600 to 1200 bar.

2-2-4. Mold temperature

The mold temperature is a key parameters for injection molding of crystalline polymers. Mold temperature may widely be set up at 60-120 °C, and a general recommendation is 70-90 °C for general purpose of KEPITAL® molding grades. If the surface finish is important or the service temperature of finished part is expected to be high, higher mold temperature would be recommended.

To obtain a good quality product, the mold temperature must be consistently maintained so that the temperature distribution in the mold may be achieved uniformly. A mold temperature controller is recommended so that temperature, water flow rate and water pressure can be maintained.

2-2-5. Injection speed

The injection speed should be determined by part geometry, such as gate size, gate location, flowability and mold temperature etc. In order to obtain better appearance, it is desirable to increase the injection speed. On the other hand, it is common to reduce the injection speed to reduce the flash, burn marks or the shear stress during injection.

2-2-6. Hold pressure

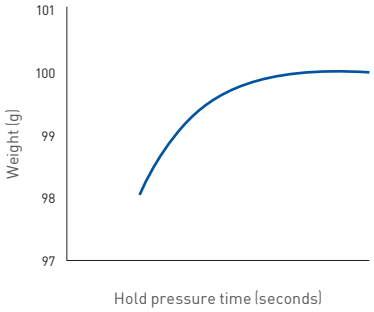
Hold pressure plays a key role in making KEPITAL® parts optimized not only in dimension but also in mechanical & physical properties. Because in the hold stage (hold/pack), remaining melt for about 1~5 % of a cavity is forced to fill in the cavity to compensate for the volume contraction during cooling. The hold (pack) time must be set to slightly exceed the gate seal time (normally ½ to 1 sec) at which a gate is completely solidified so a consistent product may be obtained.

As shown in Figure 2-3, the weight of a molded part increases upon the hold pressure time and then stops at a certain point. At this time the gate of the part is solidified entirely and no more material can be incorporated. Finally part weight shows consistency after the gate seal time. This study is commonly referred to as a Gate Freeze Study.

It is recommended that the hold pressure time be maintained until the gate seal is completed. Because the gate seal time changes mostly upon the shape of cross section and mold temperature, a proper hold pressure time must be determined such that the weight and dimension of a molded product are within a certain range.

By setting optimum hold pressure, molded parts product with consistent dimensions can be produced. As a rule of thumb, the hold time can be simply calculated by wall thickness (mm) times 8 seconds.

Fig 2-3. Hold pressure time and product weight



The hold pressure must be set in consideration of dimensional requirements. As a rule, hold pressure amounts to between 60-90 % of the injection pressure.

2-2-7. Plasticizing

Because plasticizing by an excessively fast rotating speed can make KEPITAL® decompose by high shear force, the reciprocating speed is preferably set as low as possible unless it does affect cycle time. Since screw RPM is dependent on diameter of the screw, screw line speed by screw can be utilized. As a result, screw line speed is recommended in the range of 150 mm/s to 200 mm/s, and with respect to the diameter of the screws following can be chosen.

Table 2-2. Screw rotational speed versus screw diameters

Screw Φ	25 mm	40 mm	55 mm
Screw rotational speed (rpm)	120	100	70

A back pressure of 10-20 bar is generally appropriate. However, to increase the efficiency of the dispersion of a color master batch (color concentrates) or pigment, higher mixing by increasing back pressure may be required. In addition high back pressure may be used to eliminate un-melted particles. In the case of glass fiber reinforced grades, high back pressure, proportional to rotational speed leads to breakage of the glass fiber, resulting in deterioration of mechanical strength. More importantly, excessive back pressure gives rise to lower output along with longer cycle time. Therefore, it should be taken into consideration in optimizing the back pressure.

2-2-8. Cooling

Total cooling time is determined as the sum of “hold pressure time + plasticizing time”. Once KEPITAL® is solidified entirely, no additional cooling time is needed. Most of the time affecting the cooling time is the hold time. Therefore, assuming the hold pressure time is set appropriately, only screw retraction time needs to be taken into account.

In the case of a high crystalline resin like KEPITAL®, sometimes a prolonged cooling time at high mold temperature may be applied to minimize the residual stress.

2-2-9. Flowability

Figure 2-5 shows the results of the spiral flow test in which the flow properties of standard unfilled grades were evaluated. Influence on flowability is found to depend greatly on molecular weight. In addition, Figure 2-6 shows the spiral flow test results of F20-03 at different injection pressures, indicating that flow characteristics tend to increase with higher injection pressures.

Fig 2-4. Cooling time versus mold temperature

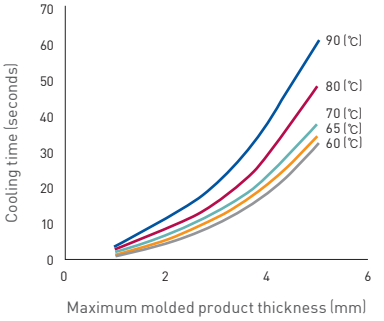


Fig 2-5. Flow path length of unfilled standard grades (melt temperature 200 ˚C, injection pressure 600 bar, thickness 3 mm spiral flow test)

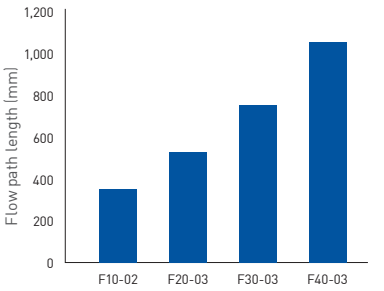


Fig 2-6. Flow path length of KEPITAL F20-03 as a function of injection pressures (melt temperature 200 ˚C, thickness 3 mm spiral flow test)

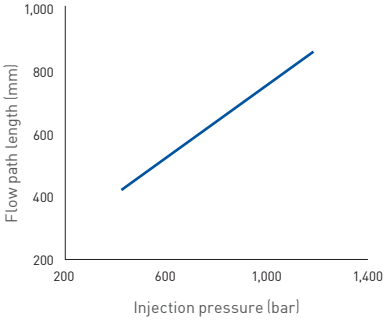


Fig 2-7. Flow characteristics of KEPITAL and other plastics during injection molding

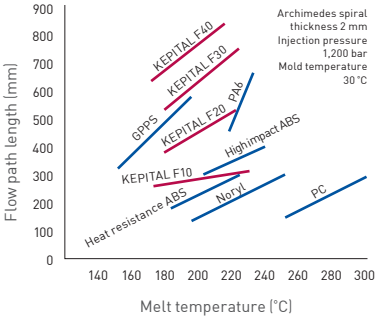


Fig 2-8. Shrinkage rate changes with mold temperature and specimen's thickness

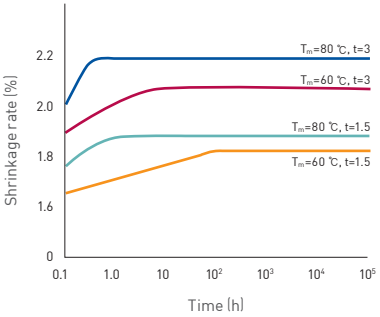


Fig 2-9. Shrinkage rate changes with injection pressures (F20-03, Melt temp. 200 °C, Specimen dia. 100 mm, t 2)

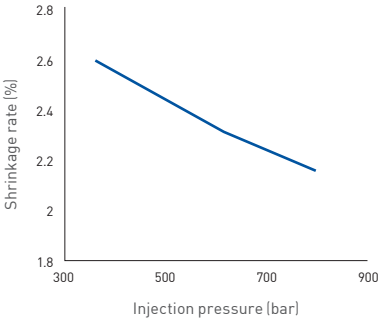
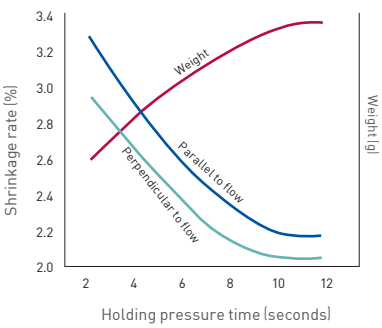


Fig 2-10. Shrinkage rate changes with holding pressures



Calculation of theoretical cooling time

$$S = \frac{t^2}{\pi^2 \alpha} \ln\left[\frac{8}{\pi^2}\frac{(T_c - T_m)}{(T_x - T_m)}\right] \qquad \alpha = \frac{R}{C_p \rho}$$

S = Theoretical cooling time
t = Maximum part wall-thickness
α = Thermal diffusivity of material
R = Thermal conductivity
C_p = Specific heat
T_x = Ejection temperature of molding
T_m = Mold temperature
T_c = Cylinder temperature

2-2-10. Cycle time

Cycle time varies with injection time, hold pressure time, cooling time, mold open time and safety margin at each cycle. Injection molding cycle time is closely related to part thickness. From a molder's stand point, a shorter cycle time is preferable; however, optimizing all time dependent parameters such as fill rate, hold pressure time and cooling time are very important to get quality parts out of KEPITAL®.

2-2-11. Shrinkage

The shrinkage rate is the most important factor determining a product's dimensions and is obtained from the sum of mold shrinkage and post-mold shrinkage. The shrinkage value, provided by KEP can be utilized in designing a part in the prototype phase. However most of the shrinkage behavior is affected by not only the plastics' characteristics but also the processing conditions and part geometry. Therefore, the shrinkage rate must be taken into account in consideration of all possible factors.

When mold temperature increases, the mold shrinkage rate increases, and post-mold shrinkage rate decreases.

In general, when the injection pressure increases, the shrinkage rate decreases. Experimentation can help to evaluate dimensions of a molded product. Key process input variables that can be adjusted by changing injection pressure and hold pressure and time can be evaluated vs key product dimensions.

Figure 2-10 demonstrates that shrinkage rate is high if hold pressure time is shorter than gate seal time.

2-3. Safety recommendation

2-3-1. Changing material in processing - Purging

In general, the cylinder (injection molding barrel) has to be cleaned/ purged with a polyolefin or a purging compound before and after KEPITAL® processing.

2-3-2. The interruption of molding cycle

Molding cycles can be stopped and interrupted by technical malfunctions in the operating machine or for other reasons. In this case, some special actions should be considered to prevent unnecessary problems. The barrel temperature should be lowered to 150 ˚C but the nozzle temperature may be maintained to prevent material from over-heating. If long-period interruption is expected close the feed throat of pellets and purge the barrel of all resin. Once completed then lower cylinder (barrel) and nozzle temperatures.

Whereas increase the nozzle temperature to 200 ˚C and then raise the cylinder temperature gradually when restarting machine with KEPITAL® to prevent the nozzle being blocked by frozen material.

2-3-3. Recycling of KEPITAL® - Use of regrind

While recycled material mixing with virgin material does not particularly interfere with color difference, mechanical properties, and moldability, the high dosing rate of recycle is likely to cause contamination, and an increase in the melt index is accompanied by recycled frequencies.

2-4. Safety Precautions during processing

In processing of KEPITAL®, a ventilation extraction hood should be equipped over the barrel unit and measures should be implemented to ensure the ventilation of the work place.

KEPITAL® decomposes when subjected to excessive heating over 230 ˚C or the residence time in the injection barrel at 200 ˚C or higher. The decomposition of KEPITAL® generates formaldehyde gas which has a pungent smell and irritates the mucous membrane. Therefore, when thermal degradation is noticeable, the cylinder should be flushed by purging out melt and the cylinder temperature must be reduced at the same time. In order to prevent odor nuisance, thermally damaged material can be cooled down in a water bath. In addition, if material stays in a cylinder under the condition of a blocked nozzle, formaldehyde gas can rapidly build up a high gaseous pressure in the cylinder. When the pressure is elevated to a certain extent, the resin and gas in a cylinder are explosively discharged through the filling hopper, which could cause serious injury to operators and damage to the injection molding machine. It is therefore important to ensure the nozzle is never frozen or obstructed during processing.

KEPITAL® is immiscible with almost all other plastics. If other materials are introduced and mixed, caution is required because problems including contamination, lamination, and deterioration of physical properties arise. In the case of a master batch that requires implementation of colors, a

product based on KEPITAL® is recommended. Special attention should be considered to limit PVC exposure to KEPITAL®, because if even a small amount of PVC resin is introduced and mixed, it causes serious degradation to the KEPITAL® resin, it is a good practice to prevent introduction and mixing of materials and also to use individual injection molding machines for PVC and KEPITAL® only.

2-5. Troubleshooting guide for KEPITAL®

Processing problem	Causes	Remedies
Sticking in cavity	- Higher resistance to eject force - Insufficient cooling time	- Decrease injection pressure and check for undercut or insufficient draft - Clean mold surface - Increase the number of ejecting pins - Lower the mold temperature and increase mold close time
Short shot	- Insufficient flowability by low melt or mold temperature - Improper design with small gate or narrow flow channel - Unbalanced filling - Insufficient metering stroke	- Increase the cylinder temperature and mold temperature. - Increase injection pressure and speed - Enlarge the gate - Adjust runner balance - Increase metering stroke
Pit mark	- Low injection speed - Low holding pressure - Low melt or mold temperature	- Increase injection speed - Increase injection and holding pressure - Increase melt or mold temperature
Flow mark	- Slow injection speed - Low mold temperature	- Increase injection speed - Change the gate location or enlarge gate size - Increase mold temperature
Silver streak	- High moisture in granule - Decomposition by over-heating - Insufficient gas vent - Air entrap into cylinder - Contamination	- Drying at 80-90 °C for 3-4 hours - Lower the cylinder temperature or shorten residence time in cylinder - Check for gas vent - Increase back pressure - Check for contamination with PVC
Discoloration or burn mark	- Over-heating or too long residence time in cylinder - Insufficient gas vent - Fast injection speed	- Lower the cylinder temperature - Check for gas vent - Decrease injection speed
Contamination	- Contamination with other material - Black specks	- Take precautions on handling - Clean the cylinder
Flash	- Low clamping force - Too high injection pressure or holding pressure - Too fast injection speed - Mold wear	- Increase clamping force - Lower injection pressure or holding pressure - Lower injection speed - Repair mold
Sink and void	- Too low holding pressure - Wear of non-return valve - Improper cushion	- Increase holding pressure and time - Increase mold temperature - Gating at thick wall - Check for non-return valve

3. UL Standards

Each grade of KEPITAL has acquired the plastics materials standard (UL standard) from Underwriters Laboratories Inc.

Accredited UL standards of KEPITAL®

File No. : E120354

Description	Material Designation	Color	Minimum Thickness (mm)	UL94 Flame Class	Relative Temperature Index (℃)			HWI	HAI	HVTR	D495	CTI
					Electric	Mechanical						
						Impact	Strength					
Polyacetal homo polymer	H100(+)	ALL	0.75	HB	4	0	50	50	50	0	3	0
			1.5	HB	4	0	50	50	50	N.A.		
			3	HB	3	0	50	50	50			
			6	HB	3	0	50	50	50			
General	F10-(xx)(+)	ALL	0.75	HB	110	95	100	-	-	0	5	1
			1.5	HB	110	95	100	4	0	N.A.		
			3	HB	110	95	100	3	0			
			6	HB	110	95	100	3	0			
	F15-(xx)(+)	NC	0.9	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		
	F20-(xx)(+)(r1)	ALL	0.75	HB	110	95	100	-	-	0	5	1
			1.5	HB	110	95	100	4	0	N.A.		
			3	HB	110	95	100	3	0			
			6	HB	110	95	100	3	0			
	F25-(xx)(+)	ALL	0.75	HB	110	95	100	-	-	0	5	1
			1.5	HB	110	95	100	4	0	N.A.		
			3	HB	110	95	100	3	0			
			6	HB	110	95	100	3	0			
	F30-(xx)(+)	ALL	0.75	HB	110	95	100	-	-	0	5	1
			1.5	HB	110	95	100	4	0	N.A.		
			3	HB	110	95	100	3	0			
			6	HB	110	95	100	3	0			

Description	Material Designation	Color	Minimum Thickness (mm)	UL94 Flame Class	Relative Temperature Index (℃)			HWI	HAI	HVTR	D495	CTI
					Electric	Mechanical						
						Impact	Strength					
General	F40-(xx)(+)	ALL	0.75	HB	110	95	100	-	-	0	5	1
			1.5	HB	110	95	100	4	0	N.A.		
			3	HB	110	95	100	3	0			
			6	HB	110	95	100	3	0			
UV & Weather resistance	F20-51U(f1)	BK	0.95	HB	50	50	50	-	-	-	-	-
	F20-52(+)	ALL	0.75	HB	110	95	100	-	-	-	-	-
Reinforced & Filled	FG2025(+)	ALL	0.75	HB	105	90	95	3	0	0	6	1
			1.5	HB	105	90	95	3	0	N.A.		
			3	HB	105	90	95	2	0			
	FG20-(c)(+)	ALL	0.75	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		
	FB-20#	ALL	0.75	HB	50	50	50	-	-	-	-	-
	TC3020(+)	ALL	0.75	HB	50	50	50	-	-	-	-	-
	FT-20(xx)(+)	ALL	0.75	HB	50	50	50	-	-	-	-	-
Friction & Wear resistance	FL-20(xx)(+)	ALL	0.75	HB	50	50	50	-	-	-	-	-
	TS-2(&)(+)	ALL	0.9-1.0	HB	50	50	50	-	-	-	-	-
	FS-20(xx)(+)	ALL	0.75	HB	50	50	50	-	-	-	-	-
	FM2020(+)	BK	0.75	HB	50	50	50	-	-	-	-	-
	FM25(xx)(+)	BK	0.94	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		
	TX-(Y)1(+)	ALL	1.5	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		
	NX-(XX)(+)	NC	0.8	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		
	CX-(XX)(+)	NC	0.8	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		

Description	Material Designation	Color	Minimum Thickness (mm)	UL94 Flame Class	Relative Temperature Index (℃)			HWI	HAI	HVTR	D495	CTI
					Electric	Mechanical						
						Impact	Strength					
Friction & Wear resistance	WX-(XX)(+)	NC	1.5	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		
	LO-2(&)(+)	ALL	0.75	HB	50	50	50	-	-	-	-	-
Impact modified	TE-2(Z)(+)	ALL	1.5-1.7	HB	50	50	50	-	-	-	-	-
	FU20-(e)(+)	ALL	1.5	HB	50	50	50	-	-	-	-	-
			3	HB	50	50	50	-	-	N.A.		
Conductive	ET-20(+)	BK	0.75	HB	50	50	50	-	-	-	-	-
	FA-20(xx)(+)	BK	0.75	HB	50	50	50	-	-	-	-	-
	FC-20(xx)(+)	BK	0.75	HB	50	50	50	-	-	-	-	-

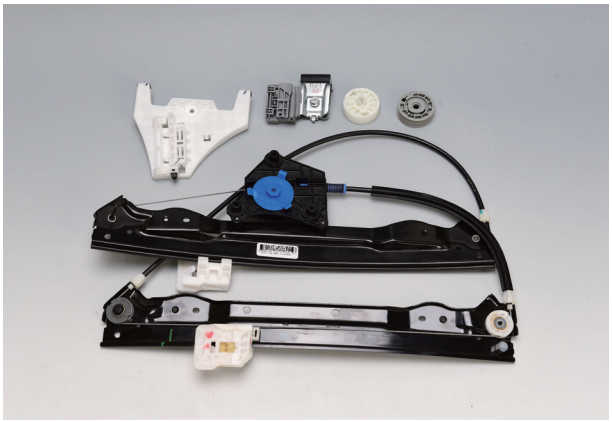
: May be replaced with two digits.
(&) : May be replaced by a digit indicating oil content.
(c) : Denotes glass fiber content 10-30% except 25%.
(e) : Denotes polyurethane content 5~50%.
(f1) : Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL 746C.
(r1) : Virgin and regrind up to 100% by weight inclusive have the same basic characteristics.
(xx) : May be replaced by one or two digits except F20-52(+), F20-61(+) and F20-51U.
(Y) : May be replaced by one digit 1-9 according to indicating to viscosity of Base Resin without any changes in the composition.
(Z) : May be replaced by one digit 1-9 indicating filler content
+ : May be replaced by one, two, three, four, or five letters and/or one, two, or three digit numbers

HWI : Hot Wire Ignition
HAI : High Ampare Arc Ignition
HVTR : High Voltage Arc Tracking Rate
D495 : Arc Resistance
CTI : Comparative Tracking Index

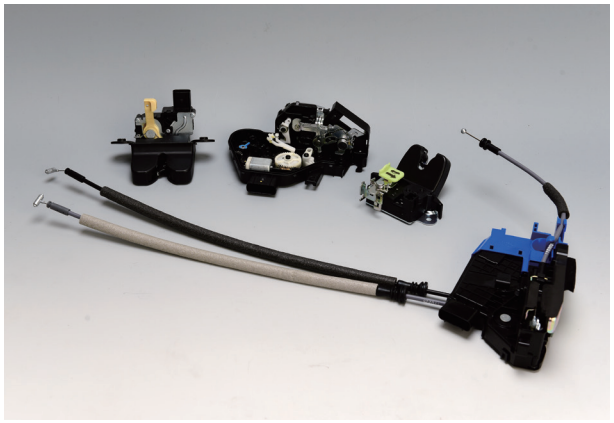
4. Applications

Automotive

Fuel pump module



Window regulator module



Door latch module

Bumper bracket parts

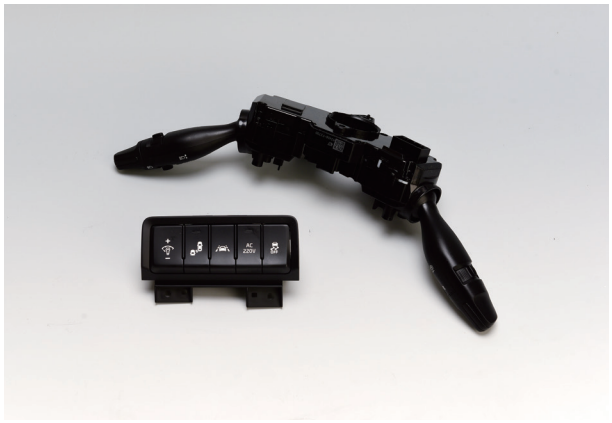
Gear parts

Side mirror parts

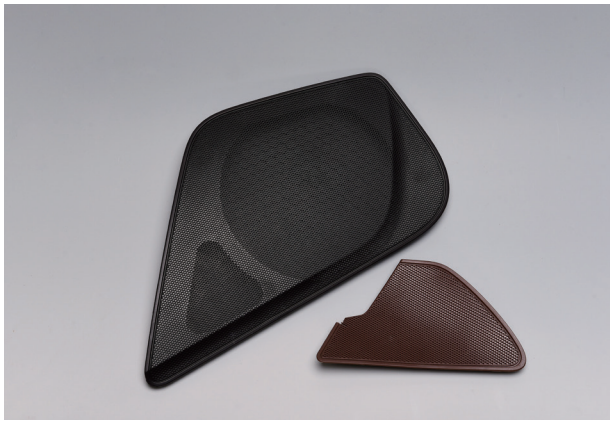
Through continuous innovation and new value creation, KEP will be the premier chemical company providing humanity with solutions for a better future.

Seat belt module

Seat parts



Combination switch module

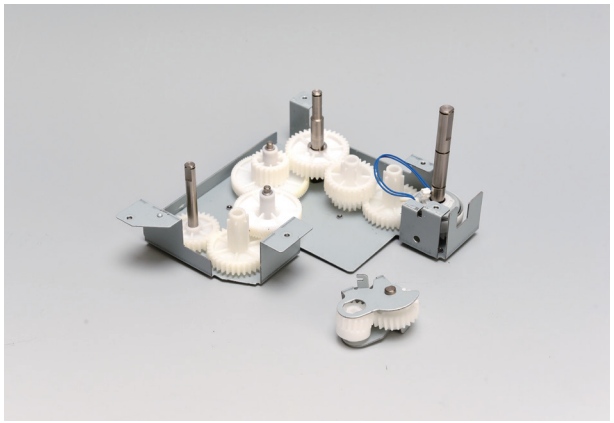


Speaker grille parts

HVAC parts

Clips (Fasteners)

Electric · Electronic · Construction & Consumer goods



Printer parts

Water purifier pitting

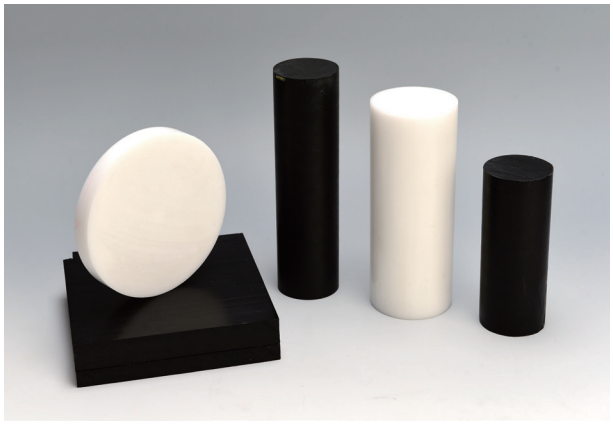
Cosmetic applications

Massage chair parts

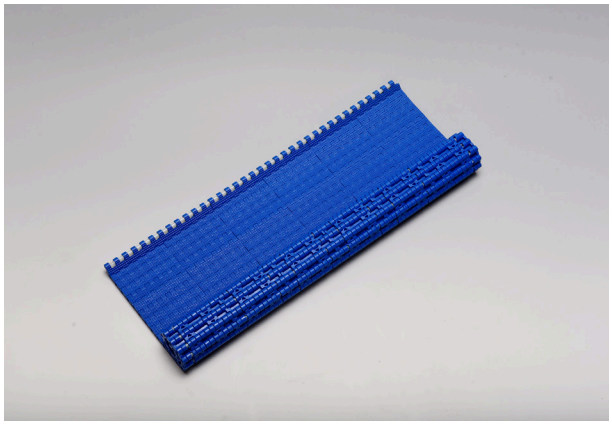
Zippers

Buckles

Sanitary parts

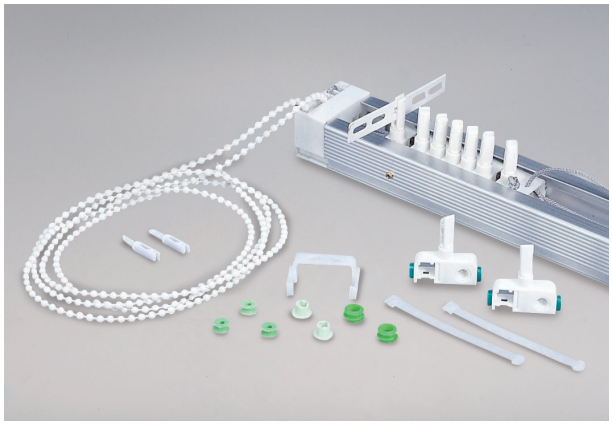


Rod and Plate



Conveyor belts

Rollers



Blind parts

Chair parts

5. Quality and standard accreditation

Korea Engineering Plastics Co., Ltd. is committed to creating profitable future for customers and has met the requirements of international quality accreditation systems such as ISO/TS 16949 and ISO 14001, starting with ISO 9000. This global company continues to rise to meet its challenges and is also recognized as an official standard testing agency based on ISO 17025 by KOLAS (Korea Laboratory Accreditation Scheme) in an effort to improve its reliability in test results. Furthermore, we have obtained standard accreditations from UL, CSA, NSF and BS6920, compliance to FDA, and have established global excellence in terms of quality and stability.

Classification	Accreditation standard
System standard	- ISO/TS 16949 - ISO 9001 - ISO 14001 - K-OHSMS 18001 - ISO/IEC 17025 (KOLAS)

- ISO/TS 16949 : Integrated quality management system in automotive
- ISO 9001 : Quality management system
- ISO 14001 : Environment management system
- K-OHSMS 18001 : Safety and health management system
- ISO/IEC 17025 (KOLAS) : Test agency accreditation system

Standard accreditation certificate

ISO 9001

ISO 14001

ISO/TS 16949

K-OHSMS 18001

ISO/IEC 17025 (KOLAS)

Properties are subject to change upon new knowledge and development

※ Although the information and recommendations set forth herein are presented in good faith and believed to be correct, we recommend that persons receiving information must make their own determination as to its suitability to their purposes prior to use. The information is based on natural colored products only through relevant test methods and conditions. It is the obligation of the customer to determine whether a particular material and part design is suitable for a particular application. The customer is responsible for evaluating the performance of all parts containing plastics prior to their commercialization.

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