

Summary of Typical Properties of PLAVIS Polyimide Resin

Property	Condition	ASTM Method	Unit	PLAVIS-N (DAELIM)			PLAVIS-G15 (DAELIM)			PLAVIS-G40 (DAELIM)			PLAVIS-MS (DAELIM)		PLAVIS-C (DAELIM)		PLAVIS-ESD (DAELIM)		PLAVIS-S (DAELIM)
				DF	ISO	CM	DF	ISO	CM	DF	ISO	CM	DF	CM	DF	CM	DF	CM	CM
MECHANICAL																			
Tensile Strength, Ultimate	23°C	D-1708	Kg/cm ² (MPa)	810 (79.4)	900 (88.3)	900 (88.3)	650 (63.7)	680 (66.7)	680 (66.7)	550 (53.9)	580 (56.9)	580 (56.9)	600 (58.8)	650 (63.7)	800 (78.4)	850 (83.3)	800 (78.4)	850 (83.3)	1,670 (164)
	260°C			400 (39.2)	420 (41.2)	420 (41.2)	330 (32.4)	350 (34.3)	350 (34.3)	270 (26.5)	280 (27.5)	280 (27.5)				370 (36.2)	400 (39.2)	370 (36.2)	400 (39.2)
Elongation, Ultimate	23°C	D-1708	%	8.5	7.5	8.0	5.5	4.5	5.0	3.5	2.5	3.0	4.5	4.0	8.0	7.0	8.0	7.0	8.0
	260°C			7.5	6.0	6.0	4.5	3.0	3.0	2.5	2.0	2.0				7.0	6.0	7.0	6.0
Flexural Strength, Ultimate	23°C	D-790	Kg/cm ² (MPa)	860 (84.3)	1,150 (112.8)	1,150 (112.8)	850 (83.4)	1,100 (107.9)		650 (63.7)	900 (88.3)		780 (76.5)	800 (78.5)	1,100 (107.9)		1,100 (107.9)		
	260°C			470 (46.1)	600 (58.8)	600 (58.8)	500 (49.0)	650 (63.7)		400 (39.2)	450 (44.1)		400 (39.2)	450 (44.1)					
Flexural Modulus of Elasticity	23°C	D-790	Kg/cm ² (MPa)	26,000 (2,550)	31,000 (3,040)	31,000 (3,040)	32,500 (3,187)	39,000 (3,825)		49,500 (4,854)	49,500 (4,854)		33,500 (3,285)	34,000 (3,334)	35,000 (3,432)		35,000 (3,432)		
	260°C			14,500 (1,422)	17,000 (1,667)	17,000 (1,667)	18,000 (1,765)	26,000 (2,550)		28,000 (2,746)	28,000 (2,746)		18,500 (1,814)	19,000 (1,863)					
Compressive Strength @1% Strain	23°C	D-695	Kg/cm ² (MPa)	250 (24.5)	250 (24.5)	250 (24.5)	230 (22.6)	300 (29.4)		250 (24.5)	350 (34.3)		350 (34.3)	350 (34.3)	250 (24.5)		250 (24.5)		
Compressive Strength @10% Strain				1,150 (112.8)	1,300 (127.5)	1,300 (127.5)	1,080 (105.9)	1,400 (137.3)		950 (93.2)	1,100 (107.9)		1,300 (127.5)	1,300 (127.5)		1,500 (147.1)		1,500 (147.1)	
Compressive Modulus	23°C	D-695	Kg/cm ² (MPa)	24,500 (2,403)	24,000 (2,354)	24,000 (2,354)	23,500 (2,304)	30,000 (2,942)		27,000 (2,648)	34,000 (3,334)		25,000 (2,452)	25,000 (2,452)	25,000 (2,452)		25,000 (2,452)		
Impact Strength Izod, Notched	23°C	D-256	Kg-cm/cm	6.0	6.0	5.0	5.0	5.0							5.0		5.0		11.7
WEAR & FRICTION																			
Wear Rate			m/s	3.27×10 ⁻²			3.27×10 ⁻²			3.27×10 ⁻²			3.27×10 ⁻²		3.27×10 ⁻²		3.27×10 ⁻²		0.4-2.0
Friction Coefficient (PV=10kg/cm ² · m/sec) (0.98Mpa-m/sec)				0.34	0.32	0.32	0.26	0.23	0.23	0.18	0.16	0.16			0.32		0.32		0.34
THERMAL																			
Coefficient Of Linear Thermal Expansion	23°C~260°C	D-696	µm/m°C (ppm/°C)	50	50	55		45		25		25	50						50
Thermal Conductivity	25°C		W/m · °C			0.36	0.45								0.37		0.37		
ELECTRICAL																			
Dielectric Constant	23°C, @106Hz	D-150				3.75													5.1
Dielectric Strength		D-149	kV/mm			21.90													
Volume Resistivity	23°C	D-257	Ω-cm			10 ¹⁶ - 10 ¹⁸		10 ¹² - 10 ¹⁵											10 ¹⁵
Surface Resistivity	23°C	D-257	Ω-□			10 ¹⁴ - 10 ¹⁶									10 ⁹ - 10 ⁹		10 ⁹ - 10 ⁹		10 ¹⁵
OTHER PROPERTIES																			
Water Absorption	50%RH (avg)	D-570	%	0.9-1.1	0.9-1.1	0.9-1.1													
Specific Gravity		D-792	g/cm ³	1.34	1.38	1.43	1.43	1.49	1.49	1.55	1.62	1.64	1.55	1.58	1.36	1.44	1.36	1.44	1.45
Hardness		D-785	Rockwell®M*	65-90	85-100	90-105	65-85			65-80			70-90	65-95	90-105	65-95	90-105	100-120	

· ISO : Isostatic Molded. · CM : Compression Molded. · Steady State, Unlubricated in the Air

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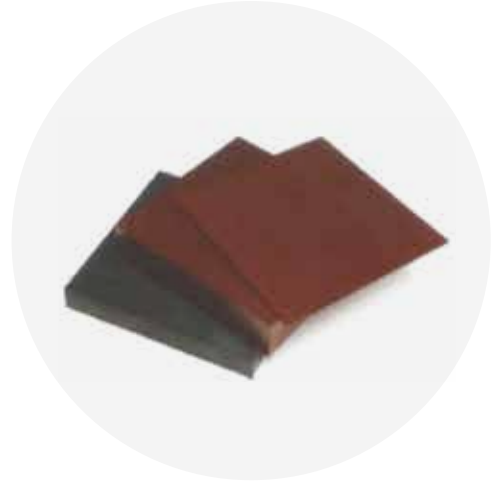
ROD

Diameter	Length
1/4" (6.35mm)	19.6"(500mm)
3/8" (9.53mm)	
7/16" (11.11mm)	
1/2" (12.70mm)	
5/8" (15.88mm)	
3/4" (19.05mm)	
1" (25.40mm)	
1-1/4" (31.75mm)	
1-1/2" (38.10mm)	
2" (50.80mm)	



PLATE

Diameter	Thickness
12"x12" (304.8mmx304.8mm)	12.7~62(mm)



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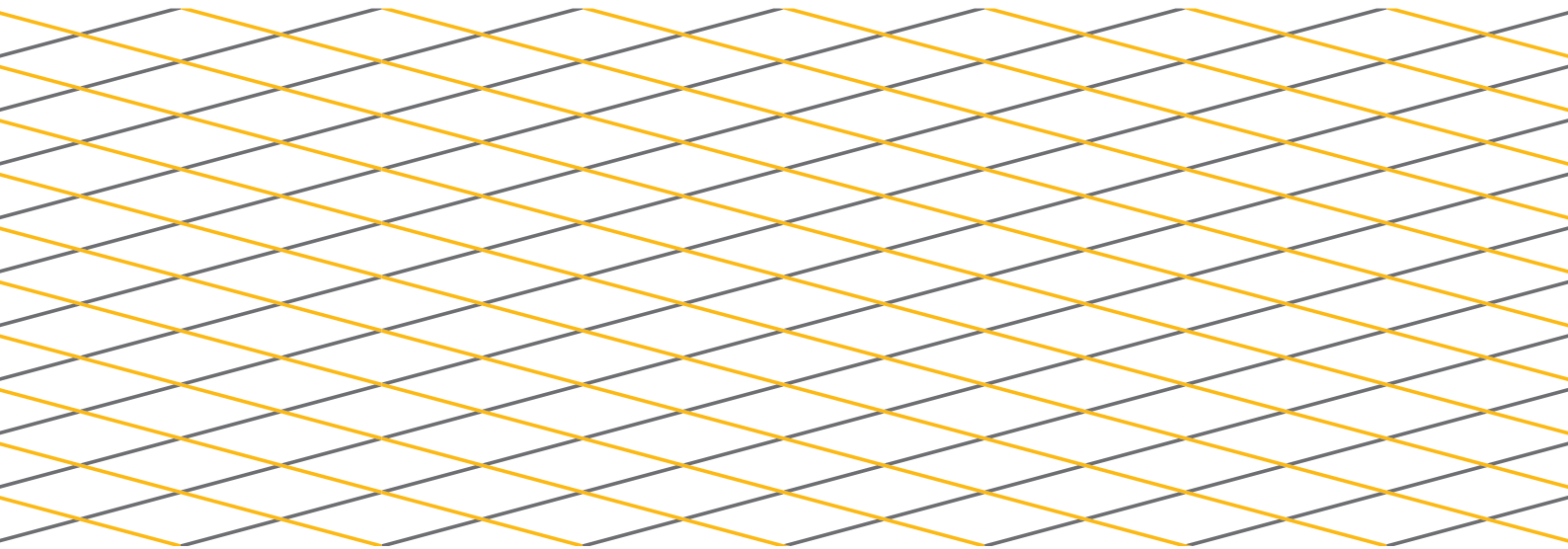
Website : <https://www.daelimcorp.co.kr/en/pc/index.do>

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DAELIM

DaelimPlavis 

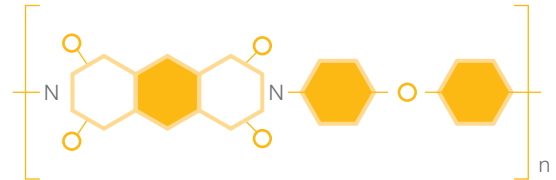
SUPER ENGINEERING PLASTIC
POLYIMIDE



PLAVIS is...

a Super Engineering Plastic which is polyimide resin. Plavis has a unique chemical structure with some of the highest properties available. Nitrogen bonded to 3 carbons is the critical part of the chain and imparts the plastic with remarkable features and benefits.

Daelim produces Plavis raw materials into molded parts, plate and rod types, and Plavis isostatic rods possess uniformed properties in all directions.



Properties

01 Thermal

One of the highest temperature plastics in the world with a continuous operating temperature of 350°C
Well suited for Cryogenic Conditions

02 Mechanical

Retains high tensile strength and modulus even at high temperatures
No crack or creep under load

03 Outgassing

Lowest outgassing of any plastics at 300°C
No contamination in vacuum chamber processing

04 Wear and Friction

1 million psi-fpm PV limit with lubrication
300,000 psi-fpm PV limit without lubrication
Stable Friction Level

05 Insulation

Pure grade can be ideal for electrical and thermal insulation.
Filled grades can be tailored to application requirements.

06 Machinability

Capable to process tiny and intricate features without cracking
Enables mirror-like finishing

Grades

Grades		Characteristics
PLAVIS-N	Non filled(N)	Best Physical Properties, Maximum Electrical and Thermal Insulation, Low Outgassing, Superior Radiation Resistance
PLAVIS-S	Non filled(S)	Best Physical Properties at High Temperatures, Continuous Operating Temp. 350°C
PLAVIS-G15	Graphite 15wt% filled (G15)	Self Lubricating Grade for Wear and Friction Applications
PLAVIS-G40	Graphite 40wt% filled (G40)	Self Lubricating Grade with Low Thermal Expansion
PLAVIS-MS	MoS2 15wt% filled (MS)	Self Lubricating Grade for Vacuum Environments
PLAVIS-C	Conductive (C)	Electrical Conductivity, High Thermal Resistance and Superior Mechanical Properties Surface Resistivity $10^2 - 10^3$
PLAVIS-ESD	Electrostatic Dissipative (ESD)	Electrostatic Dissipativity, High Thermal Resistance and Superior Mechanical Properties Surface Resistivity $10^6 - 10^9$

APPLICATIONS

01 FPD (Flat Panel Display)

- **Drying Oven(HP/CP, Baking, IR)** Glass Support Pins, Glass Holders, Rollers
- **Cleaning** EUV Rollers, Bearings
- **PVD/CVD Insulation parts** Inserts, Clamps, Bushings, Caps, Susceptor Pins, Ball bearings, etc.
- **Etcher** Screws, Bolts
- **Others** Probe unit, Station Parts



02 Solar Cell

- **Drying Oven(HP/CP, Baking, IR)** Glass Support Pins, Glass Holders, Rollers
- **Cleaning** EUV Rollers, Bearings
- **PVD/CVD Insulation Parts** Inserts, Clamps, Bushings, Caps, Susceptor Pins, Ball Bearings, etc.



03 Semiconductor

- **Wafer Processing** Wafer Clamp Rings, Insulators, Screws & Fasteners, Vacuum Pads, Alignment Pins
- **Wafer Handling** Wafer Guides, Wafer Carriers, Vacuum Pickup Strips
- **IC Handling & Testing** Die Pick-up Collects, Test Socket Insulators



04 General Industry

- **Hot Runner** System Seal Caps, Insulators
- **Plasma Cutting Torches Parts** Swirl Rings, Insulators, Caps
- **Heat Resistance Materials** Bottle Grippers, V Conveyor Tips
- **Scientific Consumable Parts** GC/Mass Ferrules, HPLC Valve Rotors
- **Textile Machines** Valve Seat, Bearings, Shedder Bushings



05 Automotive / Transportation

- **Transmissions** Thrust Washers, Seal Rings, Valve Seats, Transmission Valve Balls, Check Valves
- **Electrical Motors** Bushings, Washers, Thrust Plugs
- **Brakes** Wear Pads, Valve Seats and Balls in ABS Systems
- **Fuel Systems** Bushings, Seal Rings, Band Springs, Valve Seats
- **Turbo Chargers** Ball Bearing Retainers, Wastegate Bushings
- **Others** Vacuum Pump Vanes, Engine Belt Tensioners, Rubbing Blocks, Door Hinge Bushings, Gear Stick Rollers, Ignition Distributors, Constant Friction Pads for Split-Flywheels



06 Aerospace / Aircraft

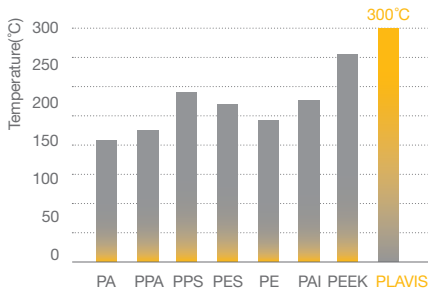
- Compressor Variable Vane Bushings and Washers, Aircraft Fan Thrust Reversers, Fan Blade Wear Strips, Locking Insert Nuts, Fuel Line Spacers, Reciprocating Shaft Seals for Jet Engine Afterburner Actuating System



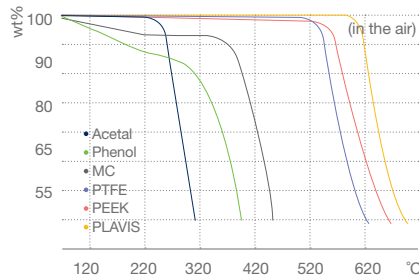
THERMAL PROPERTIES

01 High Heat Resistance

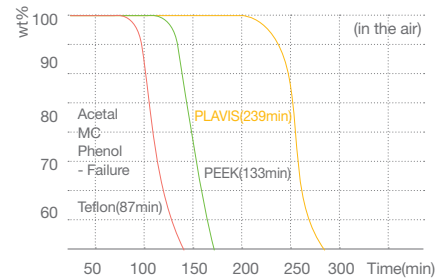
The main feature of Plavis is that it has no melting point with a continuous operating temperature of 300°C. Even at 370°C, a 50% reduction in tensile strength does not occur for 200 hours for Plavis-N(neat), 220 hours for Plavis-G15(15% graphite filled), and 360 hours for Plavis-G40 (40% graphite filled). In a vacuum or oxygen void environment, the heat resistance of Plavis is even higher. Since Plavis has no melting point unlike other polyimides or thermoplastics such as PEEK, PAI and PEI, the level of strength vs. temperature of Plavis is very linear and predictable. For applications where part dimensions and tolerances are critical over a range of temperature, Plavis is an excellent choice.



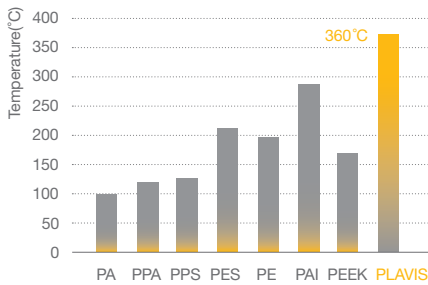
Picture1. Comparison of Continuous Operating Temperatures of Various Engineering Plastics



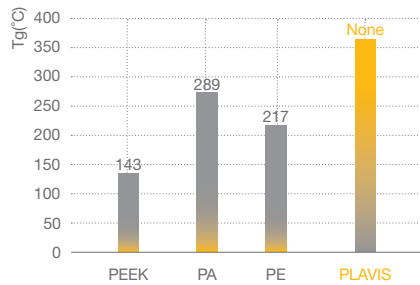
Picture2. Pyrolysis Temperature (TGA, in air)



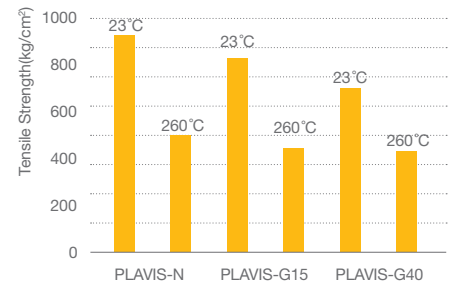
Picture3. Weight 50wt% Reduction Time (TGA, 520 °C, in air)



Picture4. Comparison of HDT with various Engineering Plastics (@264psi)



Picture5. Comparison of Tg of various Super Engineering Plastics.



Picture6. Relations between Typical Tensile Strength and Temperature of PLAVIS (ASTM-D1708)

Melting Point (Tm)	Heat Deflection Temperature	Thermal Decomposition Temperature (TGA, in air)	Thermal 50wt% Reduction Time (TGA, 520°C, in air)
None	360°C	614°C	239min

Table1. PLAVIS Heat Resistance Property

02 Thermal Expansion Property

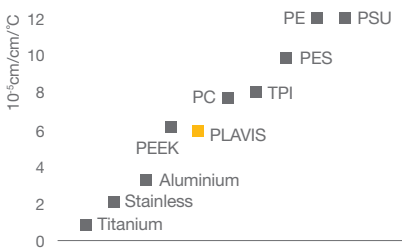
Table 2 shows the thermal expansion coefficients of Plavis grades. The addition of graphite lowers the expansion coefficient. Plavis G40 is most likely equivalent to aluminum materials.

Grade	PLAVIS-N	PLAVIS-G15	PLAVIS-G40
Thermal Expansion Coefficient (10 ⁻⁵ m/m/°C)	5.5	4.5	2.5

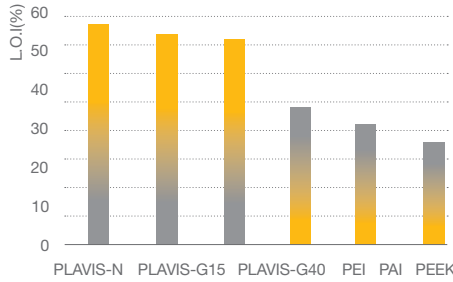
Table2. Average Thermal Linear Expansion Coefficient of Plavis MP type

03 Inflammability

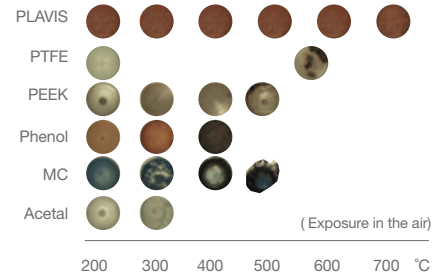
Plavis has a UL 94 listing as V0. It does not sustain a flame in air. The Limiting Oxygen Indexes that indicate the minimum oxygen required for continual burning are 55% for Plavis-N, 54.15% for Plavis-G15 and 53.7% for Plavis-G40.



Picture7. Comparison of Thermal Expansion Coefficient of Various Materials



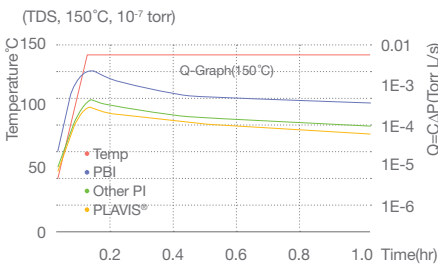
Picture8. Comparison of Limiting Oxygen Index between PLAVIS and Various Engineering Plastics



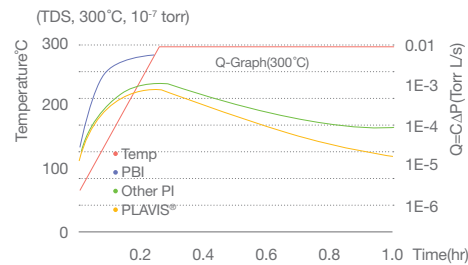
Picture9. PLAVIS-N Exposure Test at High Temperature in the Air (for one minute)

04 Low Outgassing

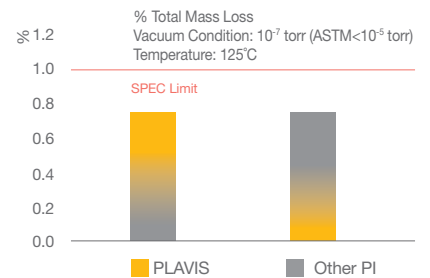
Plavis does not degrade at high temperatures or give off volatiles or condensable gasses. In vacuum processing chambers for LCD or electronics, Plavis is the one and only plastic that can replace ceramics and metals. Plavis meets the NASA specifications for total mass loss in space vacuum environments for satellite applications.



Picture10. Outgassing Characteristics of PLAVIS at 150°C



Picture11. Outgassing Characteristics of Plavis at 300°C



Picture12. Total Mass Loss(%)

FRICION & WEAR PROPERTIES

Plavis graphite filled grades are self-lubricating and can be applied to wear and friction applications such as bearings and wear strips even in high temperature oil/grease starved environments.

01 Friction

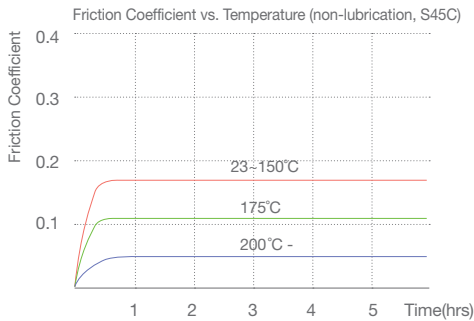
Plavis bearing grades can be operated at the highest temperatures of any plastics. No other polymers can be operated at 300°C without oil or grease lubrication.

Grade	PLAVIS-N	PLAVIS-G15	PLAVIS-G40
PV=10kg/cm ² . m/sec	0.32	0.23	0.16

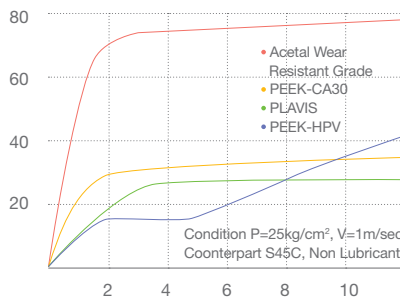
Table3. Typical Friction Coefficient of Plavis

02 Wear

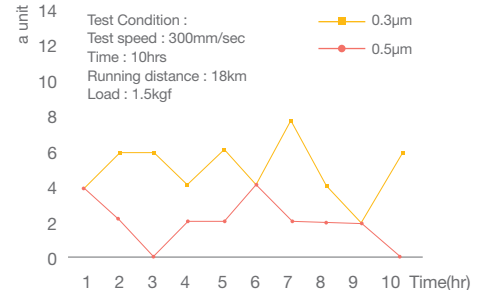
The friction level and wear rate of Plavis bearings quickly stabilize to uniform values. Temperature is an important factor for friction level of the graphite filled grades. Pure Plavis bearings are selected when low particle generation is required.



Picture13. Relations between Friction Coefficient and Temperature (Plavis-G15)



Picture14. Typical Wear Curve of Plavis-G15 (vs. Carbon Steel)



Picture15. Particle Count on Running (Plavis-N)

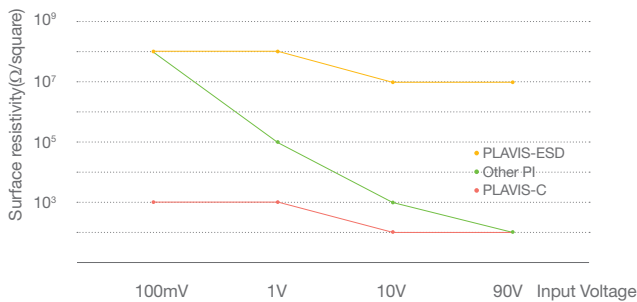
CHEMICAL STABILITY

Plavis has good resistance to many organic solvents, oils, and greases such as ATF (Automatic Transmission Fluid). Even at high temperatures in these lubricants, the mechanical properties of Plavis are not significantly changed. Plavis should not be used in strong alkali conditions such as pH over 10 due to the characteristics of chemical structure of Plavis.

SPECIAL GRADE PLAVIS-C & PLAVIS-ESD

01 Electrical Properties of Plavis-C & ESD

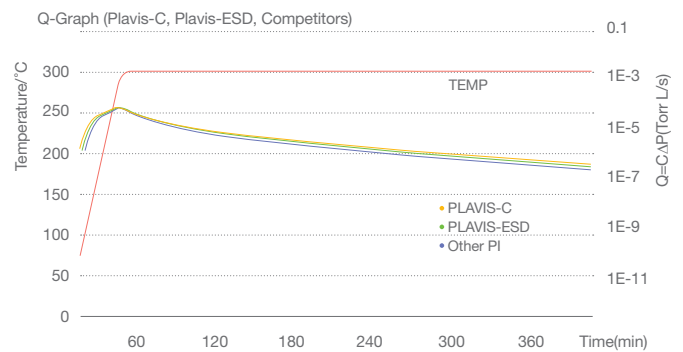
Plavis-C is conductive grade and Plavis-ESD is electrostatic dissipative grade. Plavis-C & ESD show the uniformed surface resistivity under the various input voltages.



Picture16. Surface Resistivity of Plavis-C & ESD Grades under the various Input Voltages

02 Applications

- Wafer Handling
- Flat Panel Display Glass Handling Process
- Electronics Manufacturing Line Fixtures
- Bearing in Electronic Products and Motors
- Burn in and Test Sockets



Picture17. Outgassing Property of Plavis-C & ESD