Arnite®

PBT & PET Polyesters
General Information on Properties

a DSM Product

Unlimited. DSM

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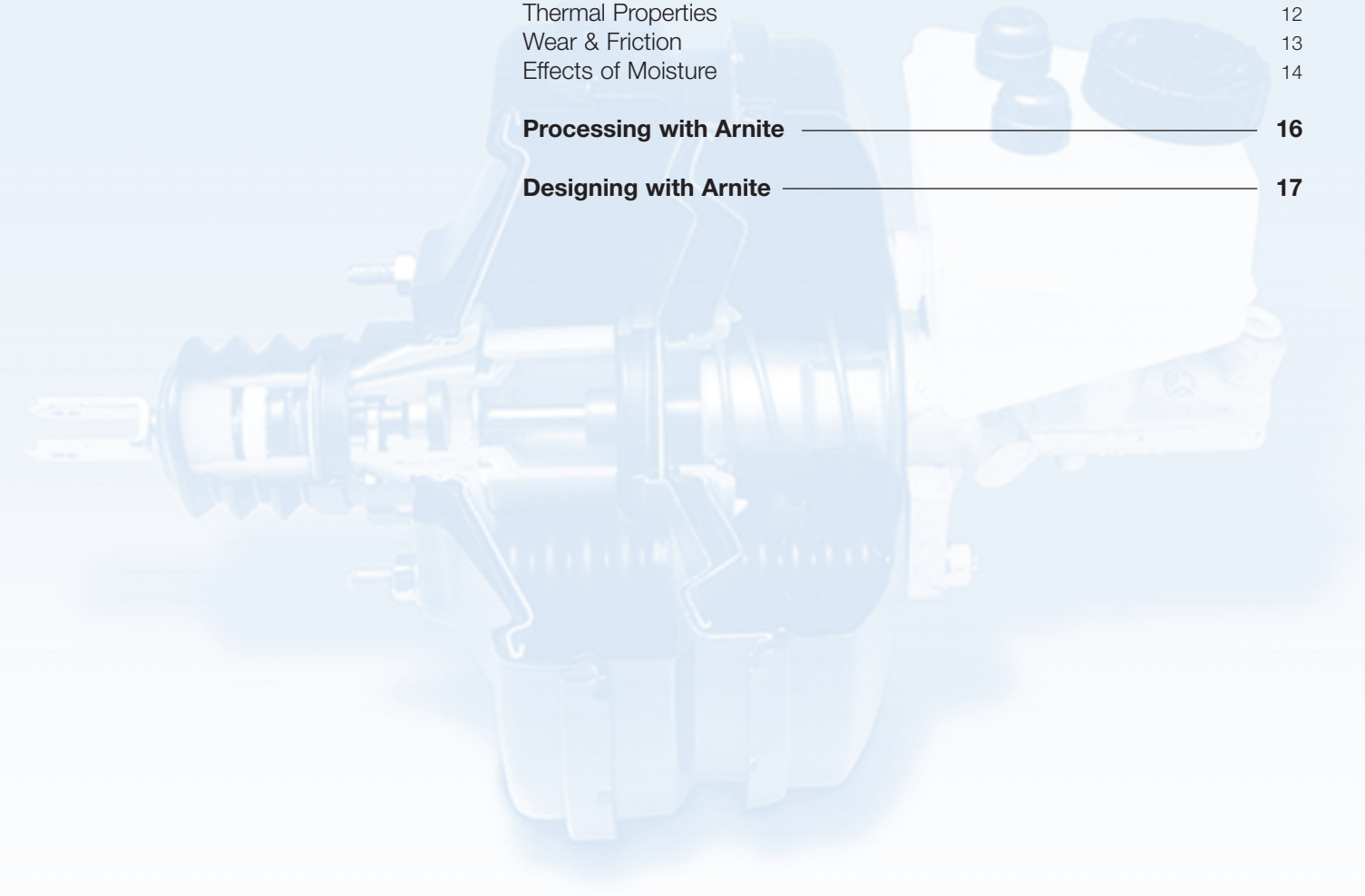


Unlimited. DSM

Arnite PBT and PET Polyesters

Arnite PBT and PET Polyesters

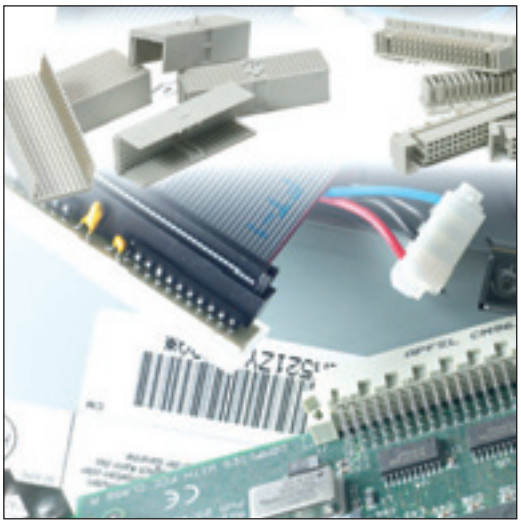
Arnite® (PBT, PET, and blends) are high-performance engineering plastics that combine high strength and rigidity with excellent processing characteristics. As a result, Arnite PBT and PET are well suited for a broad range of automotive, electrical / electronic, appliance and industrial equipment applications.

Additionally, several grades of Arnite are FDA and USP compliant and can therefore be used for food contact and medical applications. Further information can be found on our web site at **www.dsmep.com**.

Typical Properties of Arnite:

- Extremely **low moisture absorption**.
- Exceptional **dimensional stability**.
- Excellent **electrical insulation properties**, even at elevated temperatures or in humid environments.
- Excellent **chemical resistance**.
- Good **thermal resistance** and **heat aging properties**.
- High **strength and stiffness** of reinforced grades.
- Easy **moldability**.
- Good **wear resistance** properties.
- Very good **color stability**.

Arnite PBT and PET Polyesters



Arnite molding resins Portfolio

A wide portfolio of Arnite is available, including non-reinforced, reinforced and flame retardant grades. For the most up to date information about the Arnite portfolio and information regarding the properties of selected grades and availability in your region, visit the materials and applications database at **www.dsmep.com.** Some grades are not available in all regions.

Table 1 Arnite product portfolio.

Arnite A (PET)		
Non-reinforced grades		
	Arnite A02 306	PET-unfilled
	Arnite A04 900	PET-unfilled
	Arnite A06 101	PET-unfilled
	Arnite A06 300	PET-unfilled
	Arnite A06 700	PET-unfilled
Reinforced grades		
Standard	Arnite AV2 340	PET-GF20
	Arnite AV2 372	PET-GF35
	Arnite AV2 390	PET-GF50
Special grade for brake booster valve bodies	Arnite AV2 370 / B	PET-GF35
Flame retardant	Arnite AV2 360 S	PET-GF33
	Arnite AV2 365 SN	PET-GF30
Arnite D (PET)		
	Arnite D00 301	PET-unfilled
	Arnite D04 300	PET-unfilled
Arnite T (PBT)		
Non-reinforced grades		
Standard	Arnite T04 200	PBT-unfilled
	Arnite T06 200	PBT-unfilled
	Arnite T06 202	PBT-unfilled
	Arnite T08 200	PBT-unfilled
Flame retardant	Arnite T06 200 SNF	PBT-unfilled
	Arnite T06 204 SN	PBT-unfilled
Toughened	Arnite T06 206 T	(PBT+Imod)-unfilled
Special grade for very low outgassing – for bezel applications	Arnite T06 202 XL	PBT-unfilled
Reinforced grades		
Standard	Arnite TV4 220	PBT-GF10
	Arnite TV4 230	PBT-GF15
	Arnite TV4 240	PBT-GF20
	Arnite TV4 261	PBT-GF30
	Arnite TV4 270	PBT-GF35
Flame retardant	Arnite TV4 240 S	PBT-GF20
	Arnite TV4 260 S	PBT-GF30
	Arnite TV4 260 SF	PBT-GF30
	Arnite TV4 264 SN	PBT-GF30
Toughened	Arnite TV6 241 T	(PBT+Imod)-GF20
High viscous	Arnite TV8 260	PBT-GF30
Improved surface appearance	Arnite TV4 441	PBT/PET/GF20
	Arnite TV4 461	PBT/PET/GF30
UV Resistant	Arnite TV4 461 KL	PBT/PET/GF30

Mechanical Properties

Mechanical Properties

Arnite mechanical properties

Arnite has excellent mechanical properties, including high strength and stiffness, and outstanding creep resistance at elevated temperatures. Arnite also has very low wear loss and a low co-efficient of friction, making it suitable for applications where sliding forces come into play.

Strength and stiffness

Arnite grades show a dramatic increase in strength and stiffness when reinforced with fiberglass. PET has even higher mechanical properties compared to PBT, making it extremely suitable for very demanding applications such as brake booster valve bodies.

Due to low moisture uptake, Arnite shows no loss in strength and stiffness over ambient humidity levels.

Impact strength

The notched impact strength of Arnite also increases significantly when reinforced with fiberglass. For applications with even higher demands on toughness, special impact modified grades are also available.

Figure 1.
Positioning of Arnite versus other engineering thermoplastics (ambient temperature, 50% RH)

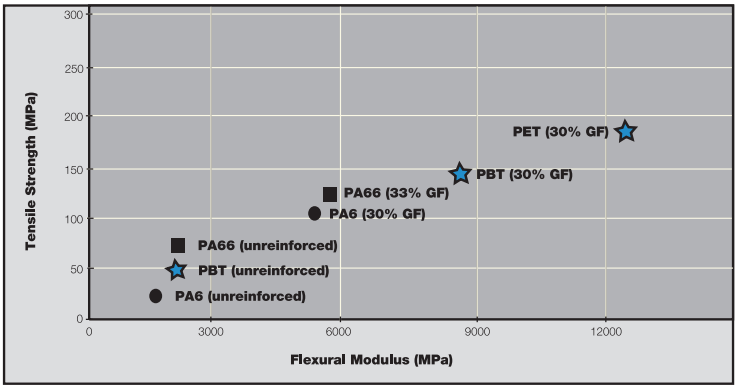


Figure 2.
Tensile creep resistance of Arnite A (AV2 372) and Arnite T (TV4 261) versus 30% GF reinforced polyamide 6 and 35% GF reinforced polyamide 66 (23 °C 10 MPa lower bound)

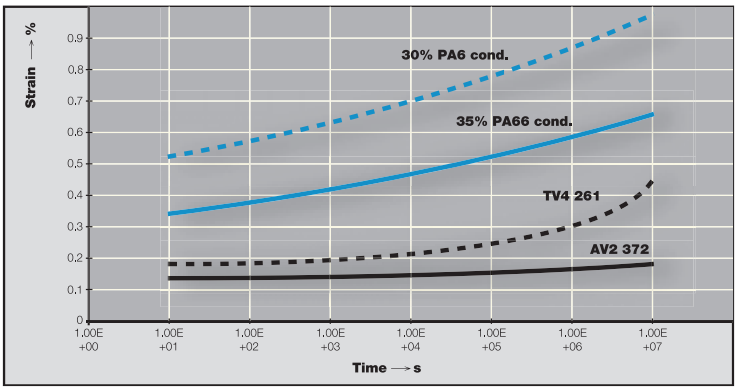


Figure 3.
Flexural creep at 27.5 MPa applied stress (conditioned at 50% RH)

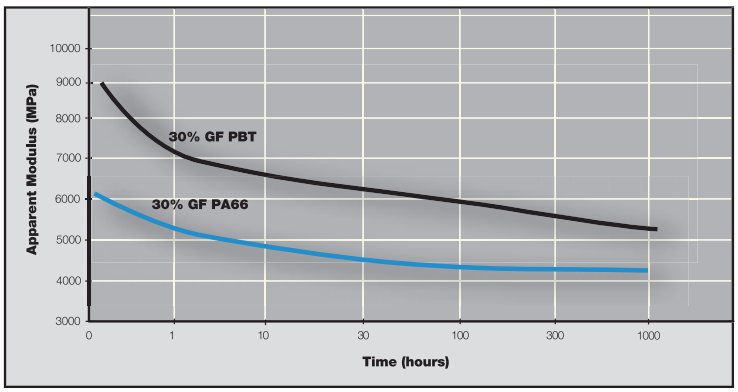
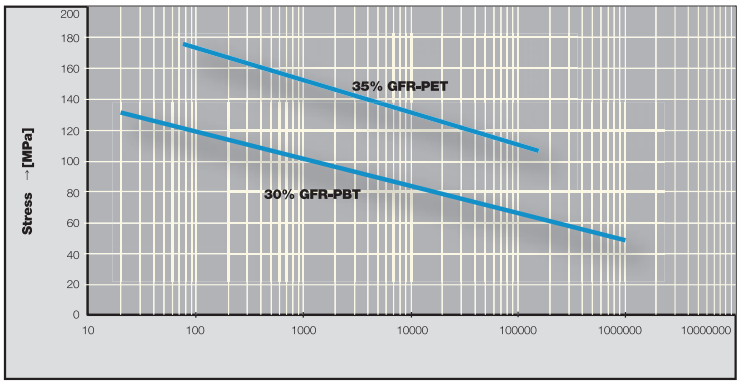


Figure 4.
Fatigue resistance (evaluated at 20°C, 50% RH)



Creep resistance

For optimum performance and maximum lifetime in applications that are subjected to long-term loading, engineering plastics must have a high creep resistance (i.e. a low plastic deformation under load). Arnite polyesters have excellent creep resistance, making them ideal materials for applications that experience large stresses for extended periods of time.

Fatigue properties

In addition, Arnite compounds show excellent fatigue properties.

Electrical Properties

Electrical Properties

Arnite has excellent dielectric strength even at elevated temperatures. Since Arnite does not absorb significant quantities of moisture, these properties do not change even when ambient humidity levels are high. Due to these characteristics, Arnite is widely used for electrical applications such as automotive fuse bodies, connectors, low voltage switchgears, telecom connectors, etc.

UL Yellow Card ratings
Detailed listings can be found at **www.ul.com**.

Underwriters Laboratories yellow card file for Arnite (UL file number: E47960)

Table 2. Arnite A (PET) UL listings.

Grade	Color	Min. Thick. (mm)	Flame Class UL94	HWI	HAI	RTI°C Elec.	RTI°C With Impact	RTI°C Without Impact	IEC GWIT	IEC GWFI	CTI	HVTR	D495
Arnite A (PET)													
Arnite A04 900	All	0.75	HB	4	0	75	75	75				2	
		1.5	HB	3	0	75	75	75				2	
		3.0	HB	3	0	75	75	75			1	2	5
Arnite A06 101	All	0.93	HB			75	75	75				0	
		1.5	HB	3	0	75	75	75				0	
		3.0	HB	3	0	75	75	75			0	0	6
Arnite AV2 340	All	0.75	HB	4	3	130	120	125				3	
		1.5	HB	3	3	130	120	125				3	
		3.0	HB	3	3	130	120	125			2	3	5
Arnite AV2 372	All	0.75	HB	2	3	150	120	130				4	
		1.5	HB	1	3	150	125	130				4	
		3.0	HB	0	3	150	130	130			2	3	5
Arnite AV2 390	All	0.81	HB	2	4	150	120	140				0	
		1.5	HB	1	4	150	120	140				0	
		3.0	HB	0	4	150	120	140			2	0	5
Arnite AV2 370 /B	All	0.75	HB	2	3	150	120	130				4	
		1.5	HB	1	3	150	125	130				4	
		3.0	HB	0	3	150	130	130			2	3	5
Arnite AV2 360 S	All	0.71	V-2	3	0	150	125	140				4	
		1.5	V-0	0	3	150	130	140				4	
		3.0	V-0	0	3	150	130	140				4	6
Arnite AV2 365 SN	All	0.75	V-0			130	120	125				0	
		1.5	V-0	0	0	130	120	125				0	
		3.0	V-0	0	0	130	120	125			3	0	5
	NC	0.4	V-0			130	120	125				0	
		2.1	5VA	0	0	130	120	125			3	0	5

Table 3. Arnite T (PBT) UL listings.

Grade	Color	Min. Thick. (mm)	Flame Class UL94	HWI	HAI	RTI°C Elec.	RTI°C With Impact	RTI°C Without Impact	IEC GWIT	IEC GWFI	CTI	HVTR	D495
Arnite T (PBT)													
Arnite T06 200	All	0.75	HB	4	0	130	95	125				0	
		1.5	HB	4	0	130	110	130				0	
		3.0	HB	3	0	130	110	130			0	0	4
Arnite T06 202	All	0.75	HB	4	0	130	95	125				0	
		1.5	HB	4	0	130	110	130				0	
		3.0	HB	3	0	130	110	130			0	0	4
Arnite T08 200	All	0.75	HB	4	0	130	95	125					
		1.5	HB	4	0	130	110	130					
		3.0	HB	3	0	130	110	130			0		
Arnite T06 200 SNF	All	0.75	V-0	4	0	140	110	130	900	960		0	
		1.5	V-0	3	0	140	110	130	675	960		0	
		3.0	V-0	2	0	140	110	130	675	960	0	0	5
Arnite T06 204 SN	All	0.75	V-0			75	75	75					
		3.0	V-0			75	75	75			3		
Arnite TV4 240	All	0.75	HB	3	1	140	130	130				2	
		1.5	HB	2	2	140	130	130				2	
		3.0	HB	1	2	140	130	130			1	2	5
Arnite TV4 261	All	0.71	HB	3	1	140	130	140				2	
		1.5	HB	2	2	140	130	140				1	
		3.0	HB	2	2	140	130	140			1	2	5
Arnite TV4 270	All	0.75	HB	3	2	140	130	140				2	
		1.5	HB	1	2	140	130	140				1	
		3.0	HB	1	2	140	130	140			1	2	6
Arnite TV4 240 S	All	0.75	V-2	3	1	140	130	140				2	
		1.5	V-0	2	2	140	130	140				2	
		3.0	V-0	2	2	140	130	140			2	2	5
Arnite TV4 260 S	All	0.50	V-2			75	75	75				1	
		0.75	V-2	3	0	140	130	140				1	
		1.5	V-0	3	0	140	130	140				1	
		3.0	V-0	2	0	140	130	140			2	1	5

Electrical Insulation Classes (UL 1446)

Table 4. Insulation class 130 (B) systems.

Class 130 (B) Systems - Arnite					Magnet wires					
								35	79	
								36	80	
	System		Grades for		26	27	30	73	82	28
Material	Designation	Table	Ground / Interwind insulation	TIW	77	78	76	74	83	75
PBT	TS201B	I	TV4 240, TV4 261, TV4 264 SN		■	■	■	■		
Arnite	TS202	I	TV4 240 S, TV4 260 S, TV4 260 SF				■	■	■	

■ *Valid with a wide rang of varnishes via Sealed Tube Testing*
No varnish applicable

Table 5. Insulation class 155 (F) systems.

Class 155 (F) Systems - Arnite					Magnet wires					
								35	79	
								36	80	
	System		Grades for		26	27	30	73	82	28
Material	Designation	Table	Ground / Interwind insulation	TIW	77	78	76	74	83	75
PBT	T200	I	TV4 261, UM551							
Arnite		II	TV4 261, UM551							
		III	TV4 261, UM551							
	TS200	I	TV4 260 S, UM551							
		II	TV4 260 S, UM551							
		III	TV4 260 S, UM551							
		IV	TV4 260 S, TV4 264 SN						■	
		V	TV4 260 S, TV4 264 SN						■	
	TS201	I	TV4 240, TV4 261, TV4 264 SN		■	■	■	■		
		II	TV4 240, TV4 261, TV4 264 SN		■	■	■	■		
		III	TV4 240, TV4 261, TV4 264 SN		■	■	■	■		
PET	AS200	I	AV2 360 S, AV2 365 SN, UM551							
Arnite		II	AV2 360 S, AV2 365 SN, UM551							
		III	AV2 360 S, AV2 365 SN, UM551							
		IV	AV2 360 S, AV2 365 SN, UM551							

■ *Only with specific varnishes*
Valid with a wide range of varnishes via Sealed Tube Testing

Table 6. Insulation class 180 (H) systems.

Class 180 (H) Systems - Arnite					Magnet wires					
								35	79	
								36	80	
	System		Grades for		26	27	30	73	82	28
Material	Designation	Table	Ground / Interwind insulation	TIW	77	78	76	74	83	75
PET	AS300	I	AV2 360 S, AV2 365 SN				■	■		
Arnite		II	AV2 360 S, AV2 365 SN				■	■		
		III	AV2 360 S, AV2 365 SN				■	■		
		IV	AV2 360 S, AV2 365 SN				■	■		

■ *Valid with a wide range of varnishes via Sealed Tube Testing*

Flame Retardancy

Flame Retardancy

Electrical equipment is governed by strict regulatory standards that exist to ensure safety. Arnite polyesters are extensively used for electrical and electronic equipment; and the Arnite portfolio covers a wide range of flame-retardant grades, both non-reinforced and glass fiber reinforced to meet these demanding standards.

Arnite is available in grades with UL94 V-0 rating at 1.5mm and 0.75 mm. The 'S'-grades (V-0 at 1.5 mm) can be used in the majority of applications, whereas the 'SF'-grades (V-0 at 0.75 mm) are high performance grades that can be used when there are more severe property demands. These grades are UL listed for all color variants, including 50% regrind. They also have very high Comparative Tracking Indices (CTI), excellent flow properties, good toughness, and high Relative Thermal Indices (RTI).

The limiting oxygen index (LOI) of unmodified Arnite T (PBT) is 18, while that of unmodified Arnite A (PET) is 21.

Detailed listings can be found at **www.ul.com**.

Chemical Resistance

At ambient temperature, Arnite polyesters possess a remarkable resistance to a variety of chemicals such as:

- aliphatic hydrocarbons,
- motor vehicle fuels,
- oils and greases,
- dilute acids and bases,
- detergents, and
- most aqueous salt solutions.

When an application requires exposure to, or immersion in chemicals, certain environments, prototypes or suitable stressed samples of the material should be tested under actual operating conditions.

Table 7. Chemical resistance.

Groups of chemicals[1)]	Unreinforced	Reinforced
Inorganic acids:		
non-oxidising, concentrated	-	-
non-oxidising, diluted (1:1)	+	+[2)]
non-oxidising, highly diluted	+	+[2)]
oxidising, concentrated	-	-
oxidising, diluted (1:1)	-	-
oxidising, highly diluted	+	+
Organic acids:		
Concentrated	□	□
diluted (1:1)	+	+
highly diluted	+	+
Bases:		
Concentrated	-	-
diluted (1:1)	□	-
highly diluted	+	-
Salt solutions:		
Acid	+	+
Neutral	+	+
Basic	+	□
Hydrocarbons:		
Aliphatic	+	+
Aromatic	+	□
Halogenated hydrocarbons:		
Perhalogenated	+	+
partly halogenated	-	-
Oils and greases	+	+
Phenols	-	-
Alcohols		
Monovalent	+	+
Polyvalent	+	□
Ketones	+	□
Esters	+	□
Ethers	+	+

+ good □ doubtful – poor

1) Resistance to groups of chemicals at room temperature.

2) With the exception of hydrofluoric acid.

Thermal Properties

Short term thermal properties

Arnite has excellent thermal properties. The HDT-B for Arnite T (PBT) grades is 170°C when non-reinforced and 220°C for glass fiber reinforced grades. For glass fiber reinforced Arnite A (PET) grades even higher HDT-B temperatures of ca. 250°C are found.

Long term thermal properties

Polyesters have excellent high temperature thermal and oxidative stability. UL RTI ratings of continuous use temperatures are generally 130 ~ 140°C for most Arnite grades. This allows Arnite to be widely used in automotive applications and electrical installations where high temperatures are encountered.

In addition, Arnite polyesters possess excellent color stability during ageing at elevated temperatures, making them particularly suited for lighting applications such as lamp holders and lamp bases.

Wear & Friction

Figure 5.
Equilibrium dynamic coefficient of friction comparison of PBT and PA6

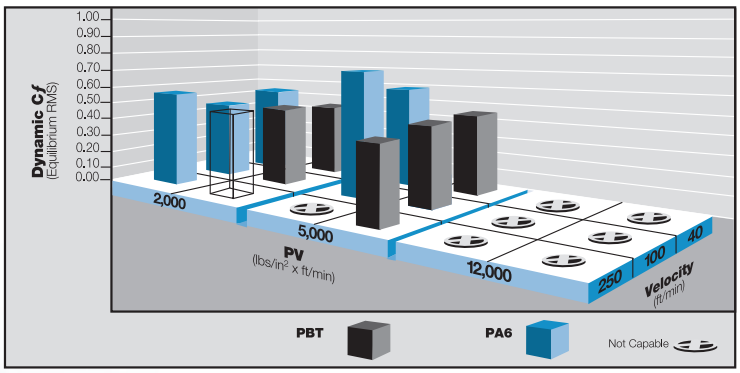
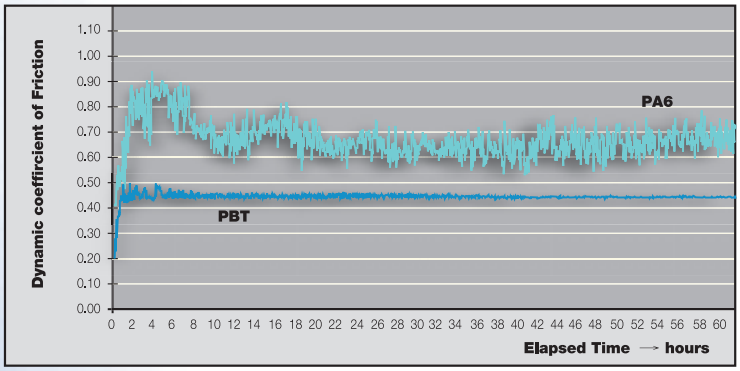


Figure 6.
Frictional noise (change in dynamic co-efficient of friction) with time for Arnite T (PBT) versus PA6 (versus C-1018 steel at PV = 5,000 lbs/in² – ft/min)

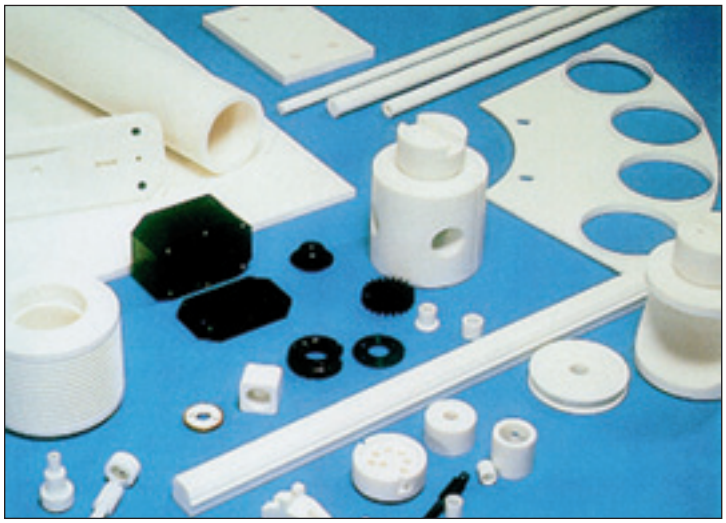


Wear & Friction

Arnite has been selected for a variety of applications where tribological (wear) characteristics are important. Arnite PBT grades display good resistance to wear and possess low frictional coefficients. More importantly, the outstanding frictional response of Arnite PBT is what sets it apart from other thermoplastics. Real-time frictional measurements comparing PA6 to Arnite PBT reveal the outstanding frictional consistency. Arnite PET is also used in a variety of applications for which extreme wear resistance is a requirement and where static and dynamic frictional coefficients should be similar.

PA6 exhibits equivalent frictional response to PBT at low to moderate PV levels, but at moderate to high PV's, PBT is superior by margins of 25 to 50%.

Not only is the overall frictional effort low for PBT, the consistency of this response is remarkable. Real time frictional measurements comparing PA6 to PBT at a PV of 5,000 graphically show the over seven-fold increase in frictional consistency. For applications that require smooth actuation as well as low overall frictional effort, Arnite PBT polyester is an outstanding engineering material.



Effects of Moisture

Effects of Moisture

Arnite polyesters experience very low moisture uptake, making them more dimensionally stable than polyamides. Arnite grades are more suitable for applications where dimensional tolerances and both long-term physical and electrical property retention are critical.

The very low water uptake of Arnite polyesters allows them to retain their stiffness even in humid conditions. Furthermore, electrical properties are maintained in humid environments as well.

Arnite PBT compounds absorb less than 0.5% water over a period of several thousand hours in ambient conditions.

Figure 7.
Moisture absorption versus Time (23 °C, 50% RH)

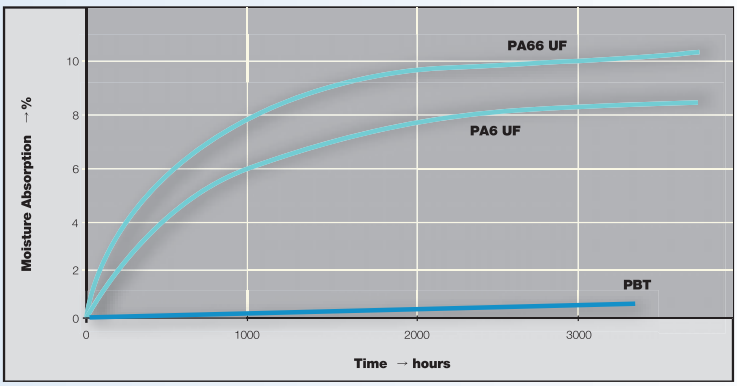


Figure 8.
Dimensional stability of PA66 versus PBT

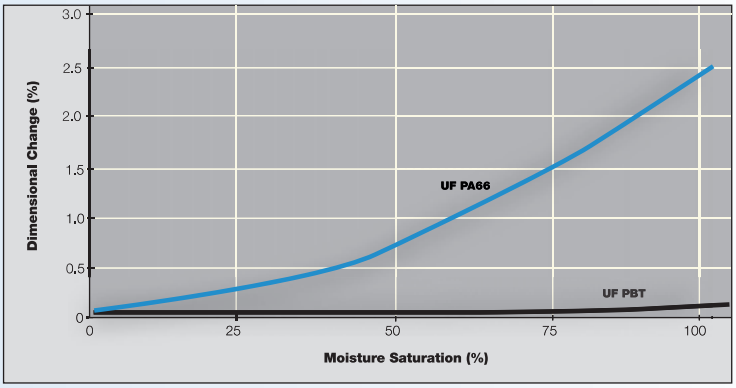


Figure 9.
Influence of moisture during processing on part performance

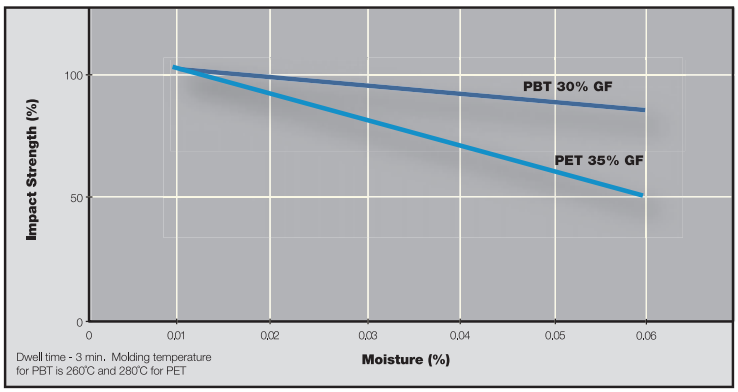


Figure 10.
Property retention after conditioning for PBT and PA66

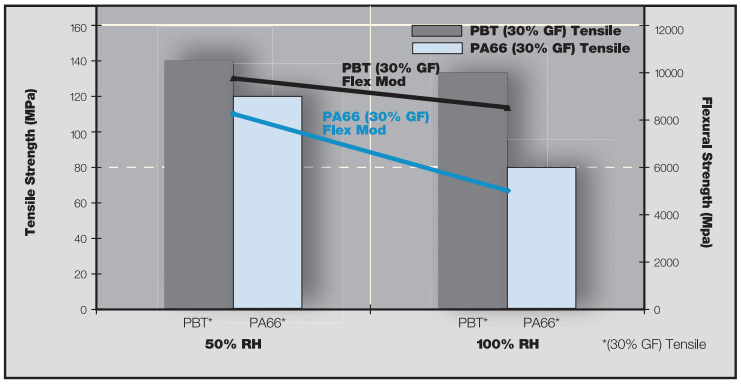
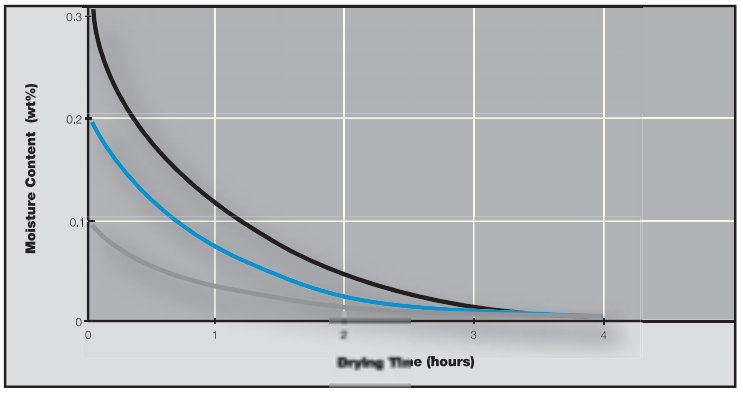


Figure 11.
Drying time in dehumidifying dryers. Air temperature 120°C with dew point under -20°C



Material handling

Although polyesters absorb very little moisture, the presence of water during processing at high temperatures may cause hydrolysis. As PET is processed at higher temperatures than PBT, hydrolysis occurs more readily for PET.

For best results, the maximum allowable moisture contents for molding should be 0.03% for Arnite T (PBT) and 0.02% for Arnite A (PET), which are typical delivery specifications on moisture content. At or below these moisture levels, no significant deterioration of properties will occur during processing.

Drying conditions

Table 8. Drying conditions.

Drying time	[hours]	4-6
Temperature	[°C]	110 - 120
Remarks	* Desiccant dryers, dew point -30°C (-22°F), and predried air dryers are used to dry Arnite®. * To prevent material discoloration while using air dryers, temperature settings >120°C (>248°F) should be avoided.	

Processing with Arnite

Processing with Arnite

Arnite polyesters can be easily processed. These materials have good flow and high crystallinity, resulting in rapid cooling times.

Typical processing temperatures for Arnite T (PBT) are 235°C ~ 275°C whereas for Arnite A (PET), a processing temperature range between 265°C – 295°C is advisable. Molds may need heating to ensure high crystallinity and better surface finish (80°C ~135°C for Arnite A (PET), and 30°C ~ 100° for Arnite T (PBT)).

Even a small amount of moisture absorbed by granules can result in moldings with poor strength, due to the breakdown of the polymer chain. Care must be taken to pre-dry granules that could have been exposed to the atmosphere, prior to molding, to remove all moisture present. Arnite polyesters come in sealed bags and are ready to be molded without pre-drying. However, if the bag has been opened and is exposed to moisture, it is essential to pre-dry the material. Drying conditions can be found on page 15.

Table 9. Processing temperatures.

	Mold [°C]	Melt [°C]	Nozzle [°C]	Front [°C]	Center [°C]	Rear [°C]
Non-reinforced, non-flame retardant Arnite A	130 -140	270 - 290	270 - 280	270 - 285	270 - 290	270 - 290
	266 - 284°F (Crystalline)	518 - 554°F	518 - 536°F	518 - 545°F	518 - 554°F	518 - 554°F
Reinforced, non-flame retardant Arnite A	130 - 140	270 - 290	270 - 280	270 - 285	270 - 290	270 - 290
	266 - 284°F (Crystalline)	518 - 554°F	518 - 536°F	518 - 545°F	518 - 554°F	518 - 554°F
Reinforced, flame retardant Arnite A	130 - 140	270 - 280	260 - 270	260 - 270	270 - 280	270 - 280
	266 - 284°F	518 - 536°F	500 - 518°F	500 - 518°F	518 - 536°F	518 - 536°F
Non-reinforced, non-flame retardant Arnite D	20	270 - 290	270 - 280	270 - 285	270 - 290	270 - 290
	68°F (Amorphous)	518 - 554°F	518 - 536°F	518 - 545°F	518 - 554°F	518 - 554°F
Non-reinforced, non-flame retardant Arnite T	80 - 100	240 - 270	240 - 260	240 - 260	230 - 250	230 - 240
	176 - 212°F	464 - 518°F	464 - 500°F	464 - 500°F	446 - 482°F	446 - 464°F
Non-reinforced, flame retardant Arnite T	80 - 100	240 - 250	240 - 250	240 - 245	235 - 240	230 - 235
	176 - 212°F	464 - 482°F	464 - 482°F	464 - 473°F	455 - 464°F	446 - 455°F
Reinforced, non-flame retardant Arnite T	80 - 100	240 - 270	240 - 260	240 - 260	230 - 250	230 - 240
	176 - 212°F	464 - 518°F	464 - 500°F	464 - 500°F	446 - 482°F	446 - 464°F
Reinforced, flame retardant Arnite T	80 - 100	240 - 250	240 - 250	240 - 245	235 - 240	230 - 235
	176 - 212°F	464 - 482°F	464 - 482°F	464 - 473°F	455 - 464°F	446 - 455°F

Table 10.
Recommended runner dimensions

Wall thickness (mm)	Maximum runner length (mm)	Minimum runner diameter (mm)
0.7 – 1.2	50	3.5
1.2 – 3	100	5
3 – 5	150	6
5>*	100	7 - 8

wall thickness larger than 5 mm must be avoided.

Designing with Arnite

Dimensional tolerance

As a rule of thumb the dimensional tolerance on parts when using Arnite is to allow +/-0.05 mm/mm tolerance for the first mm and +/-0.025 mm/mm for each additional mm, or fraction thereof. It is possible to hold tighter tolerances than these depending on the part, tool design, and processing conditions.

Surface appearance

Excellent surface reproducibility is possible with Arnite polyesters. Additionally, both high gloss and matt textures are possible.

Runner dimensions and wall thickness

Wall thickness should be the minimum allowed by the functional requirements of the part and the processing capabilities of the material. Walls that are thicker than necessary add cost by increased material usage and longer cycle times. Additionally, thicker walls may cause problems such as warpage, sink marks, internal voids, and poor surface appearance.

For parts requiring very high strength and stiffness, relatively thick walls can be employed. Generally speaking, the use of thinner walls along with cores, ribs, etc., will provide better cost-performance.

Mold shrinkage behavior

Shrinkage behavior of Arnite polyesters is directly related to mold temperature, processing temperature and whether the grade being used contains any fillers or reinforcements.

Table 11.
Effect of part thickness on shrinkage (mold temperature 66°C)

Part thickness (mm)		3.20 mm	6.35 mm
		Mold Shrinkage, %	
Non-reinforced Resins		1.60	2.00
30% Glass Reinforced Resins	Flow (length)	0.19	0.35
	Transverse (width)	0.75	0.85

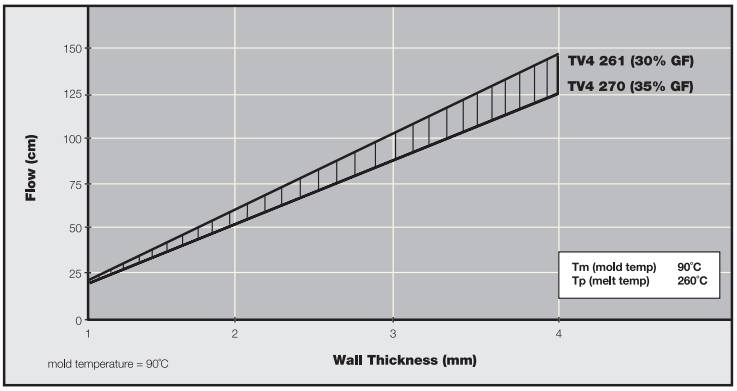
Table 12.
Effect of mold temperature on shrinkage

Mold temperature		40°C	65°C	95°C
		Mold Shrinkage, %		
Non-reinforced Resins		1.40	1.60	1.80
30% Glass Reinforced Resins	Flow (length)	0.17	0.19	0.21
	Transverse (width)	0.65	0.75	0.85

Flow behavior

Visit **www.dsmep.com** for more information related to flow.

Figure 12.
Flow behavior of Arnite

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