Polyacetal copolymer

Iupital™

Physical Properties Guide

GLOBAL POLYACETAL

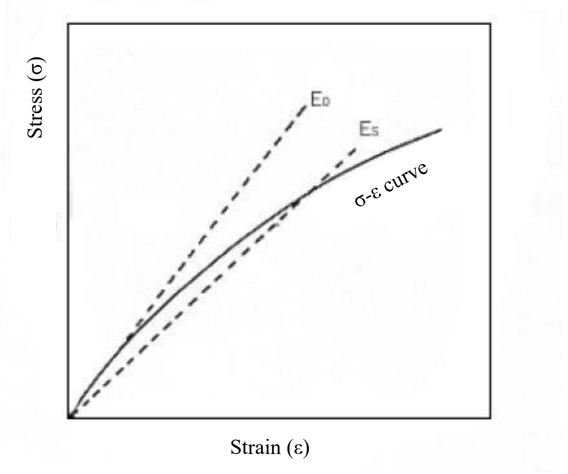
Table of Contents

1.1 Tensile strength

Fig. 1.1-1 and 1.1-2 show the stress-strain curve and elastic modulus-strain curve when Iupital is pulled by the strain rate of 5mm/min. The temperature dependence is shown in Fig. 1.1-3, and the velocity dependence is shown in Figs. 1.1-4 and 1.1-5.
The tensile properties of Iupital are as follows: (ASTM-D638)

Tensile stress625kg/cm^2
Growth rate 60%
Modulus of elasticity in tension 28900kg/cm^2

An effective data point for design that considers deformation is the secant modulus ratio, as depicted in the figure. The stress-strain curve, from the slope Eo of the tangent at the origin (the initial elastic modulus) and the slope Es of the line drawn from the origin to the respective curves (the secant elastic modulus), expressed as the secant elastic modulus ratio = Es/Eo.



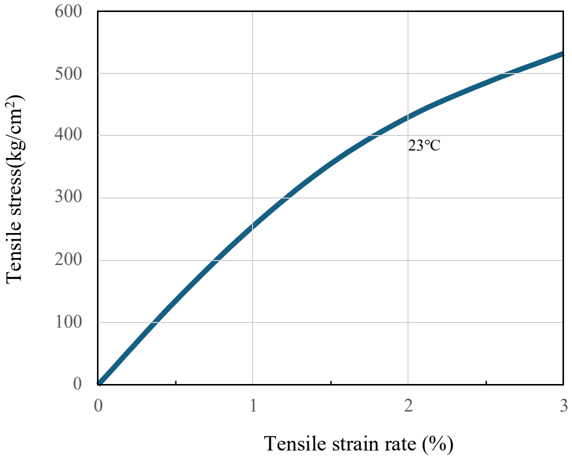


Fig. 1.1-1 Relationship between tensile stress and strain rate

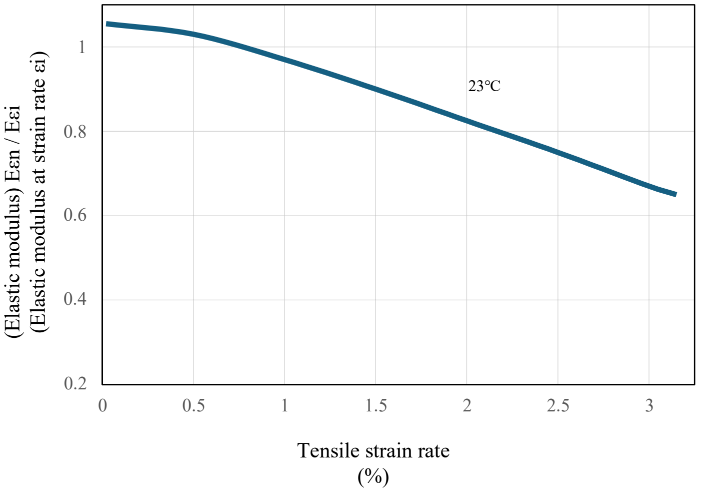


Figure 1.1-2 Relationship between split line modulus ratio and strain rate

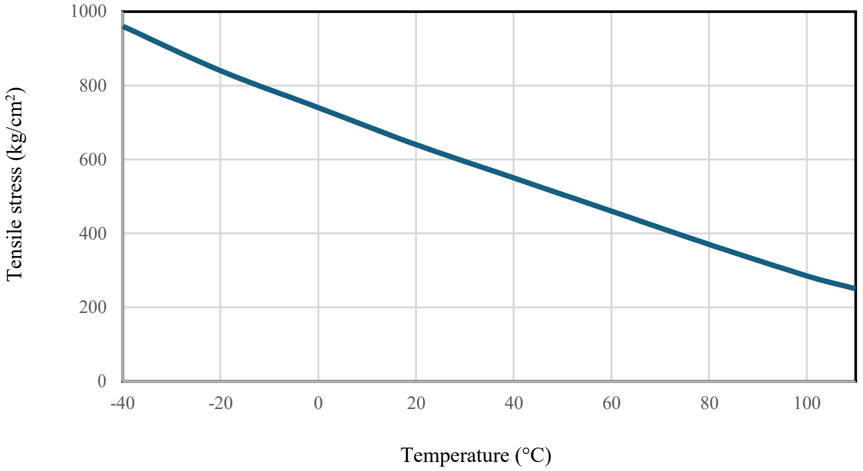


Fig. 1.1-3 Temperature dependence of tensile strength

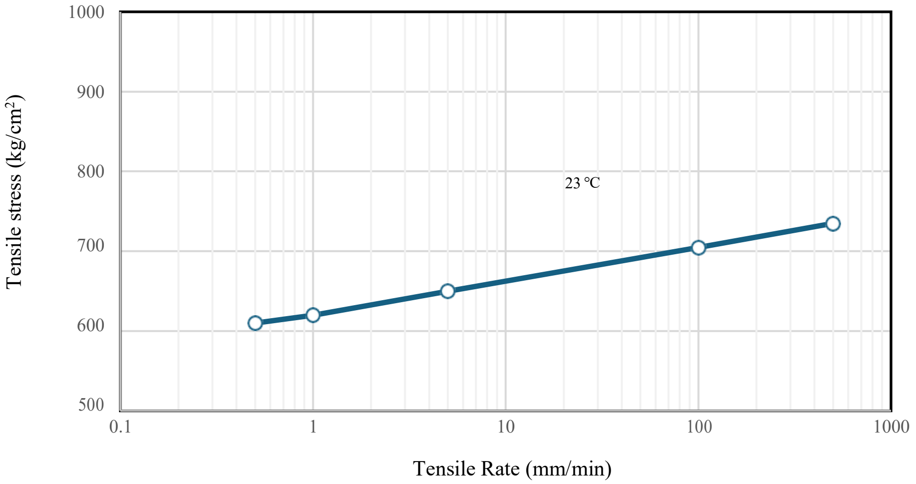


Fig. 1.1-4 Speed dependence of tensile strength

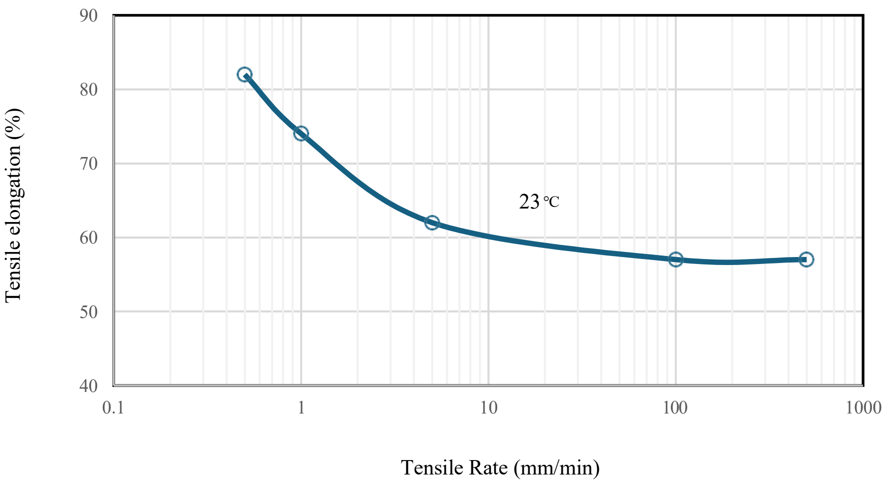


Fig. 1.1-5 Speed dependence of tensile elongation

1.2 Bending strength

Figures 1.2-1 and 1.2-2 illustrate the stress-strain curve and the elastic modulus-strain curve for Iupital under a bending deflection rate of 10 mm/min. The temperature dependence of these properties is shown in Figure 1.2-3.Iupital's flexural characteristics are as follows. (ASTM D790)

Flexural stress 915kg/cm^2
Flexural modulus 26500kg/cm^2

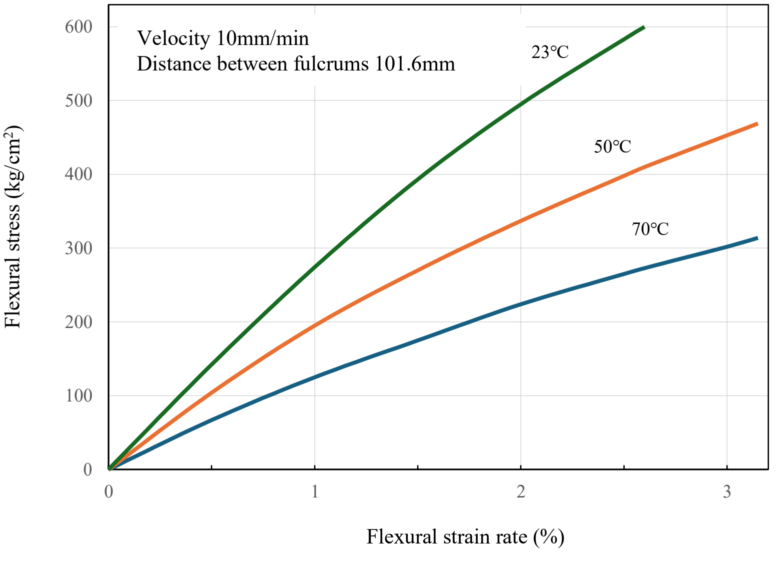


Fig. 1.2-1 Flexural stress-strain curve

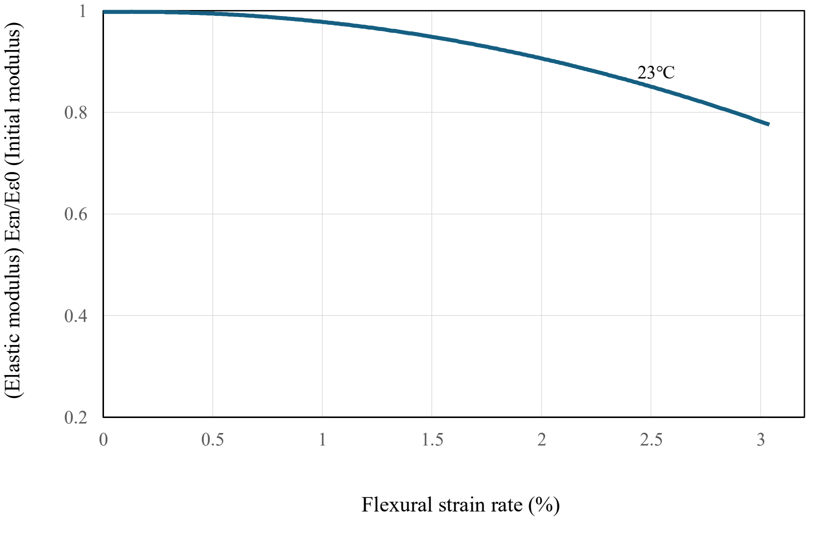


Figure 1.2-2 Relationship between split line modulus ratio and strain rate

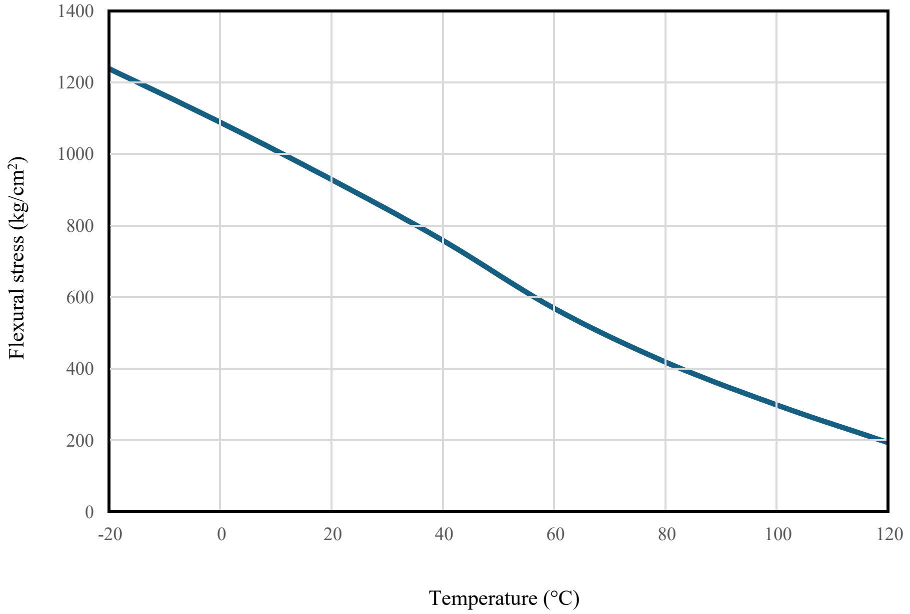


Fig. 1.2-3 Temperature dependence of flexural stress

1.3 Compressive strength

The compressive stress-strain curve is shown in Figure 1.3-1.
The compressive strength of the Iupital are as follows: (ASTM D-695)

Compressive strength 1% strain 310kg.cm2
10% Distortion 1050kg/cm^2

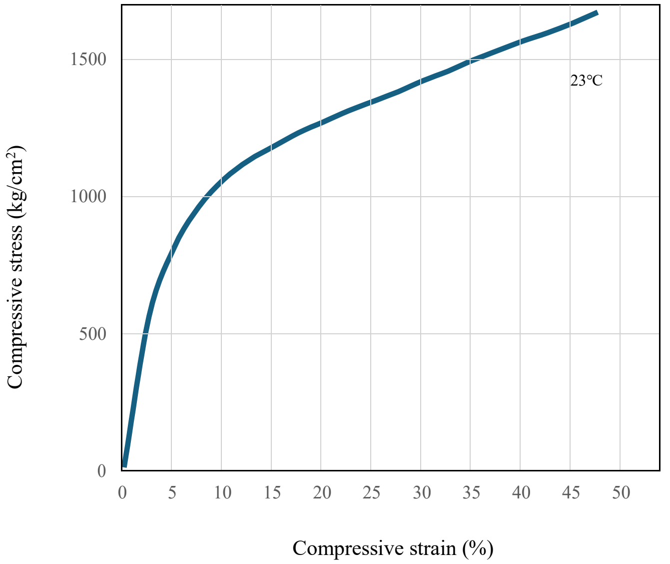


Fig. 1.3-1 Compressive stress-strain curve

1.4 Shear strength

Figure 1.4-1 shows the shear stress and shear load versus deformation curve.
The shear strength of the Iupital are as follows: (ASTM D732-78)

Shear strength 560 kg/cm 2

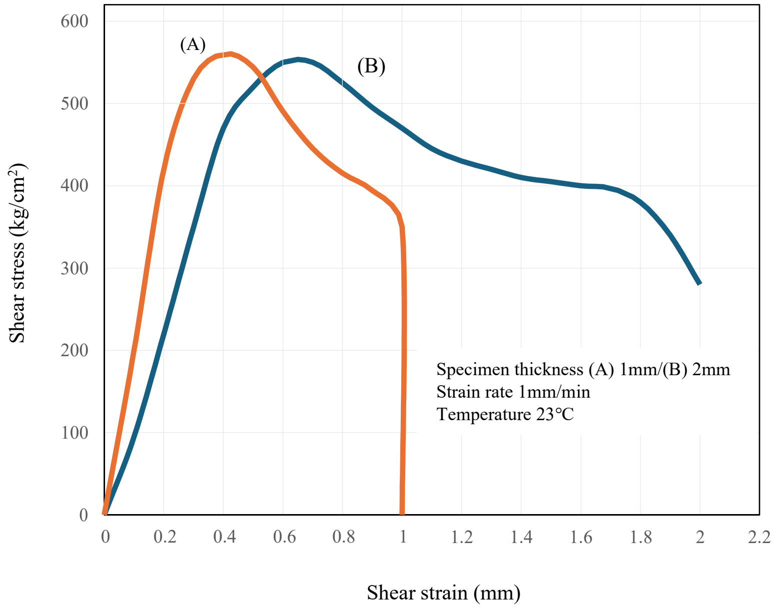


Figure 1.4-1 Relationship between shear stress and shear strain

1.5 Impact strength

Fig. 1.5-1 and 1.5-2 show the impact strength and impact fatigue properties of various corner shapes.
Iupital's impact strength is as follows.

Izod method with notch	[thickness 3.2mm]	ASTM D-256 6.5kg・cm/cm
Notch-free Izod method	[thickness 3.2mm]	> 110kg・cm/cm
Tensile impact method	[thickness 3.2mm]	ASTM D-1822 150kg・cm/cm^2
	[thickness 1.6mm]	〃 120kg・cm/cm^2
Drop ball method	[thickness 3.2mm]	25kg・cm
Sphere end 5R support 85mmφ		

Temperature dependence and thickness dependence of notched Izod are small, as shown in the figures below.

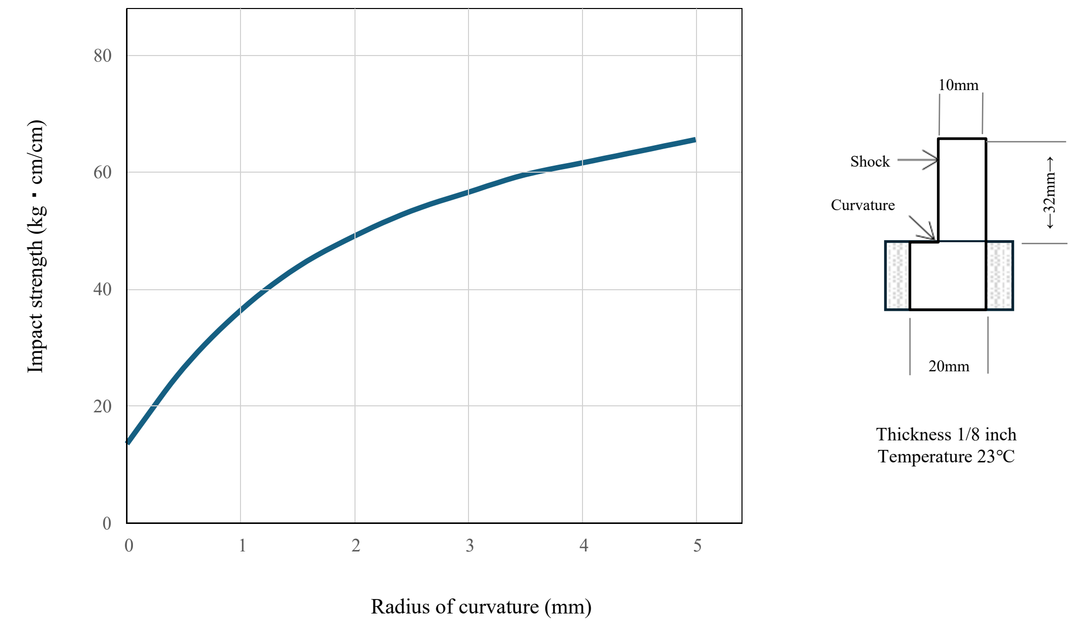


Fig. 1.5-1 Relationship between impact strength and curvature

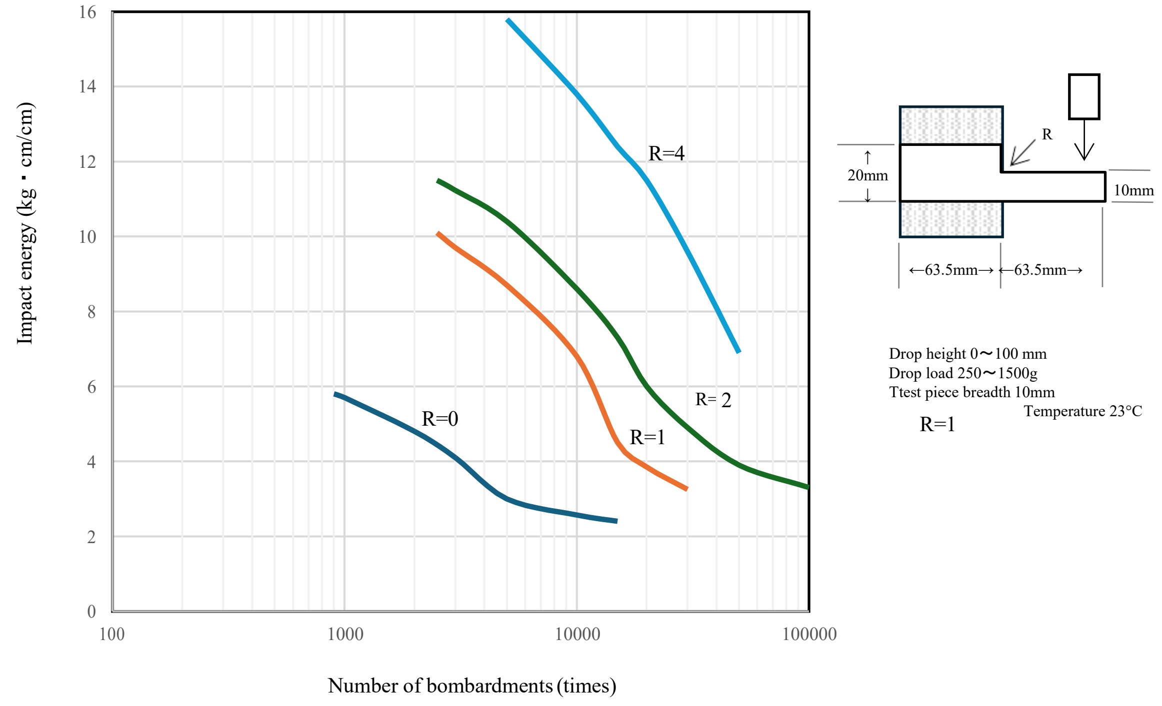


Figure 1.5-2 Repeated impact fatigue

1.6 Long-time behavior under load

1.6-1 Fatigue resistance

Fig. 1.6.1-1 and 1.6.1-2 show the results of tensile compression fatigue and bending fatigue of Iupital

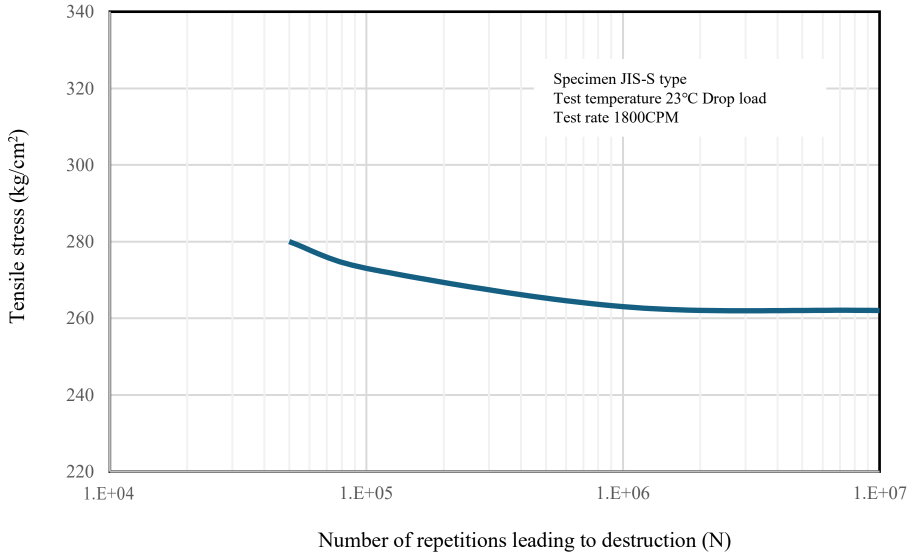


Fig. 1.6.1-1 Relationship between tensile fatigue strength and number of cycles

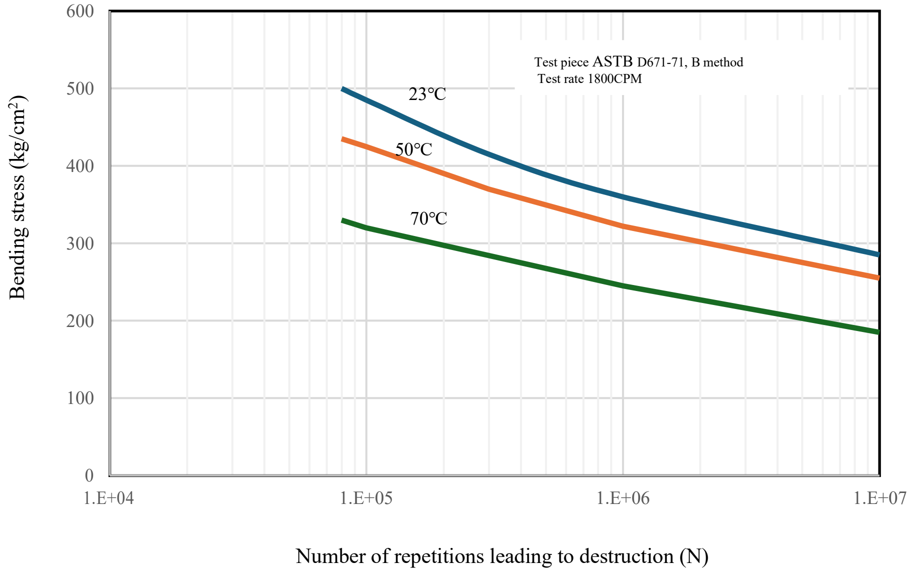


Fig. 1.6.1-2 Relationship between bending fatigue strength and number of cycles

1.6-2 Creep property

Over extended periods under constant stress, the specimen exhibits increasing deformation. This is called the creep phenomenon. Creep changes in Iupital are shown in Figures 1.6.2-1 and 1.6.2-2.

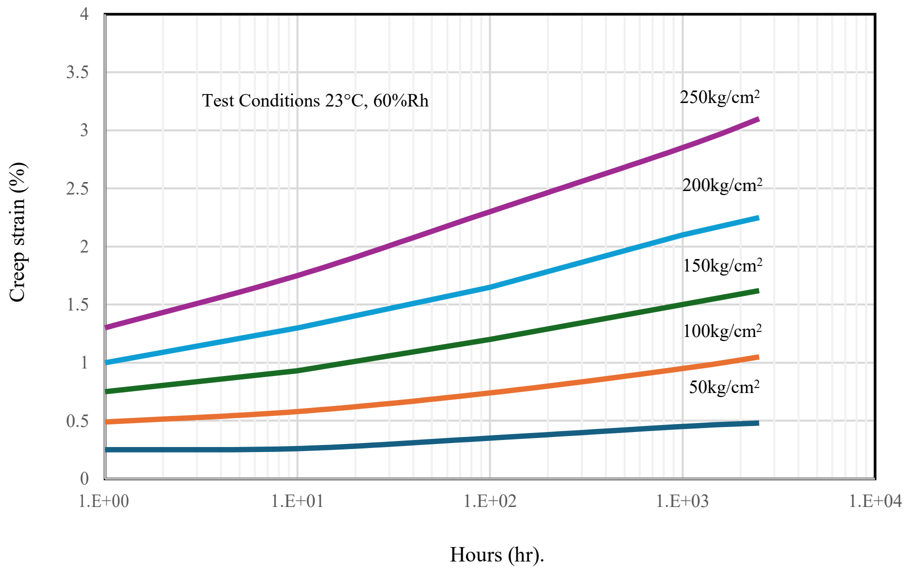


Fig. 1.6.2-1 Tensile creep change

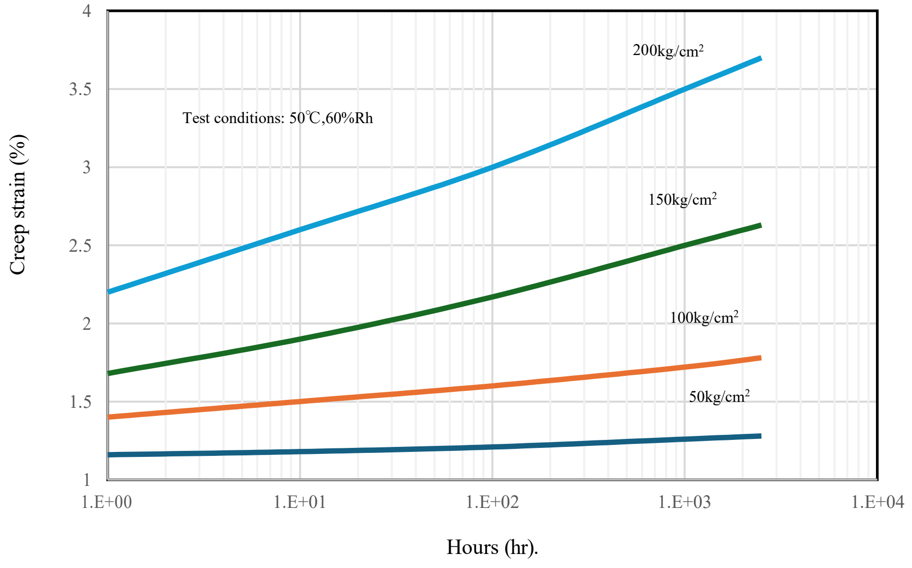


Fig. 1.6.2-2 Tensile creep change

1.6-3 Stress relaxation

Under sustained constant strain (deformation), the stress within the specimen gradually diminishes over time.
This is called the stress relaxation phenomenon.
Figure 1.6.3-1 shows the stress relaxation of Iupital.

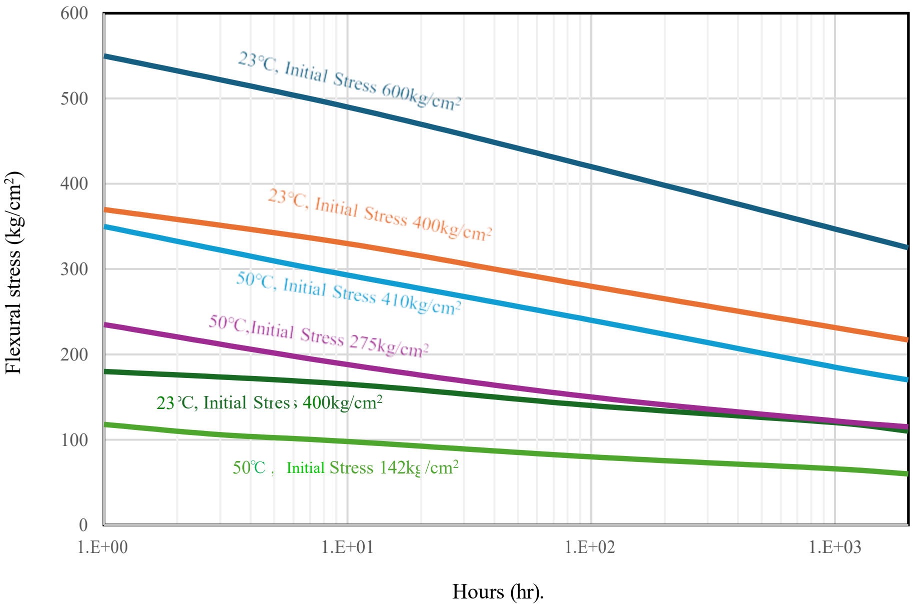


Fig. 1.6.3-1 Relaxation of bending stress

2.1 Melting point

The melting point of the polyacetal copolymer, Iupital, by DSC spectrometry is 166-170 °C.

2.2 Thermal conductivity and specific heat

Thermal conductivity of Iupital is 2×10^{-4}cal/cm・sec・° C.
The specific heat of Iupital is 0.35cal/g °C.

2.3 Coefficient of thermal expansion

The linear expansion rate of Iupital varies with temperature. Figure 2.3-1 and 2.3-2 show the temperature dependence of the dimensional increase rate and the linear expansion rate.

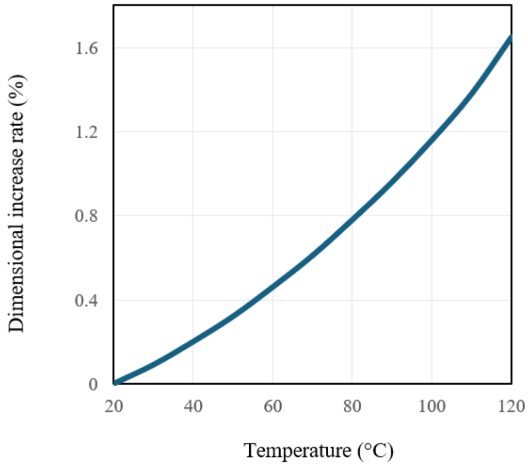


Figure 2.3-1 Dimensional Increase Rate by Temperature Change of Iupital (20°C basis)

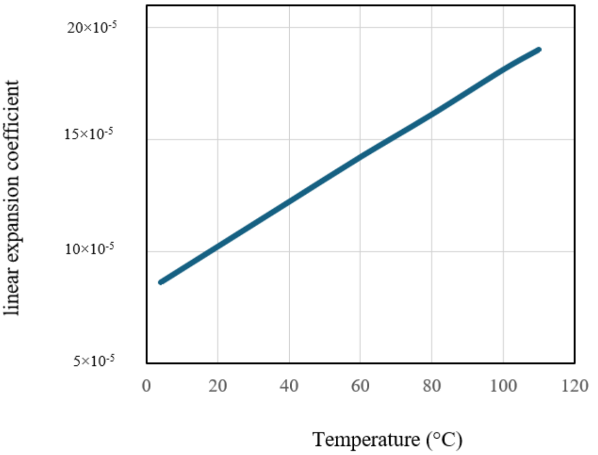


Figure 2.3-2 Temperature dependence of the linear expansion rate of Iupital

Their linear expansion coefficients are as follows.

Linear expansivity -25～25℃: 8～9×10^{-5}cm/cm/℃
20℃～80℃: 10～16×10^{-5}cm/cm/℃

2.4 Deflection temperature under load

The load deflection temperature of the Iupital is as follows.

Stress 18.6kg/cm^2 110 °C (ASTM-D648)
Stress 4.6kg/cm^2 158 °C (〃)

2.5 Characteristic change in heat treatment

The molding of intricate parts with uneven wall thickness or inserts can create non-uniformities in molten resin flow and cooling, resulting in internal residual strain and potential deformation. Crystalline resins, such as Iupital, are more susceptible to stress relaxation than amorphous resins, yet their lower residual strain minimizes stress cracking. While annealing at 140-150 °C can alleviate residual strain in Iupital moldings, these parts undergo thermal aging at operational temperatures, causing progressive crystallization. This aging process leads to increased tensile and flexural strength, but reduced elastic modulus, elongation, and impact resistance, accompanied by dimensional shrinkage. Designers must incorporate these long-term property changes into their considerations.

2.5-1 Intensity change in heat treatment

The impact of heat treatment on strength varies based on factors such as temperature, duration, and molding conditions. Generally, heat treatment tends to reduce the initial elastic modulus. Figures 2.5.1-1 and 2.5.1-2 illustrate these strength changes.

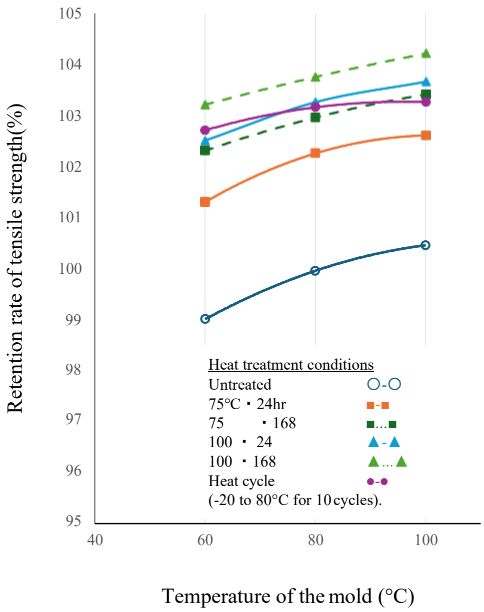


Fig. 2.5.1-1 Heat treatment conditions and tensile strength change

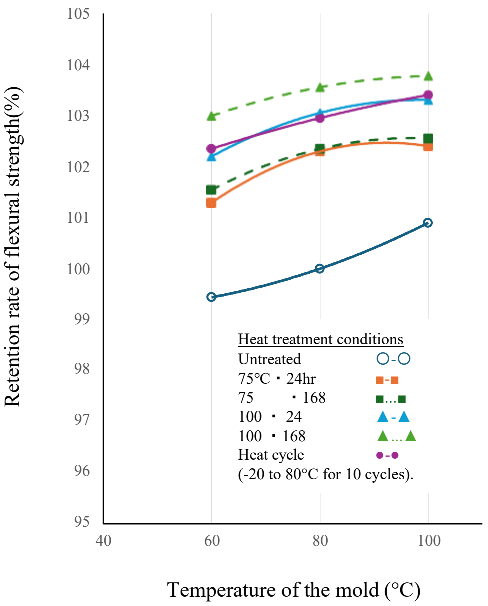


Fig. 2.5.1-2 Heat treatment conditions and Flexural strength change

2.5-2 Dimensional change due to heat treatment

Heat treatment speeds up crystallization in crystalline resins, resulting in dimensional changes. These changes are significantly influenced by both heat treatment conditions (temperature, time) and molding parameters like wall thickness and mold temperature. These relationships are shown in Figures 2.5.2-1 and 2.5.2-2.

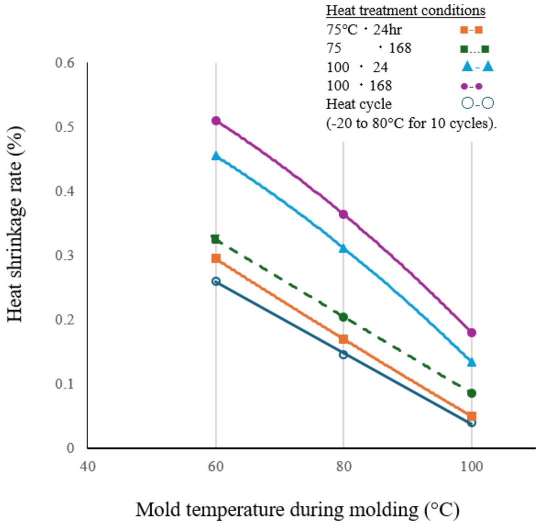


Fig. 2.5.2-1 Heat treatment conditions and tensile strength change

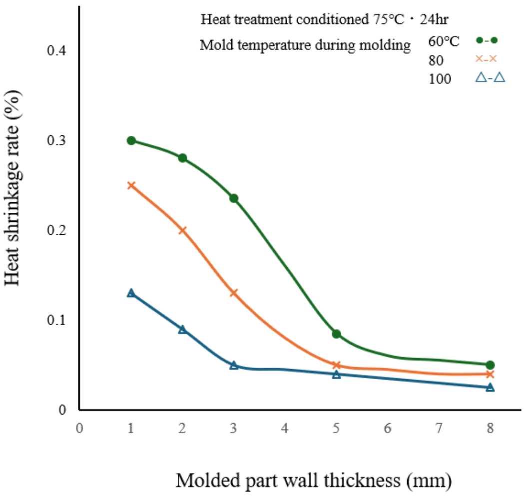


Fig. 2.5.2-2 Molded product wall thickness and heat treatment dimensional change

3.1 Water absorption and water resistance

Figure 3.1-1 shows changes in weight due to water absorption, equilibrium water absorption, and dimensions due to water absorption are shown in figures 3.1-2 and 3.103..
Figure 3.1-4 shows the change in tensile impact strength when left in high- temperature water,
The change in tensile strength is shown in Fig. 3.1-5.

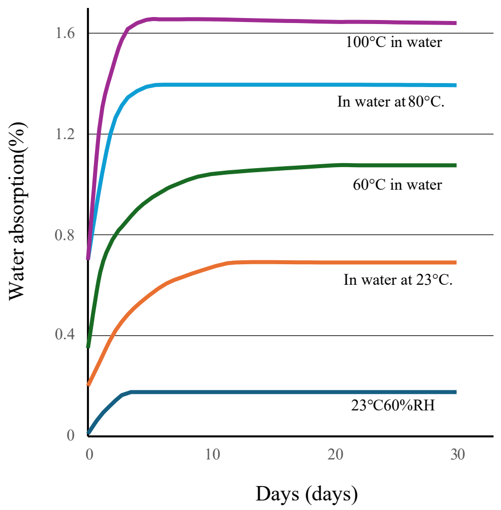


Figure 3.1-1 Water absorption

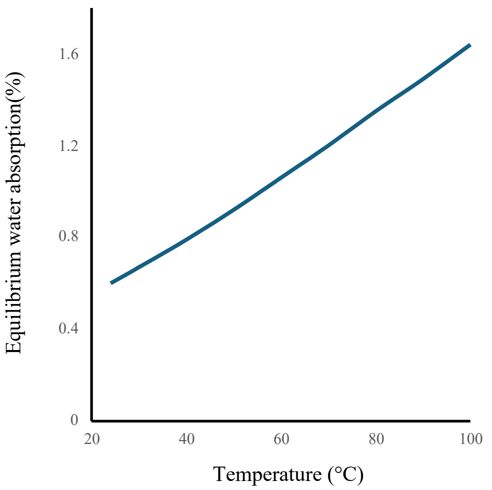


Figure 3.1-2 Temperature dependence of equilibrium water absorption

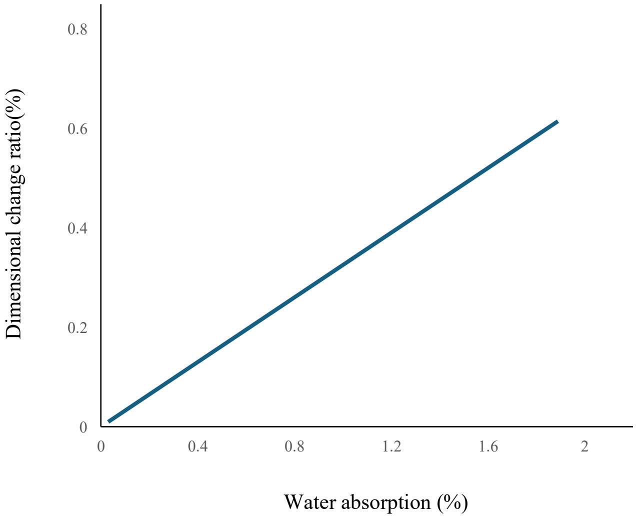


Figure 3.1-3 Dimensional changes caused by water absorption

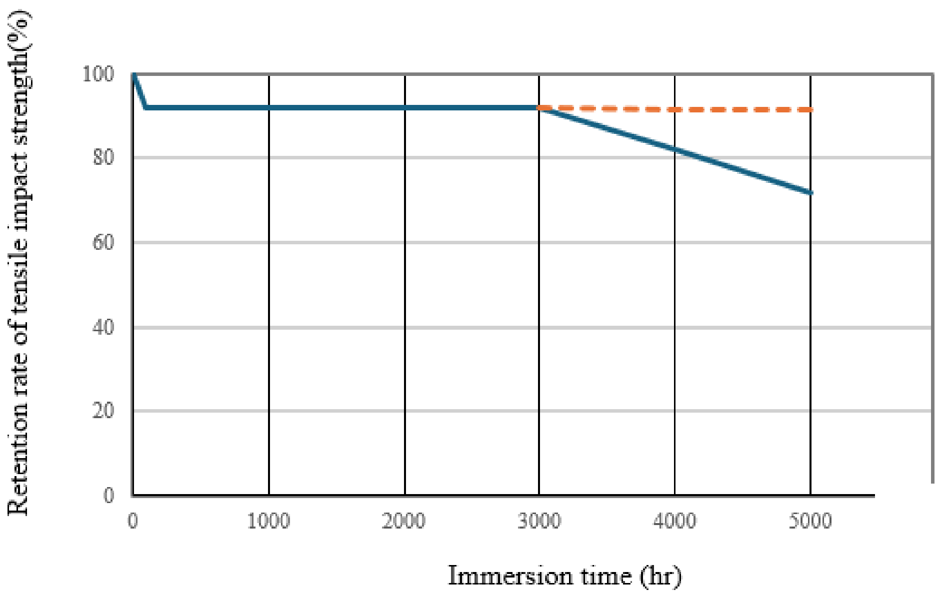


Fig. 3.1-4 Hot water immersion and change in tensile impact strength

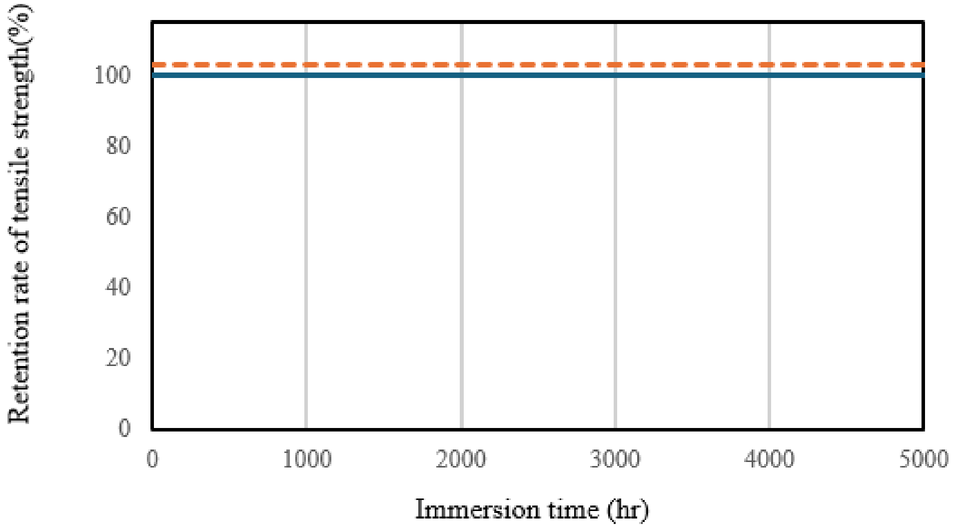


Fig. 3.1-5 Hot water immersion and change in tensile strength

3-2 Chemical resistance

Iupital boasts excellent chemical resistance to numerous organic and inorganic chemicals and petroleum-based substances (see Table 3 for physical property changes after immersion at room temperature and 70 °C). While generally resistant to stress cracking and solvent corrosion common in plastics, Iupital can be attacked by some strong acids. Cracking may also occur at stress concentration points or weld lines, particularly with chemicals like hydrochloric acid under stress.

Classification	Chemical name	Immersion conditions		Rate of change		
		Concentration (%).	Temperature (°C)	Tensile strength	Dimensions	Weight
Organic chemicals	n-heptane	100	23	±0	-0.01	+0.15
	Ethyl alcohol	99.5	23	-4.0	+0.13	+0.60
	Acetone	98	23	-4.2	+0.61	+1.50
	Carbon tetrachloride	96	23	-0.6	+0.05	+0.43
	Acetic acid	5	70	-4.5	-0.51	-1.29
Gasoline, grease, and lubricating oil	Mitsubishi high-octane gasoline	100	23	-0.8	+0.06	+0.26
	Diamond motor oil	100	70	+4.4	-0.13	+0.07
	Transmission oil	100	70	+3.7	-0.12	+0.12
	High-voltage insulating oil	100	70	+0.2	+0.07	-0.90
	Diamond chassis grease	100	70	+3.9	-0.10	+0.18
	Cup Grease No.3	100	70	+3.2	-0.06	+0.23
	Lubricating Oil Daphne #115	100	70	+4.7	-0.16	+0.08
	〃 Swarub RO-700	100	70	-2.8	+0.02	-0.33
	〃 Turbine oil #140	100	70	+4.2	-0.14	+0.09
Detergent	Mama lemon (Kao)	100	70	+2.6	-0.32	-0.33
	My pet (Kao)	100	70	+1.0	-0.25	-0.16
	Tonic shampoo (Sunstar)	100	70	+0.5	-0.08	+0.20
Inorganic chemicals	Sodium chloride	10	70	+3.1	-0.26	-0.15
	Sodium hydroxide	10	70	+4.2	-0.29	-0.27
	Sulfuric acid	3	23	+0.8	-0.03	+0.13
	HCl	10	23	×	×	×
	Hydrogen peroxide	3	23	-0.8	±0	+0.25
	Distilled water		23	+0.8	-0.02	+0.13

Measurement sample shape: Test piece for tensile strength measurement, 1/8 inch thick
Immersion time: 90 hours

4-1 Thrust friction wear

Frictional Coefficient due to Thrust Wear of Cylindrical and Flat Specimens with Contact Area 2c㎡,
The critical PV and specific wear are shown in Tables 4.1-1, 4.1-2, 4.1-3, 4.1-1, 4.1-2, 4.1-3, and 4.1-4.

Table 4.1-1 Static friction coefficient

Friction material		Static friction coefficient (μ)
Fixed side	Movable side	
Iupital	Copper	0.12～0.16
Iupital	Brass	0.13～0.18
Copper	Iupital	0.12～0.18
Iupital	Iupital	0.20～0.28

NOTE) Surface pressure 11.1kg/cm², revolution 1rpm
μ = Torque/(load × average radius)

Table 4.1-2 Static friction coefficient and surface pressure

Friction material		Face pressure (kg/cm^2)	Static friction coefficient (μ)
Fixed side	Movable side		
Iupital	Copper	5.1	0.17～0.19
		9.8	0.13～0.18
		15.1	0.13～0.16
		25.3	0.10～0.16

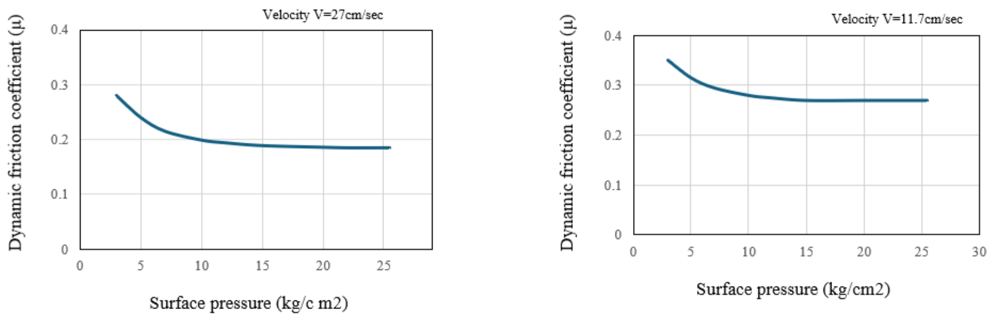


Fig. 4.1-1 Relationship between dynamic friction coefficient and surface pressure (vs. steel)
Steady-state friction coefficient after friction for 3 hours under load

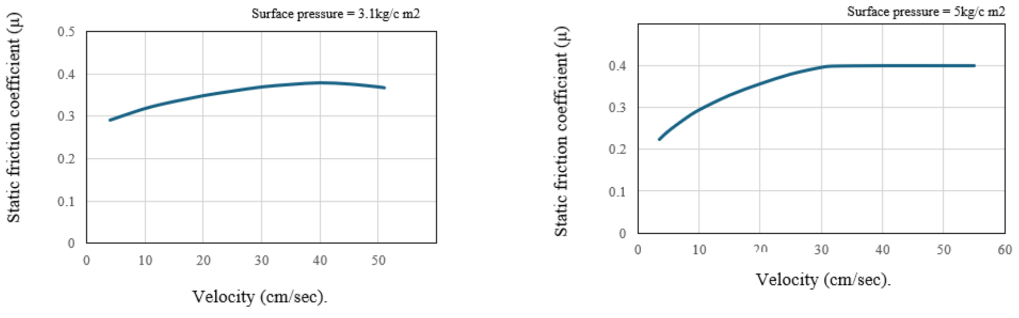


Fig. 4.1-2 Relationship between dynamic friction coefficient and speed (vs. steel)

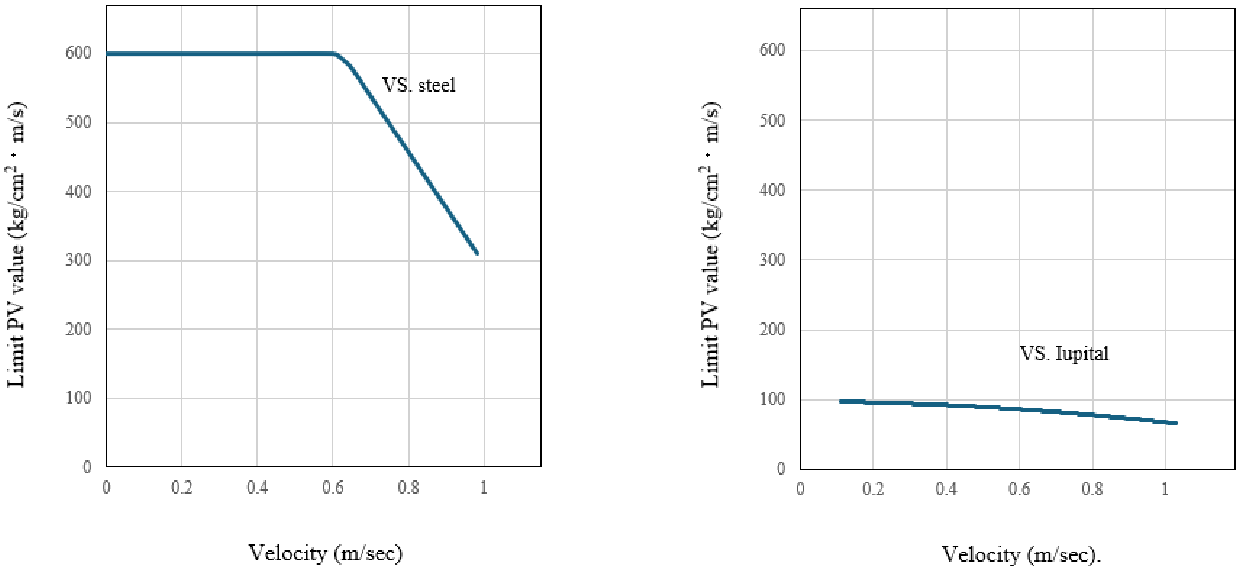


Fig. 4.1-3 Limit PV value (Step load method (every 20 minutes))

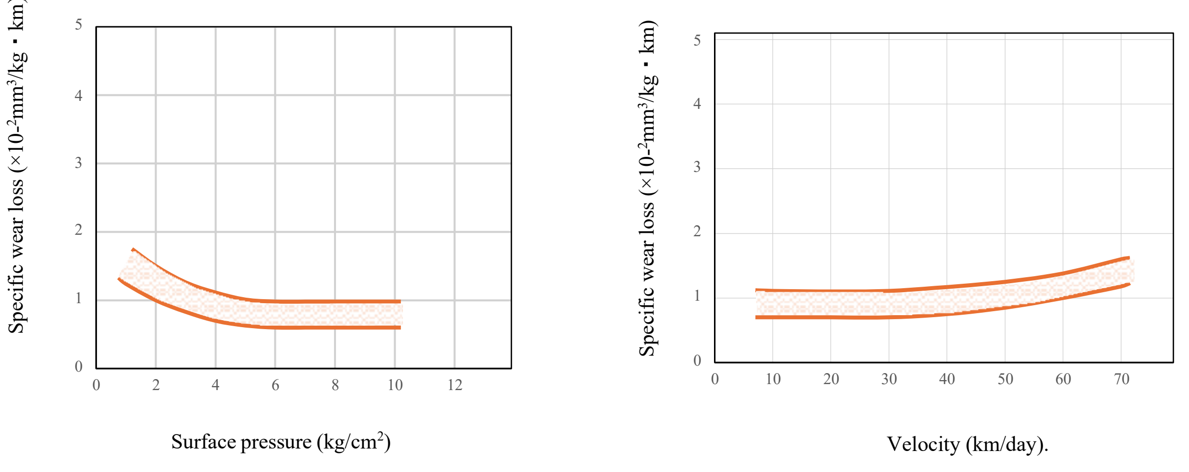


Fig. 4.1-4 Relationship between specific wear loss and surface pressure and speed (vs. steel)

Iupital™

・Typical properties (ISO notation) of the Iupital standard-grade

Item	Test methods	Test conditions	Unit	F10-01 F10-02	F20-03	F30-03	F40-03
				High viscosity	Medium viscosity	Low viscosity	Low viscosity
Physical properties							
Density	ISO 1183	-	g/cm^3	1.41	1.41	1.41	1.41
Water absorption rate	-	23℃, 60%RH	%	0.22	0.22	0.22	0.22
Rheological properties							
Melt mass flow rate	ISO 1133		g/10min	2.5	9.0	27	52
Melt volume rate			cm^3/10min	2.2	7.7	23	45
		Measured temperature	℃	190	190	190	190
		Measured load	kg	2.16	2.16	2.16	2.16
Moulding shrinkage (3 mmt)	-	MD	%	2.2	2.0	2.0	2.0
		TD		-	-	-	-
Mechanical properties							
Tensile modulus	ISO 527-1, 527-2	-	MPa	2800	2900	2900	2900
Yield stress				63	64	64	64
Yield strain			%	10	8.5	7.5	7.0
Nominal strain at break				33	30	25	20
Stress at break			MPa	-	-	-	-
Strain at break			%	-	-	-	-
Flexural strength	ISO 178	-	MPa	89	90	91	91
Flexural modulus				2500	2600	2700	2700
Charpy impact strength	ISO 179-1, 179-2	23℃	kJ/m^2	280	250	150	100
Charpy notched impact strength		23℃	kJ/m^2	8.0	7.0	6.0	5.0
Thermal property							
Melting temperature	ISO 11357-3		℃	166	166	166	166
Deflection temperature under load	ISO 75-1, 75-2	1.80MPa	℃	100	100	100	100
		0.45MPa		156	156	156	156
Coefficient of thermal expansion	ISO 11359-2	MD	1/℃	1.1E-04	1.1E-04	1.1E-04	1.1E-04
		TD		1.1E-04	1.1E-04	1.1E-04	1.1E-04
Flammability	UL94	0.8mmt	-	HB	HB	HB	HB
Electrical characteristics							
Relative permittivity	IEC 60250	100Hz	-	3.9	3.9	3.9	3.9
		1MHz	-	3.9	3.9	3.9	3.9
Dissipation factor	IEC 60250	100Hz	-	0.002	0.002	0.002	0.002
		1MHz	-	0.007	0.007	0.007	0.007
Volume resistivity	IEC 60093	-	Ω・m	1. E+12	1. E+12	1. E+12	1. E+12
Surface resistivity	IEC 60093	-	Ω	1. E+16	1. E+16	1. E+16	1. E+16
Electric strength	IEC 60243-1	1mmt	MV/m	32	32	32	32
		3mmt		19	19	19	19
Comparative tracking index	IEC 60112	-	-	600	600	600	600

※The data on this property is representative of the measured values based on the test method.

Notes. List of Physical Properties of Iupital

Iupital™

・Typical properties (ASTM notation) of the Iupital standard-grade

Item	Test method ASTM	Unit	F10-01 F10-02 High viscosity	F20-03 Medium viscosity	F30-03 Low viscosity
Physical properties (23 °C).					
Specific gravity	—	—	1.41	1.41	1.41
Water absorption (24-hour immersion in water at 23°C)	D-570	%	0.22	0.22	0.22
Water absorption (balanced 50%RH)		%	0.16	0.16	1.6
Mechanical properties (23 °C).					
Tensile strength Tensile elongation Tensile modulus	D-638 D-638 D-638	kg/㎠ % kg/㎠	620 65 28,300	625 60 28,900	630 50 29,100
Flexural strength Flexural modulus	D-790 D-790	kg/㎠ kg/㎠	890 26,200	915 26,500	920 26,700
Shear strength	D-732	kg/㎠	560	560	560
Izod impact strength (with notch) (no notch)	D-256	kg・cm/cm kg・cm/cm	7.5 >110	6.5 >110	5.5 >110
Tensile impact strength (1.6mm thick)	D-1822	kg・cm/㎠	180	120	100
Rockwell hardness	D-785	-	M78	M80	M80
Tapered wear	D-1044	mg/1,000 Cycle	14	14	14
Dynamic friction coefficient VS. copper	Waist-over type (Radial type)	-	0.13	0.13	0.13
VS. pair brass	〃	-	0.15	0.15	0.15
VS. aluminum	〃	-	0.15	0.15	0.15
VS. Iupital	〃	-	0.20	0.20	0.20
Poisson's ratio		-	0.39	0.39	0.39
Thermal property					
Melt index	D-1238	g/10min	2.5	9.0	27.0
Melting point	Temperature rise of 10°C/min	℃	165	165	165
Vicat softening temperature	D-1525	℃	162	162	162
Deflection temperature under load (18.6 kg/cm^2) (4.6kg/cm^2)	D-648	℃ ℃	110 158	110 158	110 158
Linear expansivity	-25℃～+25℃	cm/cm/℃	9×10^{-5}	9×10^{-5}	9×10^{-5}
Flammability	UL94 (1/8" and 1/16")	-	HB	HB	HB
Electrical Properties (23°C)					
Permittivity 10^2Hz	D-150	-	3.7	3.7	3.7
10^6Hz	〃	-	3.7	3.7	3.7
Dielectric tangent 10^2Hz	D-150	-	0.001	0.001	0.001
10^6Hz	〃	-	0.007	0.007	0.007
Low surface efficiency	D-257	Ω	1.0×10^{16}	1.0×10^{16}	1.0×10^{16}
Low volumetric efficiency	D-257	Ωcm	1.0×10^{14}	1.0×10^{14}	1.0×10^{14}
Arc resistance	D-495	sec	>200	>200	>200

※The data on this property is representative of the measured values based on the test method.

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