Summary of Typical Properties of PLAVIS Polyimide resin

Property	Condition	ASTM Method	Unit	PLAVIS-N (DAELIM) DF	PLAVIS-N (DAELIM) ISO	PLAVIS-N (DAELIM) CM	PLAVIS-G15 (DAELIM) DF	PLAVIS-G15 (DAELIM) ISO	PLAVIS-G15 (DAELIM) CM	PLAVIS-G40 (DAELIM) DF	PLAVIS-G40 (DAELIM) ISO	PLAVIS-G40 (DAELIM) CM	PLAVIS-MS (DAELIM) DF	PLAVIS-MS (DAELIM) CM	PLAVIS-C (DAELIM) DF	PLAVIS-C (DAELIM) CM	PLAVIS-ESD (DAELIM) DF	PLAVIS-ESD (DAELIM) CM	PLAVIS-S (DAELIM) CM
MECHANICAL																			
Tensile Strength, Ultimate	23°C	D-1708	Kgf/cm² (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)	650 (64)
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	40.0
Flexural Strength, Ultimate	23°C	D-790	Kgf/cm² (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	Kgf/cm² (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	Kgf/cm² (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)		2,141 (210)
Compressive Modulus	23°C	D-695	Kgf/cm² (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/cm² · 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, @10^3 Hz	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^{13}											10^{15}
Surface Resistivity	23°C	D-257	Ω/□		10^{14} - 10^{16}										10^{5} - 10^{9}		10^{6} - 10^{8}		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/cm³	1.33	1.38	1.43	1.41	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 : Isostatically Molded, ·CM : Compression Molded, ·Steady state, unlubricated in air

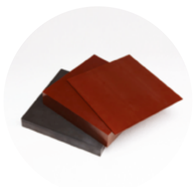
NOTICE: Prior to use for any commercial purpose, the customer is fully responsible for determining its suitability for intended application and for ensuring its disposal practices are in compliance with applicable laws and other governmental enactments. DAELIM assumes no obligation or liability in this regard. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.

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"×12" (304.8mm×304.8mm)	12.7~62 (mm)



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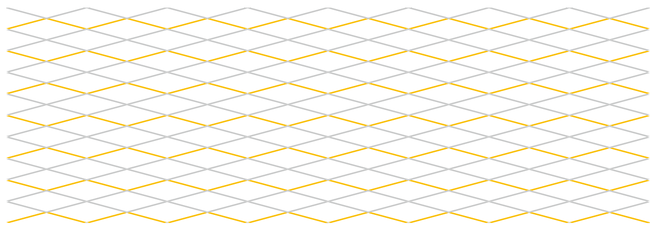
SUPER ENGINEERING
PLASTIC POLYIMIDE



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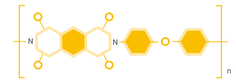
PLAVIS is...

a super engineering plastic. PLAVIS polyimide 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 makes PLAVIS raw material all the way to the molded parts, plates, and rods. PLAVIS isostatic molded rods have uniform properties in all directions.



Properties

01 Thermal
One of the highest temperature plastics in the world with a continuous operating temperature of 350℃. Well suited for cryogenic conditions.

02 Mechanical
Retains high tensile strength and modulus even at high temperatures. Will not crack or creep under load.

03 Out-gassing
Lowest out-gassing of any plastic at 300℃. Will not contaminate vacuum chamber process or products.

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 is an ideal electrical and thermal insulator. Filled grades can be tailored to application requirements.

06 Machinability
Machines like brass-capable to make tiny and intricate features without cracking. Can be lapped to mirror finish.

Grades

Grades		Characteristic
PLAVIS-N	Non filled(N)	Best physical properties, maximum electrical and thermal insulation, low out-gassing, superior radiation resistance.
PLAVIS-S	Non filled(S)	Best physical properties at high temperature, Operating Continuous is 350℃
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 conductive, high thermal resistance and superior mechanical properties, And surface resistivity 10^5-10^9
PLAVIS-ESD	Electrostatic dissipative(ESD)	Electrostatic dissipative, high thermal resistance and superior mechanical properties. And surface resistivity 10^6-10^9

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APPLICATIONS

01 FPD (Flat Panel Display)

- Drying oven(HP/CP, Baking, IR) Glass support pins, Glass holders, Rollers
- Cleaning EUV roller, Bearing
- PVD/CVD Insulation parts Insert, Clamp, Bush, Caps, Susceptor pin, Ball bearing etc.
- Etcher Screw, bolts.
- Others Probe unit, station parts


02 Solar Cell

- Drying oven(HP/CP, Baking, IR) Glass support pins, Glass holders, Rollers
- Cleaning EUV roller, bearing
- PVD/CVD Insulation parts Insert, Clamp, Bush, Caps, Susceptor pin, Ball bearing etc.


03 Semiconductor

- Wafer Processing Wafer clamp rings, Insulators, Screw & Fasteners, Vacuum pads, Alignmet pins
- Wafer handling Wafer guides, Wafer carriers, Vaccum pick up strips
- IC handling & testing Die pick up collects, Test socket insulator


04 General Industry

- Hot runner system Seal caps, Insulators
- Plasma cutting torches parts Swirl rings, Insulator, Caps.
- Heat resistance materials Bottle grippers, VConveyor tips
- Scientific consumable parts GC/Mass ferrels, HPLC valve rotors
- Textile Machines Valve seat, Bearing, Shedder Bushing


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

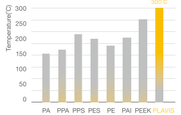
Compressor Variable Vane Bushings and Washers, Aircraft Fan Thrust Reverser, Fan Blade Wear Strips, Locking Insert Nut, Fuel Line Spacer, Reciprocating Shaft Seal for Jet Engine Afterbunner Actuating System

THERMAL PROPERTIES

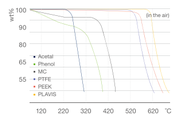
01 High Heat Resistance

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 will 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.

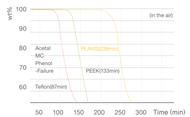
Since PLAVIS has no melting point unlike other polyimides or thermoplastics such as PEEK, PAI, PEI; the strength vs. temperature of PLAVIS is very linear and predictable. For applications where part dimensions and tolerances are critical over a range of temperature, PLAVIS is an excellent.



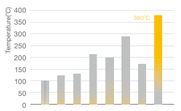
Picture1. Comparison of continuous operating temperature of various ENPLA



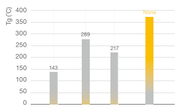
Picture2. Pyrolysis Temperature (TGA, in air)



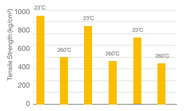
Picture3. Weight 50wt% Reduction Time (TGA, 520℃, in air)



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



Picture5. Comparison of Tg of various SUPER-ENPLA



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℃,in air)
N/A	360℃	614℃	239min

Table1. PLAVIS Heat-Resisting Property

02 Thermal Expansion Property

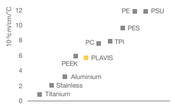
Table 2 lists the thermal expansion coefficients of PLAVIS grades. The addition of graphite lowers the expansion level all the way to that of aluminum for PLAVIS G40 grade.

Grade	PLAVIS-N	PLAVIS-G15	PLAVIS-G40
Thermal Expansion Coefficient (10^{-5}m/m/℃)	5.5	4.5	2.5

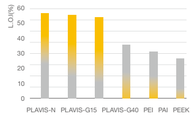
Table2. Average Thermal Linear Expansion Coefficient of Plavis MP type

03 Inflammability

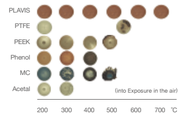
PLAVIS has a UL 94 listing as V0. It will not sustain a flame in air. The limiting oxygen index that indicates the minimum oxygen required for continual burning is 55% for PLAVIS-N. 54.15% for PLAVIS-G15, and 53.7% for PLAVIS-G40.



Picture7. Comparison of Thermal Expansion Coefficient of Various Materials



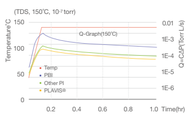
Picture8. Comparison of Limiting Oxygen Index between PLAVIS and Various Enpla



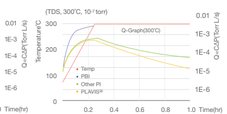
Picture9. PLAVIS-N Exposure Test at High Temperature in the Air (for one minute)

04 Low Out-gassing

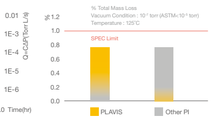
PLAVIS does not degrade at high temperatures or give off volatiles or condensable gasses. In vacuum processing chambers for LCD or Electronics, PLAVIS is the only plastic that can replace ceramics and metals. PLAVIS meets the NASA specification for total mass loss in space vacuum environments for satellite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



Picture10. Outgassing characteristics of PLAVIS at 150℃



Picture11. Outgassing characteristics of PLAVIS at 300℃



Picture12. Total Mass Loss (%)

FRICTION & 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 operate at the highest temperatures of any plastics.
No other polymer can operate at 300℃ without oil or grease lubrication.

Grade	PLAVIS-N	PLAVIS-G15	PLAVIS-G40
PV=10kg/cm², m/sec	0.32	0.23	0.16

Table3. Typical friction coefficient of PLAVIS

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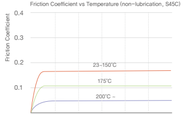
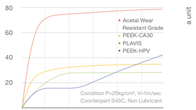
02 Wear

The friction level and wear rate of PLAVIS bearings quickly stabilize to uniform valves. 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. The chemical structure of PLAVIS is not resistant to bases.

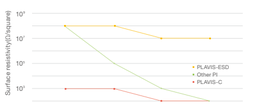
NEW GRADE PLAVIS-C & PLAVIS-ESD

01 Electrical Properties of PLAVIS-C&ESD

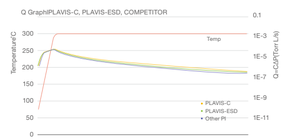
PLAVIS-C is the conductive polyimide. PLAVIS-ESD is electrostatic dissipative grade. PLAVIS-C & ESD show the uniform surface resistivity under the various input voltages

02 Applications

- Wafer handling
- Flat panel display glass handling process
- Electronics manufacturing line fixtures
- Bearing in electronic products and motors
- Burn in and test socket



Picture16. Surface resistivity of PLAVIS-C & ESD grades under the various input voltages



Picture17. Out-gassing property of PLAVIS-C & ESD