

# **Celazole<sup>®</sup> PBI** T-Series

SUPERIOR  
POLYMER DURABILITY  
FOR YOUR HIGH  
PERFORMANCE NEEDS



# FOR HIGH-PERFORMANCE THERMOPLASTIC NEEDS

Celazole® T-Series products are PBI compounds designed for injection molding and extrusion. Combining the superior mechanical properties and thermal resistance of PBI with the melt process ability of polyaryletherketones (PEEK or PEKK), these products offer cost-effective high performance. These products are available in pellet form.

Celazole® PBI (polybenzimidazole) is a unique and highly stable heterocyclic polymer. PBI polymers are characterized by high thermal stability; exhibit high strength, broad chemical resistance and unique compatibility with certain other polymers including the polyaryletherketone family.

## WEAR RESISTANCE

# 4x

increase in light fixture  
production compared  
with polyamideimide

## HIGH STRENGTH

TF-60C has

# 14,500

psi

(100 MPa)

Flexural strength

at

# 500°F

(260°C)

## COST EFFECTIVE

T-Series products are

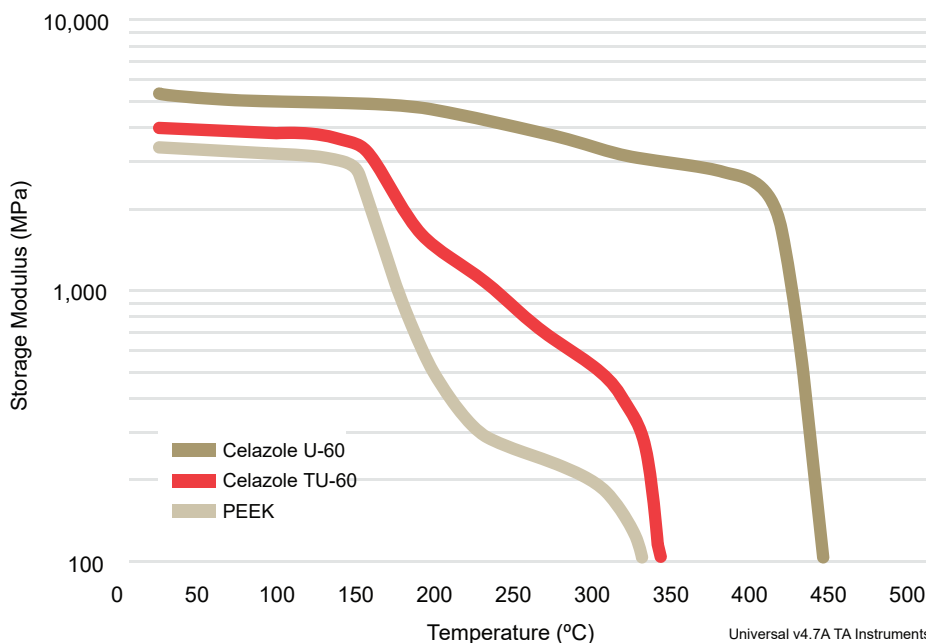
# 100%

melt processable

The advantage of T-Series over ordinary PEEK is the unexpected property set that results from the combination with PBI and other fillers (when present) that yield higher heat deflection temperatures (HDT), higher moduli, higher strength, improved wear resistance and lower creep. In the T-Series compound, HDT's can be raised to 330°C, just below the crystalline melting point of PEEK. The effect can be observed in the accompanying dynamic mechanical analysis (DMA) chart for TU-60 below.

A desirable balance of performance and tractability is obtained with the T-Series products that place the group's thermo-mechanical performance above PEEK, but below PBI. T-Series is designed for injection molding of parts that perform, but are cost effectively produced.

Celazole TU-60 DMA Storage Modulus compared with PEEK and PBI

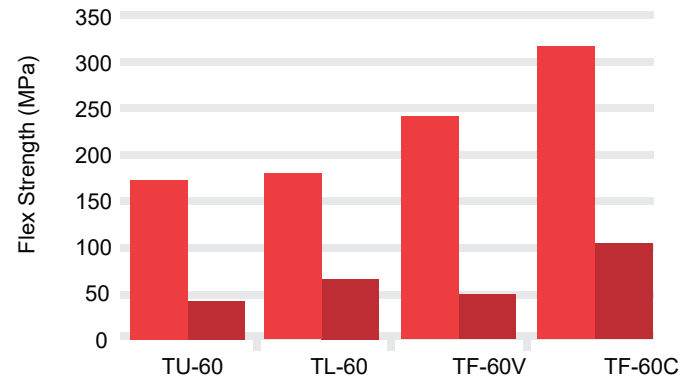


# OPTIMAL FOR PARTS AT **ELEVATED** **TEMPERATURES**

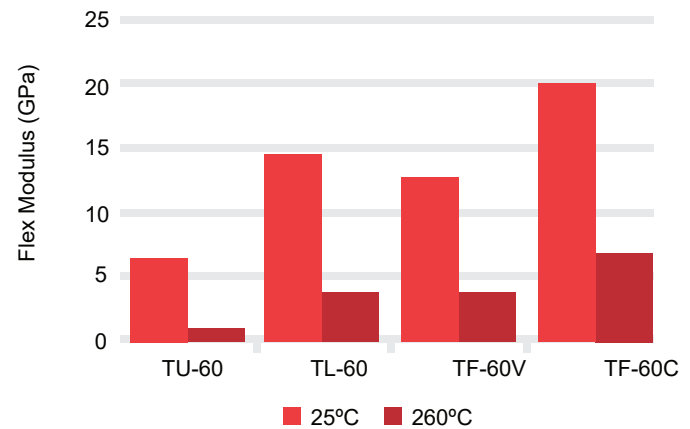
## PROPERTIES:

- Excellent mechanical properties that are maintained well above the 143°C Tg of the PEEK component
- Particularly low strain over time as compared to polyimide and filled PEEK's, even at 300°C
- Allows users to enjoy improved levels of equipment performance, weight savings and/or thinner, smaller profiles
- Suited for mechanical service applications with high load at elevated temperatures
- Excellent thermal stability – enabling metal replacement
- Self-lubricating TL-60 displays low wear rates under conditions of high pressure (P) and velocity (V), a high limiting PV and cool operating temperatures in a lubricant free environment

Celazole T-Series – Strength vs. Temperature



Celazole T-Series – Modulus vs. Temperature



## EXCEPTIONAL WEAR PERFORMANCE

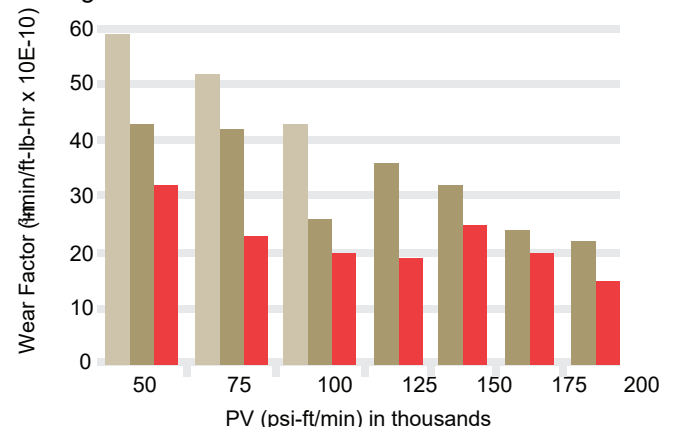
Celazole TL-60 is an injection moldable polymer containing a dry-lube package with superior wear resistance.

In a PV range of 100,000 – 200,000 psi-ft/min (3.5 – 7 MPa-m/sec), it's Wear Factor K is just  $20 \times 10^{-10}$  in<sup>3</sup>-min/ft-lb-hr ( $4.0 \times 10^{-7}$  mm<sup>3</sup>/N-m) and its Dynamic Coef. of Friction is just 0.055.

This material is designed for high loads at any speed and outperforms wear-grade PAI, PI, and PEEK under similar conditions. Without additional lubrication, it runs 40-50F cooler than the competition.

PAI wear grade PI wear grade Celazole TL-60

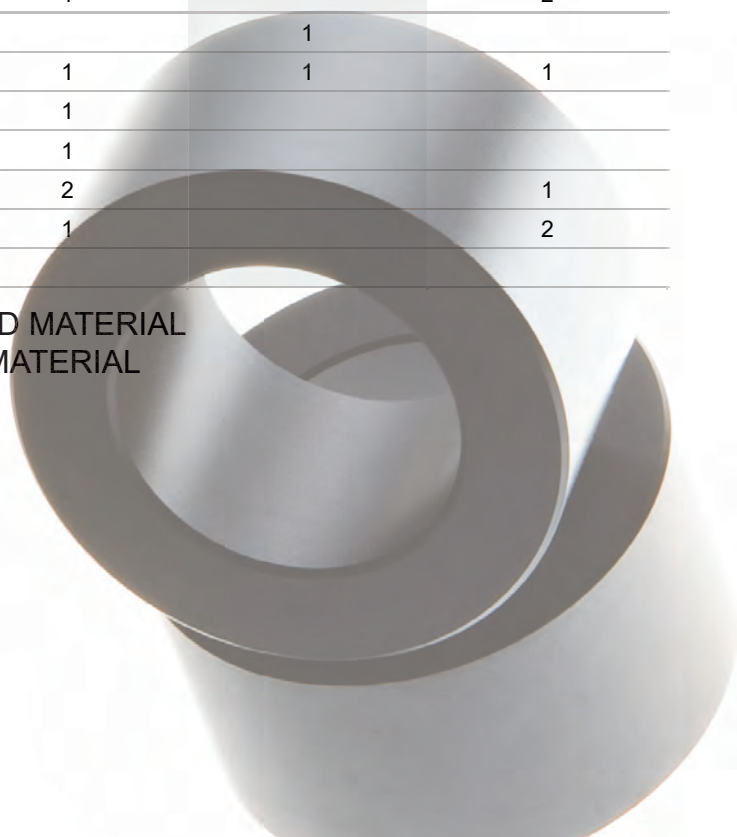
Average Wear Factor: 50-800 ft/min



# INJECTION MOLDING THERMOPLASTIC POLYMERS

	<b>TU-60</b> <b>Unfilled</b> High temperature performance, chemical resistant, V-0 flame rating	<b>TL-60</b> <b>Self-lubricating</b> Superior wear resistance, low friction and cool running... even under load	<b>TF-60V</b> <b>Glass fiber reinforced</b> Thermal and electrical insulation, low creep, high strength	<b>TF-60C</b> <b>Carbon fiber reinforced</b> Highest strength, very low fatigue; a mechanical workhorse in the heat
Bearing cages		1		2
Bushings		1		
Compressor vanes		2		1
Conveyor systems		1		2
Dynamic load bearing components		1		
Dynamic seals	1		1	1
Electrical connectors	2		1	
End effector pads	2			1
Gears				1
Glass handling	1		1	1
Metal spinning rollers	1			
Office equipment	1	1	1	1
Oil field equipment	1		1	2
Oven conveyors		1	2	2
Piston rings		1		
Plane bearings		1		
Planetary gears			2	1
Plasma torch tips, insulators, swirl baffles	2		1	
Pump bearings		1		
Semiconductor wafer transportation	2			1
Sliding surfaces		1		
Soldering equipment				1
Synchronizer rings		1		2
Temperature sensor housings			1	
Textile equipment	1	1	1	1
Thrust washers		1		
Tilt pad bearings		1		
Turbines		2		1
Turbo charger bushings		1		2
Valve seats, stem seals, packings	1			

1 RECOMMENDED MATERIAL  
2 ALTERNATIVE MATERIAL



# Celazole T-Series Injection Molding Recommendations

## Set-up

### Equipment Requirement

Machine Temperature Capability	450°C (845°F)
Cylinder & Screw	Abrasion Resistant; HRC hardness 56-60
Injection Pressure	200-250 MPa (26–36 kpsi)
Injection Speed	High speed; up to 400 cm³/sec
Temperature Control	Cartridge heater for molds

## Recommendation

Temperature Profile (°C)	TU-60	TF-60C	TF-60V	TL-60
Cylinder Nozzle	430	450	450	450
Cylinder Front	430	450	450	450
Cylinder Middle	420	420	420	420
Cylinder End	380	380	380	380
Mold	200	210	210	210

### Injection Speed

Typical	200 cm³/sec or less
Thin parts (.4-.5mm)	400 cm³/sec

### Mold Requirements

Mold Surface	Cr Steel; HRC hardness 50-60
Sprue	Taper 2-5 degrees; mirrored face

### Pellet Storage/Drying

Storage	Keep dry; use soon after opening
Dry before use	4-6 hrs @ 180°C or 6-16 hrs @ 140°C plus 1-2 hrs @ 180°C



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# Celazole® TF-60V

## Glass Fiber Reinforced Melt Processable PBI

### Typical Properties

PROPERTIES	ASTM METHOD	ENGLISH VALUE	METRIC VALUE
<b>MECHANICAL</b>			
Tensile Strength	D-638	22 kpsi	150 MPa
Modulus		1750 kpsi	12,000 MPa
Elongation		1.4%	1.4%
Flexural Strength	D-790	32.6 kpsi	225 MPa
Modulus		1810 kpsi	12,500 MPa
Compressive Strength	D-695	32 kpsi	220 MPa
Modulus		530 kpsi	3600 MPa
<b>ELECTRICAL</b>			
Dielectric Strength	D-149	410 V/mil	16 KV/mm
Volume Resistivity	D-257	1 X 10 <sup>16</sup> ohm-cm	1 X 10 <sup>16</sup> ohm-cm
Dissipation Factor			
1 kHz	D-150	0.000	0.000
10 kHz	D-150	0.001	0.001
Dielectric Constant			
1 kHz	D-150	3.9	3.9
10 kHz	D-150	3.9	3.9
Arc Resistance	D-495	180 seconds	180 seconds
<b>THERMAL</b>			
Coefficient of Linear Thermal Expansion			
75-300°F	TMA	9 x 10 <sup>-6</sup> in/in°F	17 µm/m°C
Heat Capacity @ 158°F	DSC	0.27 Btu/lb°F	1130 J/Kg°C
Heat Deflection Temperature @ 264 psi	D-648	590°F	310°C
Temp. of Initial (5%) Weight Loss In:			
Air	TGA	1125°F	607°C
Nitrogen	TGA	1175°F	635°C
Thermal Conductivity @ 75°F	F-433	2.5 Btu in/hr•ft <sup>2</sup> °F	0.31 kcal/mh°C
<b>OTHER</b>			
Specific Gravity		1.52	1.52
Hardness, Rockwell A	D-785	30	30
Poisson's Ratio		0.34	0.34
Water Absorption			
24 hours @ 73°F	D-570	0.25 %	0.25 %
@ Equilibrium	D-570	4.6 %	4.6 %

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# Celazole<sup>®</sup> TK-60C

## Carbon Fiber Reinforced Melt Processable PBI/PEKK

### Typical Properties

PROPERTIES	ASTM METHOD	ENGLISH VALUE	METRIC VALUE
<b>MECHANICAL</b>			
Flex Strength	D-790	44.2 kpsi	305 MPa
Modulus		2600 kpsi	17,900 MPa
Elongation		2.1%	2.1%
<b>THERMAL</b>			
Glass Transition (1 <sup>st</sup> /2 <sup>nd</sup> )	DSC	340F/ 797F	171C/ 425C
Melt Point	DSC	658F	348C
Thermal Conductivity 25C/ 100C	C-518	2.4/ 2.8 BTU·in/hr·ft <sup>2</sup> °F	0.34/ 0.41 W/mK
<b>OTHER</b>			
Specific Gravity		1.42	1.42
Hardness, Rockwell E	D-785	92	92

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# Celazole® TK-60

Unreinforced Melt Processable PBI/PEKK

## Typical Properties

PROPERTIES	ASTM METHOD	ENGLISH VALUE	METRIC VALUE
<b>MECHANICAL</b>			
Tensile Strength	D-638	14.5 kpsi	100 MPa
Modulus		740 kpsi	5,100 MPa
Elongation		2.2%	2.2%
Flex Strength	D-790	25.4 kpsi	175 MPa
Modulus		755 kpsi	5,200 MPa
Elongation		3.4%	3.4%
<b>THERMAL</b>			
Glass Transition (1 <sup>st</sup> /2 <sup>nd</sup> )	DSC	340F/ 797F	171C/ 425C
Melt Point	DSC	658F	348C
<b>OTHER</b>			
Specific Gravity		1.3	1.3
Hardness, Rockwell E	D-785	83	83
Melt Viscosity at 420C, 1000 s <sup>-1</sup>	D-3835		635 Pa-s

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# Celazole® TKL-60

Self Lubricating Melt Processable PBI/PEKK

## Typical Properties

PROPERTIES	ASTM METHOD	ENGLISH VALUE		METRIC VALUE
MECHANICAL				
Tensile Strength	D-638	18 kpsi		125 MPa
Modulus		2510 kpsi		17,300 MPa
Elongation		1.0 %		1.0 %
Flex Strength	D-790	26 kpsi		180 MPa
Modulus		2120 kpsi		14,600 MPa
Elongation		1.3 %		1.3 %
THERMAL				
Glass Transition (1 <sup>st</sup> /2 <sup>nd</sup> )	DSC	340F/ 797F		171C/ 425C
Melt Point	DSC	658F		348C
Thermal Conductivity 25C/ 100C	C-518	3.0/ 3.5 BTU·in/hr·ft²°F		0.43/ 0.50 W/mK
OTHER				
Specific Gravity		1.43		1.43
Hardness, Rockwell E	D-785	72		72
TRIBOLOGICAL		PV 50K (psi-ft/min)	PV 125K (psi-ft/min)	PV 250K (psi-ft/min)
Dynamic Coef. Friction				
50 fpm		0.08	0.06	0.06
800 fpm		0.12	0.06	
Wear Factor K (in³min/ft·lb·hr) x 10 <sup>-10</sup>				
50 fpm		31	15	9
800 fpm		47	21	

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# Celazole® TL-60

## Self Lubricating Melt Processable PBI

### Typical Properties

PROPERTIES	ASTM METHOD	ENGLISH VALUE	METRIC VALUE
<b>MECHANICAL</b>			
Tensile Strength	D-638	17.4 kpsi	120 MPa
Modulus		2650 kpsi	18,300 MPa
Elongation		0.9%	0.9%
Flexural Strength	D-790	27.6 kpsi	190 MPa
Modulus		2320 kpsi	16,000 MPa
Compressive Strength	D-695	18 kpsi	123 MPa
Modulus		740 kpsi	5100 MPa
<b>TRIBOLOGICAL *</b>			
Wear Rate		0.20 in/1000 hrs	5 mm/1000 hrs
Running Temperature		350°F	177°C
Static Coefficient of Friction		0.30	0.30
Dynamic Coefficient of Friction		0.05	0.05
<b>THERMAL</b>			
Coefficient of Linear Thermal Expansion			
75-300°F	TMA	14 X 10 <sup>-6</sup> in/in°F	26µm/m°C
Heat Capacity @ 158°F	DSC	0.28 Btu/lb°F	1160 J/kg°C
Heat Deflection Temperature	D-648	590°F	310°C
Temp. of Initial (5%) Weight Loss In:			
Air	TGA	1116°F	602°C
Nitrogen	TGA	1123°F	606°C
Thermal Conductivity @ 70°F	F-433	5.3 Btu in/hr•ft <sup>2</sup> °F	0.76 W/M°C
<b>OTHER</b>			
Specific Gravity		1.44	1.44
Hardness, Rockwell E	D-785	65	65
Poisson's Ratio		0.42	0.42
Water Absorption	D-570		
24 hours @ 73°F		0.20 %	0.20 %
@ Equilibrium		3.8 %	3.8 %

**\*Test Conditions**

Mating Material – 1018 Steel  
Pressure – 125 psi  
Velocity – 800 ft/min  
Surface Finish – 16 rms

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# Celazole® TU-60

## Unreinforced Melt Processable PBI

### Typical Properties

PROPERTIES	ASTM METHOD	ENGLISH VALUE	METRIC VALUE
<b>MECHANICAL</b>			
Tensile Strength	D-638	14.5 kpsi	100 MPa
Modulus		730 kpsi	5000 MPa
Elongation		2.2 %	2.2 %
Flexural Strength	D-790	25.4 kpsi	175 MPa
Modulus		725 kpsi	5000 MPa
Compressive Strength	D-695	30 kpsi	206 MPa
Modulus		430 kpsi	2900 MPa
<b>THERMAL</b>			
Coefficient of Linear Thermal Expansion			
75-300°F	TMA	$19 \times 10^{-6}$ in/in°F	34 $\mu$ m/m°C
390-570°F	TMA	$39 \times 10^{-6}$ in/in°F	70 $\mu$ m/m°C
Temperature of Initial (5%) Weight Loss In:			
Air	TGA	930°F	499°C
Nitrogen	TGA	930°F	499°C
<b>ELECTRICAL</b>			
Dielectric Strength	D-149	433 V/mil	17KV/mm
Volume Resistivity	D-257	$2 \times 10^{16}$ ohm-cm	$2 \times 10^{16}$ ohm-cm
Dissipation Factor			
1 kHz	D-150	0.000	0.000
10 kHz	D-150	0.001	0.001
Dielectric Constant			
1 kHz	D-150	3.4	3.4
10 kHz	D-150	3.4	3.4
Arc Resistance	D-495	135 seconds	135 seconds
<b>OTHER</b>			
Water Absorption			
@ Equilibrium	D-570	6.5%	6.5%
Specific Gravity		1.3	1.3
Hardness, Rockwell A	D-785	25	25

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# Celazole<sup>®</sup> TF-60C

## Carbon Fiber Reinforced Melt Processable PBI

### Typical Properties

PROPERTIES	ASTM METHOD	ENGLISH VALUE	METRIC VALUE
<b>MECHANICAL</b>			
Tensile Strength	D-638	33 kpsi	230 MPa
Modulus		3500 kpsi	24,000 MPa
Elongation		1.4 %	1.4 %
Flexural Strength	D-790	46.5 kpsi	320 MPa
Modulus		3050 kpsi	21,000 MPa
Compressive Strength	D-695	32 kpsi	220 MPa
Modulus		550 kpsi	3800 MPa
<b>THERMAL</b>			
Coefficient of Linear Thermal Expansion			
75-300°F	TMA	$14 \times 10^{-6}$ in/in°F	26 $\mu$ m/m°C
Heat Capacity @ 158°F	DSC	0.28 Btu/lb°F	1180 J/kg°C
Heat Deflection Temperature @ 264 psi	D-648	608°F	320°C
Temp. of Initial (5%) Weight Loss In:			
Air	TGA	1110°F	599°C
Nitrogen	TGA	1160°F	627°C
Thermal Conductivity @ 75°F	F-433	3.1 Btu-in/hr•ft <sup>2</sup> °F	0.39 kcal/mh°C
<b>OTHER</b>			
Specific Gravity		1.41	1.41
Hardness, Rockwell A	D-785	30	30
Poisson's Ratio		0.39	0.39
Water Absorption			
24 hours @ 73°F	D-570	0.15 %	0.15 %
@ Equilibrium	D-570	4.0 %	4.0 %

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