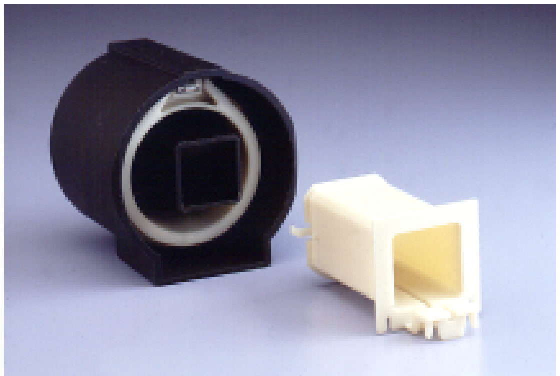
Rynite® PET

thermoplastic polyester resin

T-Roof Rail: Stiffness, strength and toughness, combined with good surface appearance.

Oven Handle: High stiffness, low discoloration and distortion, and light color availability.



Coil Bobbin: Excellent dielectric properties, outstanding heat resistance, combined with lasting adhesion.

Encapsulated Motor Stator: All-in-one molded stator assembly, lower production time, and cooler operation.

Start with DuPont

Identity and Trademark Standards

Guidelines for Customer Use—Joint ventures and authorized resellers

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Only by DuPont

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Rev. August 1995

DUPONT®

Rynite® PET

thermoplastic polyester resin

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Chapter 1

Introduction and General Properties

General Description

Rynite® PET thermoplastic polyester resins contain uniformly dispersed glass fibers or mineral/glass fiber combinations in polyethylene terephthalate (PET) resin that has been specially formulated for rapid crystallization during the injection molding process. Rynite® PET thermoplastic polyester resins are among the strongest and stiffest engineering resins available. As an engineering polymer resin family, Rynite® PET thermoplastic polyester resins offer a unique combination of properties—high strength, stiffness, excellent dimensional stability, outstanding chemical and heat resistance, and good electrical properties.

Specific grades of Rynite® PET thermoplastic polyester resin are formulated with special emphasis on strength, low warp and dimensional stability, toughness, high-temperature color stability, electrical properties, and excellent UL flammability and relative temperature index ratings.

Rynite® PET thermoplastic polyester resins are noted for their excellent flow characteristics in thin wall applications, close molding tolerances, and high productivity from multicavity molds. Several compositions are exceptional in encapsulation applications. The properties, processing characteristics, and competitive price of Rynite® PET thermoplastic polyester resins lead to high value-in-use and lower part cost and weight as compared to metals such as zinc or aluminum.

Among the many successful applications for Rynite® PET thermoplastic polyester resins are housings and covers, support brackets, pump parts, electrical sensor housings, motor parts, lamp sockets, terminal blocks, switches, bobbins, oven handles and control panels, small appliance housings, automotive support brackets, exterior components, headlamp retainers, ignition components, and luggage racks.

Table 1
Compositions

Standard Compositions	Characteristics	Candidate Uses
General-Purpose Grades		
Rynite® 520	20% glass-reinforced modified polyethylene terephthalate—good balance of strength, stiffness, specific gravity, and toughness with good surface appearance.	Housings, electrical components, covers, frames, bobbins.
Rynite® 530	30% glass-reinforced modified polyethylene terephthalate—outstanding balance of strength, stiffness, and toughness, excellent electrical properties, surface appearance, and chemical resistance.	Electrical/electronic parts such as ignition components, relay bases, lamp sockets, bobbins; housings and other parts for pumps; mechanical components including gears, sprockets, vacuum cleaner parts, motor end bells; chair arms, casters, and other furniture parts.
Rynite® 545	45% glass-reinforced modified polyethylene terephthalate—greater strength and stiffness, excellent dimensional stability, and creep resistance.	Lamp housings, compressor housings, fuel, air, and temperature sensor housings, sunroof frames, spools, bobbins, transmission components, medical devices.
Rynite® 555	55% glass-reinforced modified polyethylene terephthalate—superior stiffness, dimensional stability, heat resistance, and outstanding resistance to creep.	Structural support brackets, housings and covers, auto parts, bicycle components, propellors.
Low Warp Grades		
Rynite® 935	35% mica/glass-reinforced modified polyethylene terephthalate—exceptionally low warpage, excellent electrical properties, high stiffness, and high heat resistance.	Exterior body parts, structural housings and frames, irrigation components, electrical components including transformer and ignition coil housings.
Rynite® 940	40% mica/glass-reinforced modified polyethylene terephthalate—greater strength, stiffness, and low warpage.	Frames, exterior body parts; structural supports.
Toughened Grades		
Rynite® 408	30% glass-reinforced modified polyethylene terephthalate with improved impact resistance. Excellent balance of strength, stiffness, toughness, and temperature resistance.	Water pump housings, structural housings and brackets, electrical and electronic housings, luggage rack components.
Rynite® 415HP	15% glass-reinforced modified polyethylene terephthalate—improved for easy, fast processing over a broad molding range—excellent balance of strength, stiffness, and temperature resistance.	Snap fit applications, encapsulation of sensors, coils, etc.
Rynite® SST 35	35% stiffened, super-tough, glass-reinforced modified polyethylene terephthalate—superior combination of toughness and stiffness. Excellent surface appearance, moldability, and temperature resistance.	Automotive parts, wheels, yard and shop tools, sporting goods, luggage components, appliance housings, structural furniture components.

(continued)

Table 1
Compositions *(continued)*

Standard Compositions	Characteristics	Candidate Uses
Flame-Retardant Grades*		
Rynite® FR330	Flame-retardant, 30% glass-reinforced modified polyethylene terephthalate. Recognized by UL as 94 V-0 at 0.032″. Has a 140°C (284°F) temperature index. Excellent balance of electrical and mechanical properties. High temperature resistance and flow.	Electrical and electronic connectors and components such as relays, switches, lamp sockets, and fans. Used in structural components such as office equipment, fans, fan housings, and oven handles.
Rynite® FR515	Flame-retardant, 15% glass-reinforced modified polyethylene terephthalate. Recognized by UL as 94 V-0 at 0.034″. Has a 140°C (284°F) temperature index. Excellent balance of electrical and mechanical properties. High temperature resistance and flow.	Electrical and electronic connectors and components such as relays, switches, lamp sockets, and fans.
Rynite® FR530	Flame-retardant, 30% glass-reinforced modified polyethylene terephthalate. Recognized by UL as 94 V-0 at 0.014″. Has a 150°C (302°F) temperature index. Outstanding balance of properties and excellent flow characteristics.	Electrical and electronic connectors and other components requiring flame-retardant characteristics. Used in applications employing vapor phase and wave soldering techniques.
Rynite® FR543	Flame-retardant, 43% glass-reinforced polyethylene terephthalate. Has a 155°C (311°F) temperature index—equivalent to many thermosets. Recognized by UL as 94 V-0 at 0.032″.	Electrical/electronic applications such as relays, switches, lighting ballasts, and terminal blocks.
Rynite® FR943	Flame-retardant, 43% glass-reinforced modified polyethylene terephthalate. Recognized by UL as 94 V-0 at 0.014″. Has a 155°C (311°F) temperature index. Excellent balance of electrical and mechanical properties. Low warp characteristics.	Electrical and electronic connectors and other components requiring low warp characteristics. Used in electronic applications such as connector bodies and terminal blocks.
Rynite® FR945	Flame-retardant, 45% mineral/glass-reinforced modified polyethylene terephthalate. Recognized by UL as 94 V-0 at 0.032″. Has a 150°C (302°F) temperature index. Low warpage, high stiffness, and economical price.	Electrical and electronic components. Economical for large parts requiring flame-retardant characteristics, such as motor housings, bobbins, terminal blocks, and fans.
Rynite® FR946	Flame-retardant, 46% glass-reinforced modified polyethylene terephthalate. Recognized by UL as 94 V-0 at 0.032″. Has a 150°C (302°F) temperature index. Excellent balance of stiffness, strength, toughness, good surface appearance, and electrical properties.	Electrical and electronic components. Economical for large parts requiring flame-retardant characteristics, such as connector bodies, bobbins, and terminal blocks.

*This numerical flame spread rating is not intended to reflect hazards presented by this or any other material under actual fire conditions.

Table 2
Typical Properties of Rynite® PET

	Property[1]	Method	Unit	General-Purpose				Low Warp		Toughened			Flame-Retardant						
				Rynite® 520	Rynite® 530	Rynite® 545	Rynite® 555	Rynite® 935	Rynite® 940	Rynite® 408	Rynite® 415HP	Rynite® SST 35	Rynite® FR330	Rynite® FR515	Rynite® FR530	Rynite® FR543	Rynite® FR943	Rynite® FR945	Rynite® FR946
Strength	Tensile Strength	ASTM																	
	–40°C	D638	MPa	148	214	242	220	121	152	206	145	190	193	138	193	210	155	139	145
	–40°F		kpsi	21.5	31.0	35.1	31.9	17.5	22.0	29.9	21.0	27.5	28.0	20.0	28.0	30.5	22.5	20.2	21.0
	23°C		MPa	114	159	186	189	89.6	117	126	79.0	103	138	107	138	172	124	104	103
	73°F		kpsi	16.5	23.0	27.0	27.5	13.0	17.0	18.3	11.5	15.0	20.0	15.5	20.0	25.0	18.0	15.1	15.0
	90°C		MPa	58.6	83.4	91.7	95.8	40.7	55.2	70.3	44.8	55.2	72.4	55.2	72.4	86.5	65.5	51.0	55.2
	194°F		kpsi	8.5	12.1	13.3	13.9	5.9	8.0	10.2	6.5	8.0	10.5	8.0	10.5	12.5	9.5	7.4	8.0
	150°C		MPa	41.4	56.5	66.9	70.0	29.7	38.6	55.2	35.9	44.8	44.8	38.0	44.8	55.2	40.0	31.7	34.5
	300°F		kpsi	6.0	8.2	9.7	10.0	4.3	5.6	8.0	5.2	6.5	6.5	5.5	6.5	8.0	5.8	4.6	5.0
	Elongation at Break	ASTM																	
	–40°C (–40°F)	D638	%	2.1	2.5	1.7	1.5	1.8	1.6	3.0	3.0	3.2	1.9	2.5	1.9	1.7	1.3	1.4	1.2
	23°C (73°F)		%	2.3	2.7	2.1	1.6	2.0	1.9	3.3	6.0	5.0	2.1	2.6	2.1	1.8	1.5	1.4	1.2
	90°C (194°F)		%	6.0	5.7	4.5	3.5	5.0	5.5	7.0	13	8.5	3.5	4.7	3.5	4.3	3.0	4.0	3.0
	150°C (300°F)		%	7.0	6.5	6.0	4.0	7.0	6.5	7.5	14	8.5	4.0	6.7	4.0	5.5	4.5	5.0	4.0
	Tensile Modulus	ASTM																	
	–40°C	D638	MPa	8,280	11,300	16,400	20,500	11,200	13,900	9,790	6,400	10,900	12,500	7,100	12,500	17,100	15,700	16,400	15,800
	–40°F		kpsi	1,200	1,640	2,380	2,970	1,620	2,010	1,420	928	1,580	1,810	1,030	1,810	2,480	2,280	2,380	2,290
	23°C		MPa	7,240	10,700	15,500	17,900	9,930	11,600	9,310	4,220	7,590	11,000	6,890	11,000	16,500	11,900	12,300	14,500
	73°F		kpsi	1,050	1,550	2,250	2,590	1,440	1,680	1,350	612	1,100	1,590	999	1,590	2,390	1,720	1,780	2,100
	90°C		MPa	3,370	4,540	8,410	9,100	3,170	4,450	3,280	1,830	3,240	5,580	3,040	5,580	8,210	6,470	5,900	4,920
	194°F		kpsi	488	658	1,220	1,320	460	645	475	265	470	809	441	809	1,190	939	857	713
	150°C		MPa	2,090	3,090	5,100	6,380	2,420	3,190	2,700	1,690	2,300	3,890	2,280	3,890	5,050	4,300	2,450	3,610
	300°F		kpsi	303	448	740	925	351	462	392	245	333	564	331	564	732	628	355	523
	Shear Strength	ASTM																	
	23°C	D732	MPa	—	79.0	86.5	82.7	53.7	60.7	—	40.0	38.0	60.0	52.0	60.0	58.6	55.2	48.3	52.0
	73°F		kpsi	—	11.5	12.5	12.0	7.8	8.8	—	5.8	5.5	8.7	7.5	8.7	8.5	8.0	7.0	7.5
Stiffness and Creep	Flexural Strength	ASTM																	
	–40°C	D790	MPa	200	269	324	345	176	261	266	210	276	262	179	262	310	227	210	207
	–40°F		kpsi	29.0	39.0	47.0	50.0	25.5	37.9	38.6	30.5	40.0	38.0	26.0	38.0	45.0	33.0	30.5	30.0
	23°C		MPa	172	235	283	290	141	198	193	93.1	145	200	158	200	248	186	154	165
	73°F		kpsi	25.0	34.0	41.0	42.0	20.5	28.7	28.0	13.5	21.0	29.0	23.0	29.0	36.0	27.0	22.3	24.0
	90°C		MPa	90.3	114	141	159	62.1	73.1	86.2	48.3	69.0	107	69.0	107	138	103	95.2	96.5
	194°F		kpsi	13.1	16.5	20.5	23.0	9.0	10.6	12.5	7.0	10.0	15.5	10.0	15.5	20.0	15.0	13.8	14.0
	150°C		MPa	55.9	75.8	96.5	110	42.7	49.0	60.0	34.5	—	69.0	44.8	69.0	79.3	64.1	66.9	55.2
	300°F		kpsi	8.1	11.0	14.0	16.0	6.2	7.1	8.7	5.0	—	10.0	6.5	10.0	11.5	9.3	9.7	8.0
	Flexural Modulus	ASTM																	
	–40°C	D790	MPa	7,590	10,300	15,200	20,700	11,700	13,200	8,900	5,860	8,970	11,000	6,550	11,000	15,200	14,500	14,500	13,800
	–40°F		kpsi	1,100	1,500	2,200	3,000	1,700	1,920	1,290	850	1,300	1,600	950	1,600	2,200	2,100	2,100	2,000
	23°C		MPa	6,480	8,960	17,900	17,900	9,600	11,700	8,280	3,600	6,890	10,300	5,860	10,300	14,500	13,100	11,700	12,400
	73°F		kpsi	940	1,300	2,000	2,600	1,400	1,700	1,200	525	1,000	1,500	850	1,500	2,100	1,900	1,690	1,800
	90°C		MPa	2,690	3,580	5,510	9,210	3,370	3,580	3,010	1,280	2,480	4,650	2,410	4,650	6,890	5,860	4,480	5,860
	194°F		kpsi	390	520	800	1,330	489	520	436	185	360	674	350	674	1,000	850	650	850
	150°C		MPa	1,870	2,690	4,000	5,730	2,200	2,100	2,250	1,100	1,900	2,650	1,520	2,650	2,900	3,440	2,900	3,280
	300°F		kpsi	271	390	580	832	320	300	326	155	275	384	220	384	450	500	420	475
	Compressive Strength	ASTM																	
	23°C	D695	MPa	172	227	235	241	141	175	148	93.0	81.0	200	172	200	231	193	168	193
	73°F		kpsi	25.0	33.0	34.0	35.0	20.5	25.4	21.5	13.5	11.7	29.0	24.9	29.0	33.5	28.0	24.4	28.0
	Deformation Under Load 27.6 MPa (4,000 psi)	ASTM																	
	23°C (73°F)	D621	%	—	0.4	0.4	—	—	0.6	—	2.2	2.8	0.3	0.3	0.5	0.1	0.3	0.4	0.3
	50°C (122°F)		%	—	1.6	1.2	—	—	1.5	—	4.4	4.6	1.7	1.1	1.2	0.3	1.7	1.2	0.8
	Flexural Creep 27.6 MPa (4,000 psi) 5,000 hr	ASTM																	
	23°C (73°F)	D2990	%	—	0.56	0.32	0.19	0.50	0.51	—	1.98	1.22	0.37	0.70	0.46	0.37	0.39	0.46	0.40
	60°C (60°F)		%	—	1.18	0.70	—	0.91	1.29	—	2.94	1.43	0.87	1.18	1.01	0.63	0.72	0.87	0.50
	125°C (257°F)		%	—	1.65	1.14	0.81	2.50	1.80	—	—	2.84	1.59	2.99	1.86	1.39	1.48	1.83	1.20
	Heat Deflection Temp.	ASTM																	
	1.8 MPa	D648	°C	210	224	226	229	215	211	220	207	220	222	215	224	224	220	200	225
	(264 psi)		°F	410	435	440	445	420	412	428	405	428	432	420	435	435	428	392	437
	0.46 MPa		°C	240	247	248	246	241	241	240	235	246	247	244	246	247	245	237	250
	(66 psi)		°F	465	477	478	475	466	466	465	454	475	477	471	475	477	473	459	482

(continued)

[1] These values are for natural color (NC010) resins only (except 940 BK505). Colorants or other additives may alter some or all of these properties. The data listed here fall within the normal range of product properties, but they should not be used to establish specification limits nor used alone as the basis of design.

Table 2
Typical Properties of Rynite® PET *(continued)*

	Property[1]	Method	Unit	General-Purpose Rynite® 520	Rynite® 530	Rynite® 545	Rynite® 555	Low Warp Rynite® 935	Rynite® 940	Toughened Rynite® 408	Rynite® 415HP	Rynite® SST 35	Flame-Retardant Rynite® FR330	Rynite® FR515	Rynite® FR530	Rynite® FR543	Rynite® FR943	Rynite® FR945	Rynite® FR946
Toughness	Unnotched Impact Strength	ASTM D4812																	
	–40°C		**J/m**	**385**	**750**	**800**	**585**	**280**	**415**	**960**	**640**	**1,070**	**535**	**350**	**535**	**510**	**385**	**285**	**375**
	–40°F		ft lb/in	7.2	14	15	11	5.2	7.8	18	12	20	10	6.6	10	9.5	7.2	5.3	7.0
	23°C		**J/m**	**510**	**960**	**1,000**	**855**	**425**	**530**	**960**	**855**	**1,200**	**695**	**530**	**585**	**750**	**480**	**375**	**375**
	73°F		ft lb/in	9.5	18	19	16	8.0	9.9	18	16	23	13	9.9	11	14	9.0	7.0	7.0
	Izod Impact Strength	ASTM D256																	
	–40°C		**J/m**	**53**	**96**	**123**	**107**	**43**	**69**	**101**	**69**	**160**	**85**	**59**	**80**	**91**	**53**	**43**	**37**
	–40°F		ft lb/in	1.0	1.8	2.3	2.0	0.8	1.3	1.9	1.3	3	1.6	1.1	1.5	1.7	1.0	0.8	0.7
	23°C		**J/m**	**69**	**101**	**117**	**107**	**64**	**75**	**133**	**133**	**235**	**91**	**69**	**91**	**96**	**64**	**48**	**48**
	73°F		ft lb/in	1.3	1.9	2.2	2.0	1.2	1.4	2.5	2.5	4.4	1.7	1.3	1.7	1.8	1.2	0.9	0.9
	Fatigue Endurance at 10^6 Cycles	ASTM D671	**MPa**	—	**40.7**	**51.0**	**53.8**	**33.1**	**42.7**	**34.5**	**20.7**	**26.9**	**41.3**	**44.1**	**41.3**	**50.2**	**45.0**	**38.0**	**37.2**
			kpsi	—	5.9	7.4	7.8	4.8	6.2	5.0	3.0	3.9	6.0	6.4	6.0	7.3	6.5	5.5	5.4
Thermal	Melting Point	DSC	**°C**	**254**	**254**	**254**	**254**	**252**	**250**	**254**	**250**	**250**	**254**	**254**	**254**	**254**	**250**	**250**	**254**
			°F	489	489	489	490	485	482	489	482	482	489	489	489	489	482	482	489
	Coeff. of Linear Thermal Expansion Flow Direction	ASTM E831																	
	–40° to 23°C		**10^{-4} mm/mm/°C**	**0.31**	**0.22**	**0.18**	**0.13**	**0.26**	**0.22**	**0.24**	**0.40**	**0.21**	**0.21**	**0.33**	**0.22**	**0.16**	**0.21**	**0.17**	**0.19**
	–40° to 73°F		10^{-4} in/in/°F	0.17	0.12	0.10	0.07	0.14	0.12	0.13	0.22	0.12	0.12	0.18	0.12	0.09	0.12	0.09	0.11
	22 to 55°C		**10^{-4} mm/mm/°C**	**0.25**	**0.10**	**0.13**	**0.08**	**0.16**	**0.15**	**0.14**	**0.20**	**0.06**	**0.16**	**0.18**	**0.19**	**0.11**	**0.19**	**0.13**	**0.14**
	73 to 131°F		10^{-4} in/in/°F	0.14	0.06	0.07	0.04	0.09	0.08	0.08	0.11	0.03	0.09	0.10	0.11	0.06	0.11	0.07	0.08
	55 to 160°C		**10^{-4} mm/mm/°C**	**0.11**	**0.04**	**0.05**	**0.01**	**0.14**	**0.06**	**0.08**	**0.32**	**0.13**	**0.06**	**0.12**	**0.10**	**0.07**	**0.06**	**0.03**	**0.07**
	131 to 320°F		10^{-4} in/in/°F	0.06	0.02	0.03	0.01	0.08	0.03	0.04	0.18	0.07	0.03	0.07	0.06	0.04	0.03	0.02	0.04
	Cross Flow	ASTM E831																	
	–40° to 23°C		**10^{-4} mm/mm/°C**	**0.72**	**0.67**	**0.54**	**0.54**	**0.53**	**0.54**	**0.85**	**0.98**	**1.13**	**0.62**	**0.70**	**0.68**	**0.55**	**0.51**	**0.49**	**0.35**
	–40° to 73°F		10^{-4} in/in/°F	0.40	0.37	0.30	0.30	0.29	0.30	0.47	0.54	0.63	0.34	0.39	0.38	0.31	0.28	0.27	0.19
	23 to 55°C		**10^{-4} mm/mm/°C**	**0.93**	**0.81**	**0.71**	**0.75**	**0.52**	**0.60**	**0.85**	**1.17**	**1.26**	**0.76**	**0.88**	**0.92**	**0.79**	**0.65**	**0.65**	**0.36**
	73 to 131°F		10^{-4} in/in/°F	0.52	0.45	0.39	0.42	0.29	0.33	0.47	0.65	0.70	0.42	0.49	0.51	0.44	0.36	0.36	0.20
	55 to 160°C		**10^{-4} mm/mm/°C**	**0.90**	**1.07**	**0.95**	**0.95**	**0.81**	**0.84**	**0.92**	**1.09**	**1.12**	**0.72**	**1.05**	**0.98**	**0.96**	**0.84**	**0.82**	**0.59**
	131 to 320°F		10^{-4} in/in/°F	0.50	0.59	0.53	0.53	0.45	0.47	0.51	0.61	0.62	0.40	0.58	0.54	0.53	0.47	0.46	0.33
	Thermal Conductivity	ASTM C177	**W/m K**	—	**0.29**	**0.32**	**0.33**	**0.26**	—	—	**0.26**	—	**0.25**	**0.23**	**0.25**	**0.22**	**0.31**	**0.24**	**0.37**
			Btu/hr/ft²/°F/in	—	2.0	2.2	2.3	1.8	—	—	1.8	—	1.7	1.6	1.7	1.49	2.3	1.65	2.6
Electrical	Volume Resistivity	ASTM D257	ohm·cm	—	10^{15}	10^{15}	—	10^{15}	10^{15}	10^{15}	10^{13}	10^{14}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}
	Surface Resistivity	ASTM D257	ohm/Sq	—	10^{14}	10^{14}	—	10^{14}	10^{14}	10^{14}	10^{13}	10^{13}	10^{13}	10^{13}	10^{14}	10^{13}	10^{13}	10^{13}	10^{14}
	Dielectric Strength, 500 V/s, Short Time in Oil	ASTM D149																	
	1.59 mm at 23°C		**kV/mm**	**25.0**	**25.5**	**24.5**	**24.5**	**29.5**	**23.0**	**26.5**	**24.0**	**25.5**	**25.0**	**26.0**	**25.0**	**23.5**	**25.0**	**24.5**	**24.5**
	1⁄16 in disk at 73°F		V/mil	635	650	620	620	750	585	675	610	650	635	660	635	600	635	620	620
	1.59 mm at 95°C		**kV/mm**	**22.5**	**22.5**	**22.5**	**22.5**	**25.5**	**19.0**	**24.0**	**15.5**	**16.0**	**23.5**	**26.5**	**23.5**	**21.5**	**23.0**	**23.0**	**24.5**
	1⁄16 in disk at 203°F		V/mil	570	570	570	570	650	485	610	395	405	600	675	600	550	585	585	620
	1.59 mm at 150°C		**kV/mm**	**14.5**	**15.5**	**16.0**	**16.5**	**14.5**	**15.0**	**14.5**	**8.5**	**9.5**	**13.0**	**13.0**	**13.0**	**13.5**	**12.0**	**13.0**	**22.0**
	1⁄16 in disk at 300°F		V/mil	375	395	405	420	375	380	375	215	240	330	330	330	340	300		
	3.18 mm at 23°C		**kV/mm**	**20.0**	**20.5**	**20.0**	**20.0**	**23.5**	**16.5**	**21.5**	**18.0**	**19.5**	**18.0**	**18.5**	**18.0**	**17.0**	**18.0**	330 **17.0**	560 **18.0**
	1⁄8 in disk at 73°F		V/mil	510	520	510	510	600	415	550	460	495	460	470	460	430	460	430	460
	3.18 mm at 95°C		**kV/mm**	**17.5**	**16.5**	**17.5**	**17.0**	**19.5**	**14.0**	**17.5**	**11.0**	**10.5**	**18.0**	**22.0**	**18.0**	**16.0**	**18.0**	**17.5**	**20.5**
	1⁄8 in disk at 203°F		V/mil	445	420	445	430	495	355	445	280	270	460	560	460	405	460	445	520
	3.18 mm at 150°C		**kV/mm**	**11.5**	**12.0**	**12.5**	**12.5**	**12.0**	**10.5**	**12.0**	**6.5**	**7.5**	**9.0**	**11.0**	**9.0**	**12.0**	**10.5**	**10.5**	**17.0**
	1⁄8 in disk at 300°F		V/mil	295	300	320	320	300	265	300	170	190	230	280	230	300	265	265	430
	Step by Step																		
	3.18 mm at 23°C	—	**kV/mm**	—	**17.5**	**17.5**	—	**21.0**	**19.0**	—	**16.5**	**17.0**	**16.0**	**17.0**	**14.0**	**15.0**	**17.0**	**15.0**	**15.5**
	1⁄8 in disk at 73°F		V/mil	—	445	445	—	530	485	—	420	430	405	430	355	380	430	380	395
	Dielectric Constant	ASTM D150																	
	10^3 Hz			**3.2**	**3.6**	**4.0**	—	**3.8**	**3.8**	**3.4**	**3.9**	—	**3.3**	**3.1**	**3.8**	**4.1**	**4.1**	**4.1**	**3.7**
	10^6 Hz			3.0	3.5	3.9	—	3.7	3.7	3.3	3.7	4.1	3.3	3.0	3.7	4.1	4.1	4.0	3.6
	Dissipation Factor	ASTM D150																	
	10^3 Hz			**0.010**	**0.005**	**0.005**	—	**0.008**	**0.007**	**0.010**	**0.019**	—	**0.005**	**0.004**	**0.011**	**0.009**	**0.010**	**0.009**	**0.007**
	10^6 Hz			0.015	0.012	0.011	—	0.010	0.015	0.015	0.022	0.023	0.014	0.015	0.018	0.017	0.015	0.017	0.014
	Arc Resistance	ASTM D495	S	300–360	120–180	120–180	120–180	120–180	—	—	60–120	—	60–120	0–60	60–120	120–180	60–120	120–180	60–120

(continued)

[1] These values are for natural color (NC010) resins only only (except 940 BK505). Colorants or other additives may alter some or all of these properties. The data listed here fall within the normal range of product properties, but they should not be used to establish specification limits nor used alone as the basis of design.

Table 2
Typical Properties of Rynite® PET *(continued)*

	Property[1]	Method	Unit	General-Purpose				Low Warp		Toughened			Flame-Retardant						
				Rynite® 520	Rynite® 530	Rynite® 545	Rynite® 555	Rynite® 935	Rynite® 940	Rynite® 408	Rynite® 415HP	Rynite® SST 35	Rynite® FR330	Rynite® FR515	Rynite® FR530	Rynite® FR543	Rynite® FR943	Rynite® FR945	Rynite® FR946
Flammability	UL Flammability[2,3]	UL-94		HB	HB	HB	HB	HB	HB	HB	HB	HB	V-0 at 0.86 mm 1/32 in 5V at 1.57 mm 1/16 in	V-0 at 0.81 mm 1/32 in 5V at 1.57 mm 1/16 in	V-0 at 0.35 mm 1/64 in 5V at 1.57 mm 1/16 in	V-0 at 0.80 mm 1/32 in	V-0 at 0.35 mm 1/64 in 5V at 1.57 mm 1/16 in	V-0 at 0.80 mm 1/32 in	V-0 at 0.80 mm 1/32 in
Flammability	Oxygen Index	ASTM D2863	% O_2	—	20	20	—	—	—	—	19	—	29	30	33	35	31	33	35
Flammability	High-Current Arc Ignition	—	No. of arcs	60–120	60–120	60–120	60–120	60–120	—	30–160	>120	>120	60–120	60–120	60–120	60–120	30–60	60–120	15–30
Flammability	High-Voltage Arc Tracking	—	mm/min	80–150	25–80	10–25	10–25	10–25	—	0–10	25–80	80–150	80–150	>150	10–25	10–25	10–25	10–25	10–25
Flammability	Hot Wire Ignition	UL-746A	S	>120	>120	>120	>120	>120	—	>120	>120	60–120	>120	>120	>120	>120	>120	>120	>120
Flammability	Comparative Tracking Index	—	V	175–250	250–400	250–400	175–250	250–400	—	250–400	250–400	400–600	175–250	175–250	250–400	175–250	250–400	250–400	175–250
Temp. Indexing	Electrical	UL-746B	°C	140	140	140	140	140	—	140	140	150	140	140	150	155	155	150	150
Temp. Indexing	Mechanical w/Impact	UL-746B	°C	140	140	140	140	140	—	140	120	150	140	140	150	155	155	150	150
Temp. Indexing	Mechanical w/o Impact	UL-746B	°C	140	140	140	140	140	—	140	140	150	140	140	150	155	155	150	150
Miscellaneous	Specific Gravity	ASTM D792		1.47	1.56	1.70	1.81	1.58	1.64	1.51	1.39	1.52	1.65	1.55	1.67	1.79	1.79	1.85	1.84
Miscellaneous	Water Absorption 24 hr at 23°C (73°F)	ASTM D570	%	—	0.05	0.04	0.04	0.05	0.05	0.06	0.24	0.25	0.07	0.07	0.05	0.06	0.04	0.05	0.04
Miscellaneous	Poisson's			0.40	0.41	0.39	0.37	0.38	0.36	0.45	0.49	0.49	0.40	0.41	0.40	0.38	0.35	0.38	0.33
Miscellaneous	Hardness, Rockwell M	ASTM D785		90	95	95	100	75	75	70	55	50	95	95	95	95	95	95	95
Miscellaneous	R			120	120	120	120	115	115	115	110	105	120	120	120	120	120	120	120
Miscellaneous	Coefficient of Friction Against Self	ASTM D1894		—	0.18	0.17	0.27	0.21	—	—	0.42	—	0.24	0.21	0.18	0.18	0.29	0.20	0.27
Miscellaneous	Against Steel			—	0.17	0.20	0.18	0.19	—	—	0.27	—	0.18	0.18	0.19	0.16	0.18	0.20	0.18
Miscellaneous	Taber Abrasion CS-17 Wheel, 1,000 g	—	mg/1,000 cycles	—	30	44	—	—	81	—	35	82	88	88	38	69	82	81	74
Miscellaneous	Mold Shrinkage[4] for 3.18 mm (1/8 in) 104°C (220°F) Mold Flow	—	%	0.35	0.25	0.20	0.20	0.35	0.30	0.20	0.40	0.25	0.25	0.50	0.25	0.20	0.35	0.35	0.25
Miscellaneous	Transverse		%	0.90	0.80	0.75	0.70	0.65	0.70	0.75	0.95	0.85	0.75	0.95	0.75	0.65	0.70	0.70	0.45
Miscellaneous	Mold Shrinkage[4] for 1.57 mm (1/16 in) 104°C (220°F) Mold Flow	—	%	0.23	0.18	0.15	0.13	0.28	0.17	0.21	0.24	0.13	0.16	0.34	0.16	0.13	0.22	0.22	0.20
Miscellaneous	Transverse		%	0.82	0.78	0.67	0.66	0.52	0.55	0.63	0.67	0.59	0.69	0.69	0.68	0.48	0.57	0.71	0.40
Processing	Melt Temperature Range	—	**°C**	**280–300**	**280–300**	**280–300**	**280–300**	**280–300**	**280–300**	**270–290**	**270–290**	**270–290**	**270–290**	**270–290**	**270–290**	**270–290**	**270–290**	**270–290**	**270–290**
Processing		—	°F	535–570	535–570	535–570	535–570	535–570	535–570	520–555	520–555	520–555	520–555	520–555	520–555	520–555	520–555	520–555	520–555
Processing	Mold Temperature Range	—	**°C**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**	**>95**
Processing		—	°F	>205	>205	>205	>205	>205	>205	>205	>205	>205	>205	>205	>205	>205	>205	>205	>205
Processing	Drying Time, Dehumidifed Dryer	—	h	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Processing	Drying Temperature	—	**°C**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**
Processing		—	°F	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Processing	Processing Moisture Content	—	%	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Chemical	Acid Resistance	Good at room temperature. Attacked by strong and weak acids at elevated temperatures.																	
Chemical	Base Resistance	Good at room temperature. Attacked by strong and weak bases at elevated temperatures.																	
Chemical	Solvent Resistance	Excellent resistance to wide variety of fluids such as gasoline, motor oil, transmission fluid, hydrocarbons, and organic solvents. Some absorption by ketones and esters causes plasticization and small dimensional changes.																	

[1] These values are for natural color (NC010) resins only (except for 940 BK505). Colorants or other additives may alter some or all of these properties. The data listed here fall within the normal range of product properties, but they should not be used to establish specification limits nor used alone as the basis of design.

[2] Based on specimens 0.8 mm (1/32 in) thick unless otherwise stated.

[3] This small test does not indicate combustion characteristics under actual fire conditions.

[4] 76.2 × 127 × 3.18 mm (3 in × 5 in × 1/8 in) end-gated plaques and 76.2 × 127 × 1.6 mm (3 in × 5 in × 1/16 in) end-gated plaques.

Chapter 2

Mechanical Properties

Tensile Strength

Rynite® PET thermoplastic polyester resins exhibit high tensile strength over a wide temperature range. Stress-strain data for various Rynite® PET thermoplastic polyester resins at temperatures from –40 to 150°C (–40 to 300°F) are shown in **Figures 1** through **15**. For all Rynite® PET thermoplastic polyester resins, the pull rate for tensile testing is 5 mm (0.2 in)/min. Before testing, sample bars are conditioned for a minimum of 40 hr at 23°C (73°F) and 50% RH. Conditioning reduces the tensile strength by about 5% from the values obtained on bars tested without conditioning.

Figure 1. Rynite® 520 NC010 Stress-Strain Curves

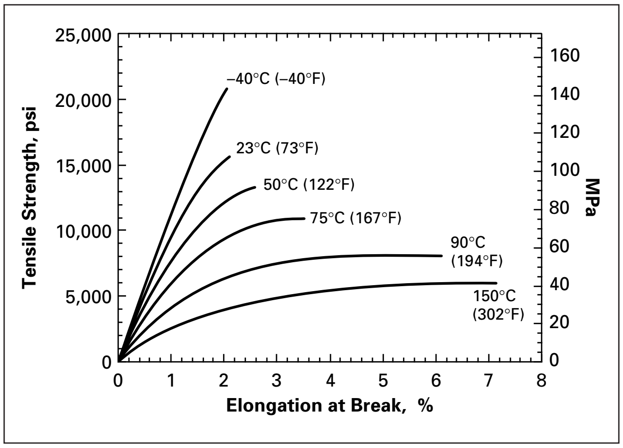


Figure 2. Rynite® 530 NC010 Stress-Strain Curves

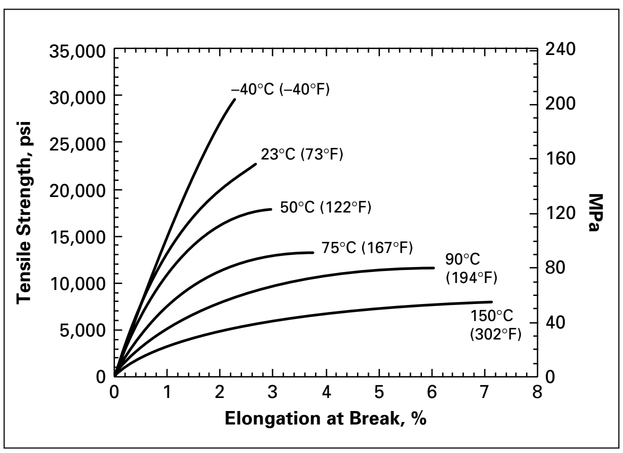


Figure 3. Rynite® 545 NC010 Stress-Strain Curves

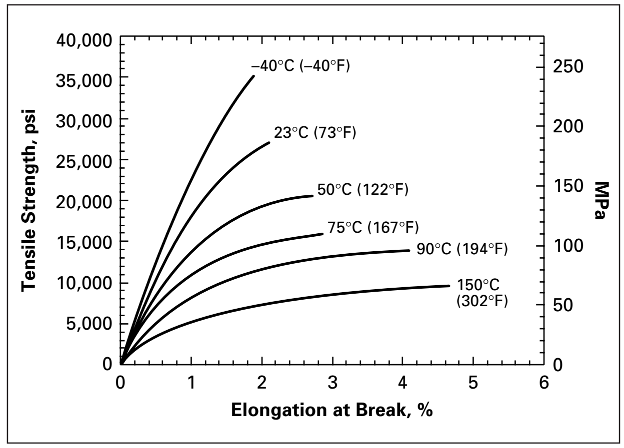


Figure 4. Rynite® 555 NC010 Stress-Strain Curves

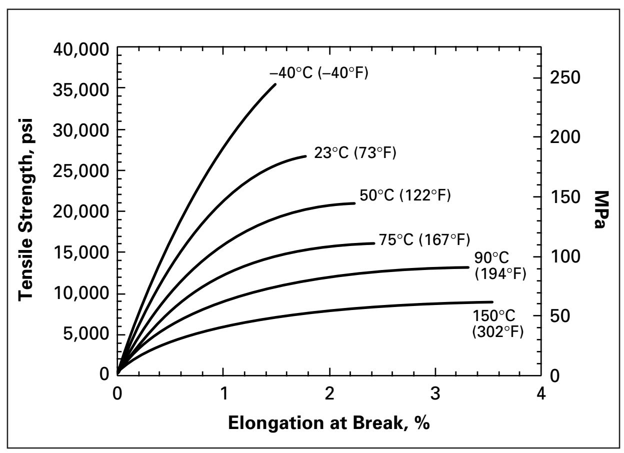


Figure 5. Rynite® 935 NC010 Stress-Strain Curves

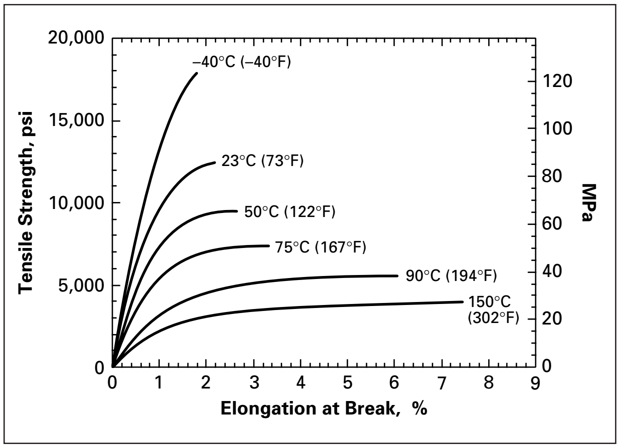


Figure 8. Rynite® 415HP NC010 Stress-Strain Curves

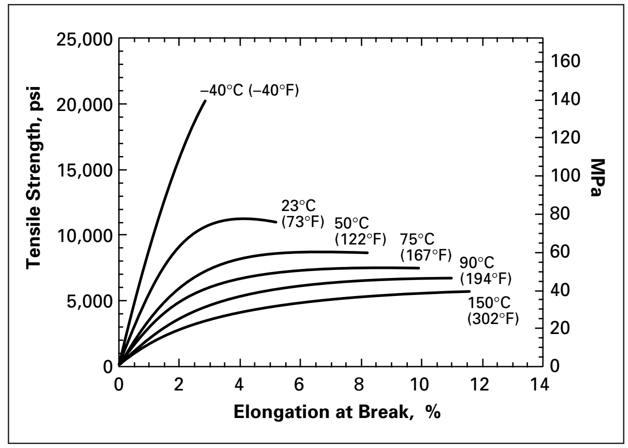


Figure 6. Rynite® 940 BK505 Stress-Strain Curves

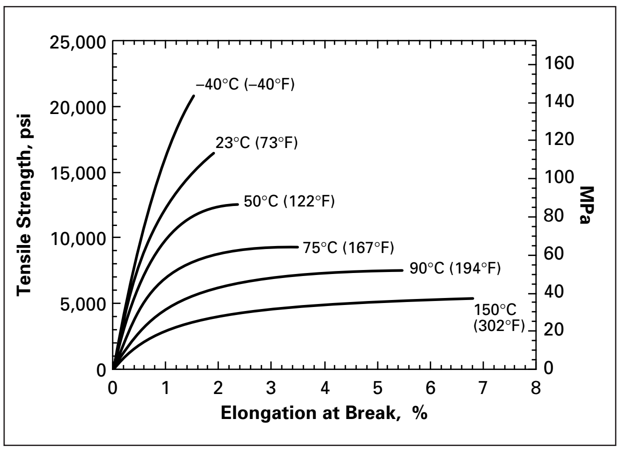


Figure 9. Rynite® SST 35 NC010 Stress-Strain Curves

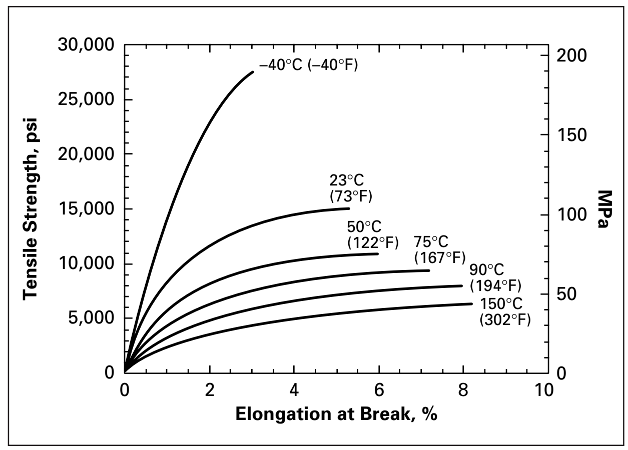


Figure 7. Rynite® 408 NC010 Stress-Strain Curves

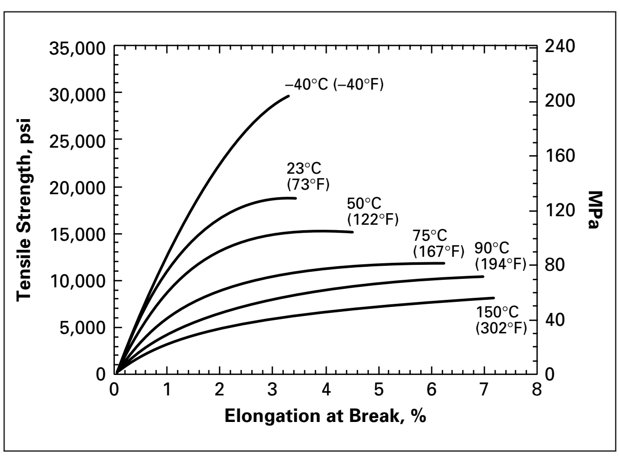


Figure 10. Rynite® FR515 NC010 Stress-Strain Curves

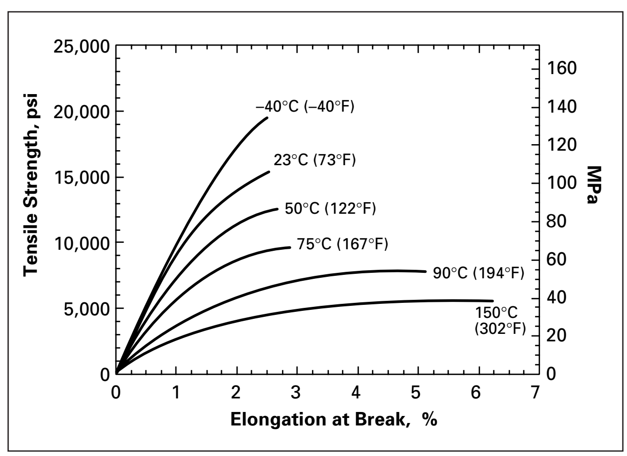


Figure 11. Rynite® FR530 NC010 Stress-Strain Curves

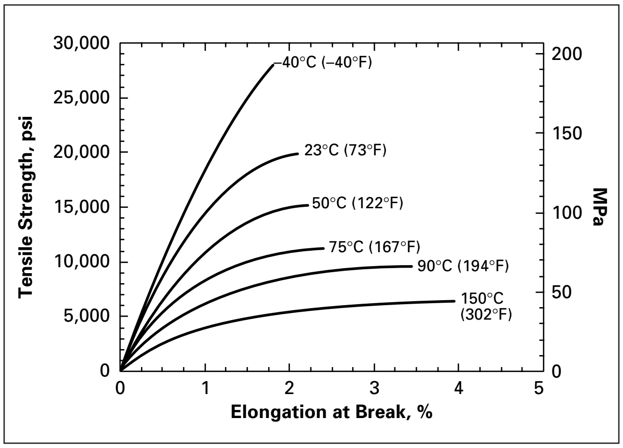


Figure 14. Rynite® FR945 NC010 Stress-Strain Curves

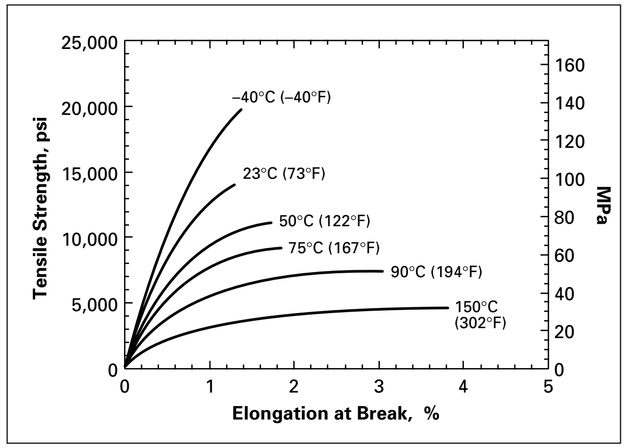


Figure 12. Rynite® FR543 NC010 Stress-Strain Curves

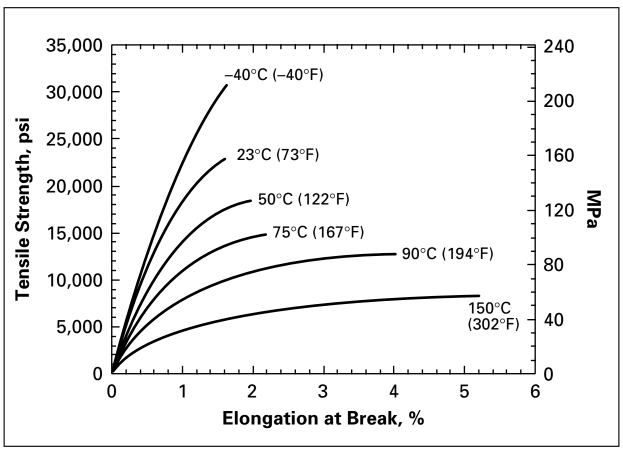


Figure 15. Rynite® FR946 NC010 Stress-Strain Curves

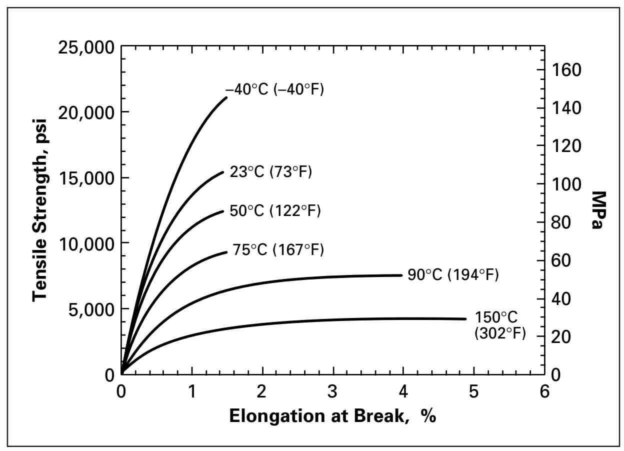
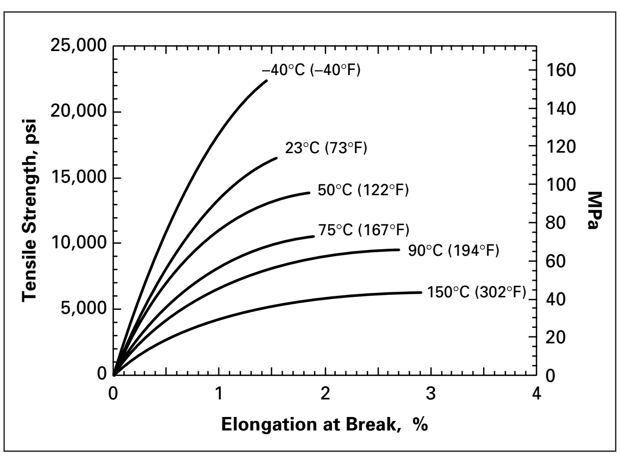


Figure 13. Rynite® FR943 NC010 Stress-Strain Curves



Flexural Modulus

The effect of temperature on the flexural modulus of Rynite® PET thermoplastic polyester resins is shown in **Figures 16** through **20**. As with all other physical tests performed on Rynite® PET thermoplastic polyester resins, samples are conditioned a minimum of 40 hr at 23°C (73°F) and 50% RH before testing.

Figure 16. Flexural Modulus versus Temperature

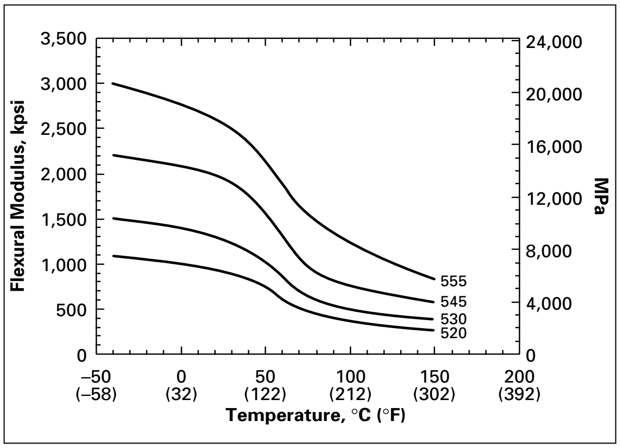


Figure 17. Flexural Modulus versus Temperature

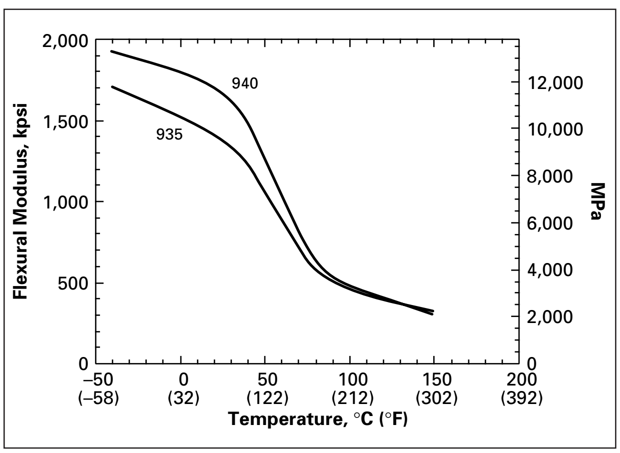


Figure 18. Flexural Modulus versus Temperature

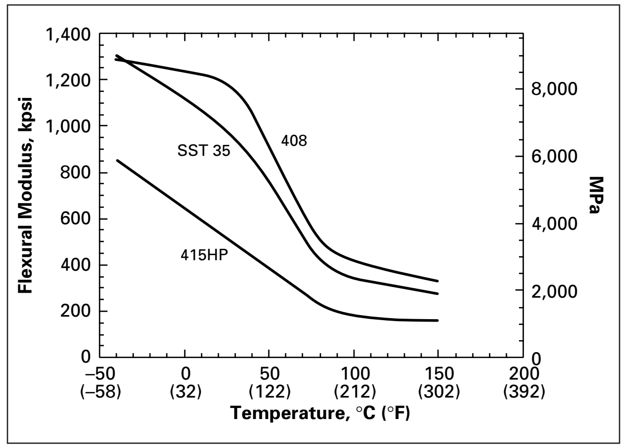


Figure 19. Flexural Modulus versus Temperature

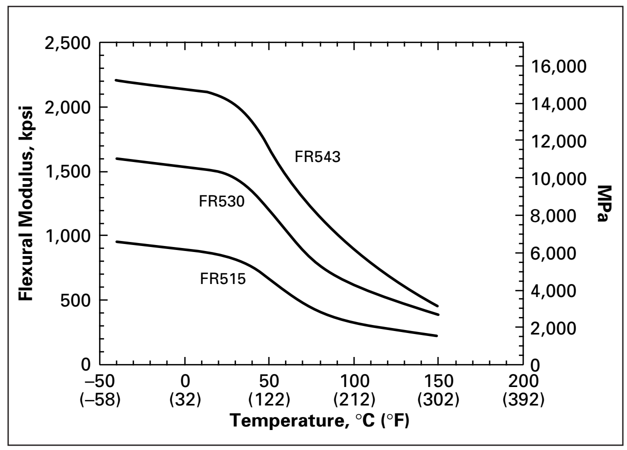
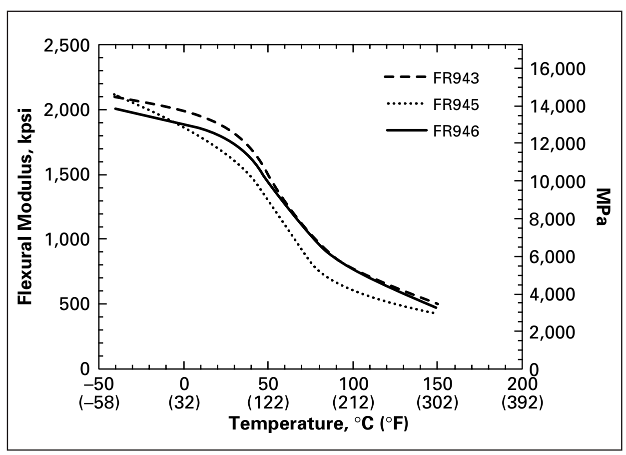


Figure 20. Flexural Modulus versus Temperature



Flexural Creep

Deformation under load with time is called creep. The amount of creep depends on composition (type of plastic, fillers, etc.), time, temperature, the applied stress level, and molding conditions. For Rynite® PET thermoplastic polyester resins, creep is decreased as crystallinity of the sample increases. Maximum resin crystallinity in a part is achieved by using a hot (≥93°C [200°F]) mold. The creep characteristics of Rynite® PET thermoplastic polyester resins molded in hot molds (≥93°C [200°F]) are shown in **Figures 21** through **50**. These data, determined according to ASTM D2990, indicate that Rynite® PET thermoplastic polyester resins have good resistance to creep at high temperatures and stress levels.

Figure 21. Rynite® 530 Flexural Creep at 27.6 MPa (4,000 psi) Stress

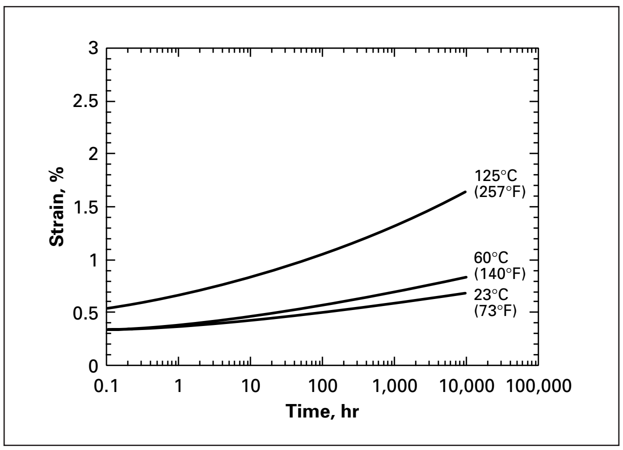


Figure 22. Rynite® 545 Flexural Creep at 27.6 MPa (4,000 psi) Stress

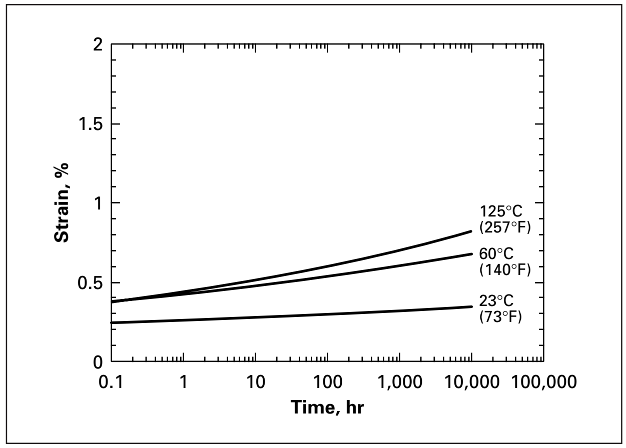


Figure 23. Rynite® 555 Flexural Creep at 6.9 MPa (1,000 psi) Stress

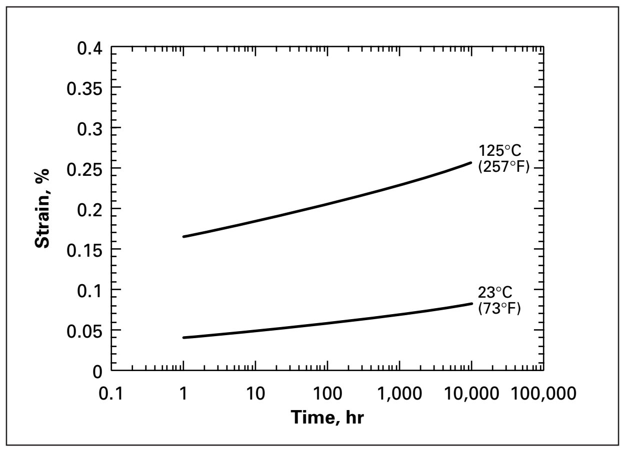


Figure 24. Rynite® 555 Flexural Creep at 13.8 MPa (2,000 psi) Stress

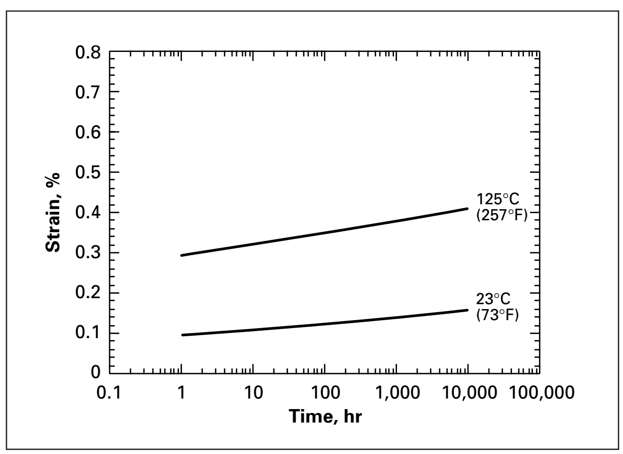


Figure 25. Rynite® 555 Flexural Creep at 27.6 MPa (4,000 psi) Stress

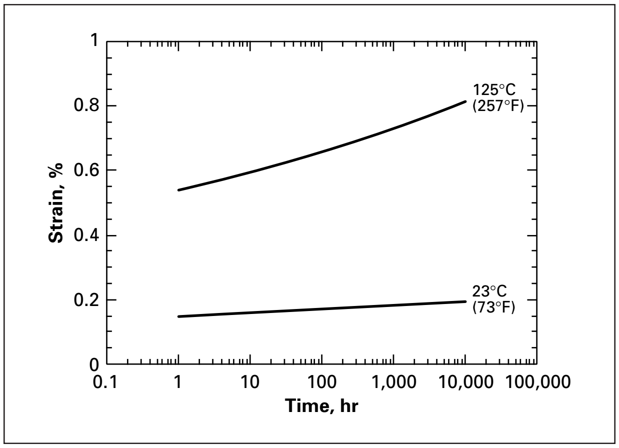


Figure 26. Rynite® 935 Flexural Creep at 6.9 MPa (1,000 psi) Stress

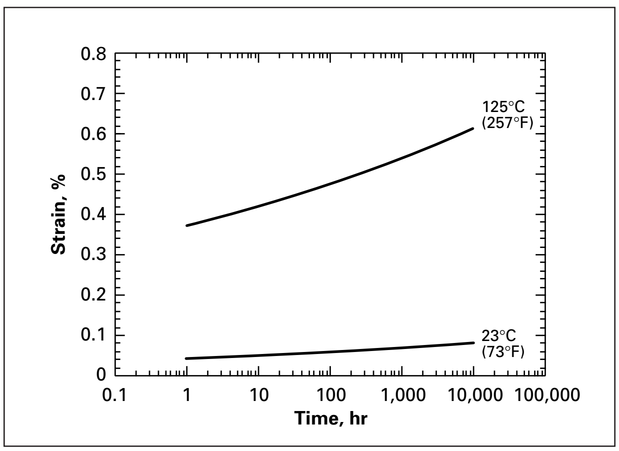


Figure 27. Rynite® 935 Flexural Creep at 13.8 MPa (2,000 psi) Stress

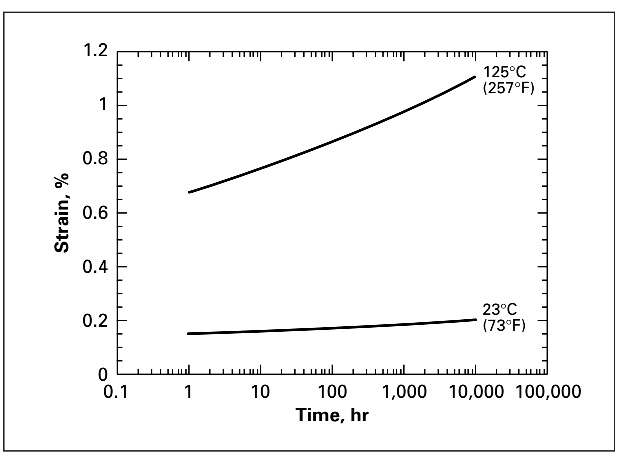


Figure 28. Rynite® 935 Flexural Creep at 27.6 MPa (4,000 psi) Stress

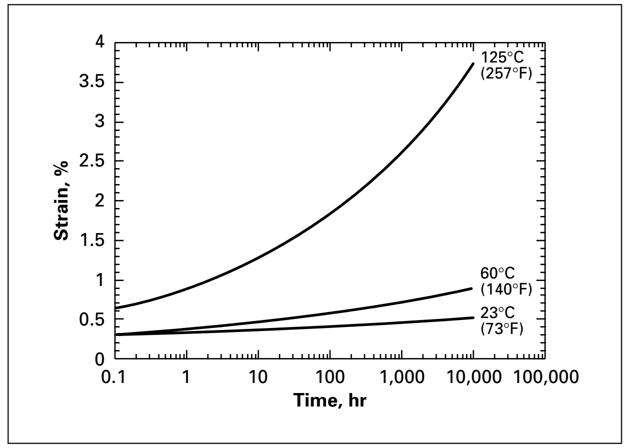


Figure 29. Rynite® 940 Flexural Creep at 27.6 MPa (4,000 psi) Stress

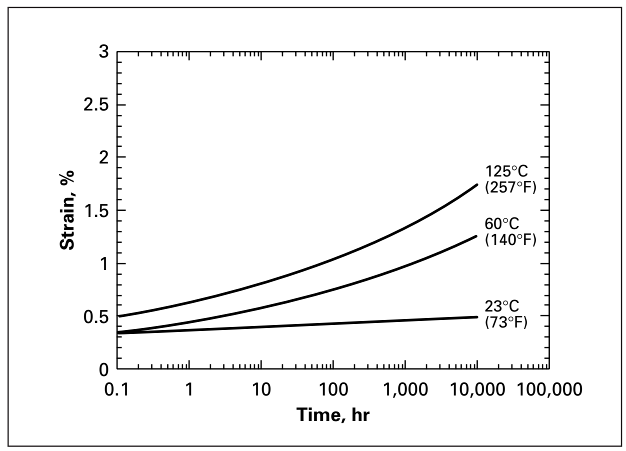


Figure 30. Rynite® 415HP Flexural Creep at 27.6 MPa (4,000 psi) Stress

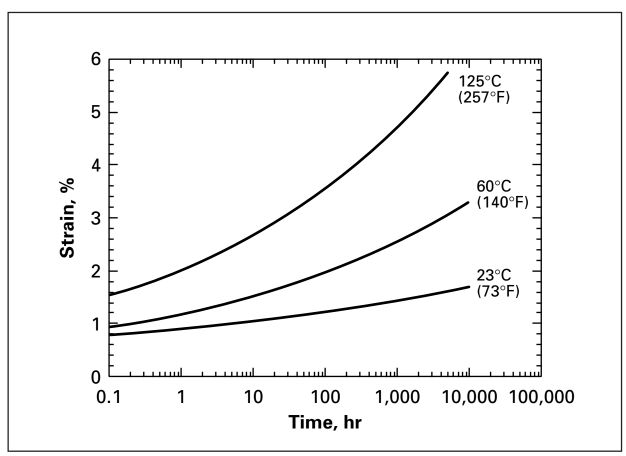


Figure 31. Rynite® SST 35 Flexural Creep at 27.6 MPa (4,000 psi) Stress

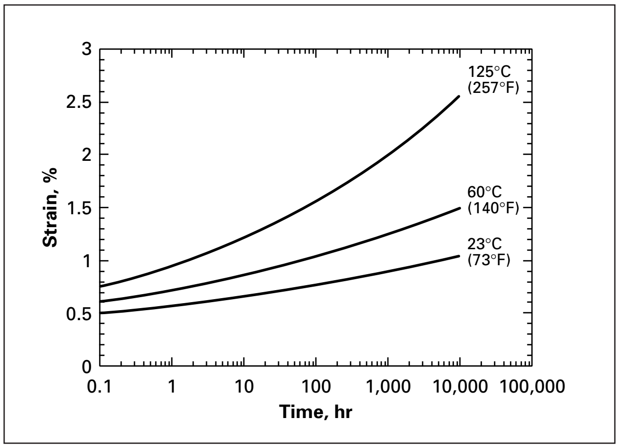


Figure 34. Rynite® FR943 Flexural Creep at 27.6 MPa (4,000 psi) Stress

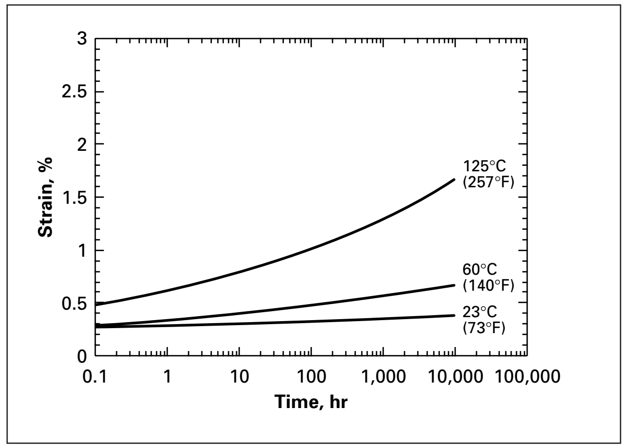


Figure 32. Rynite® FR515 Flexural Creep at 27.6 MPa (4,000 psi) Stress

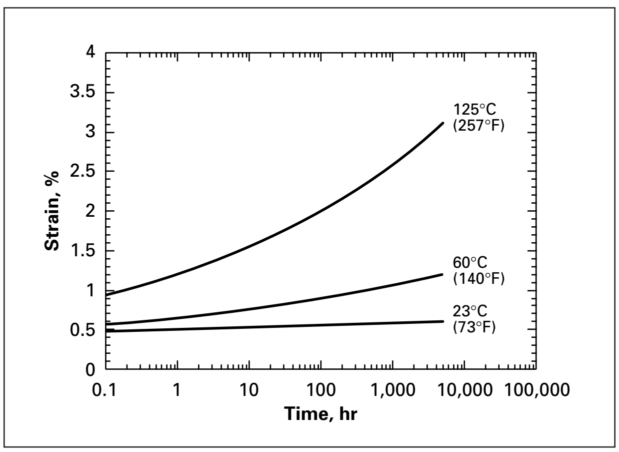


Figure 35. Rynite® FR946 Flexural Creep at 27.6 MPa (4,000 psi) Stress

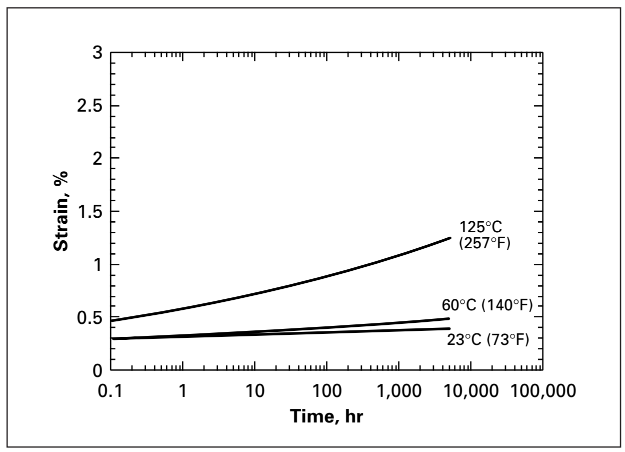


Figure 33. Rynite® FR530 Flexural Creep at 27.6 MPa (4,000 psi) Stress

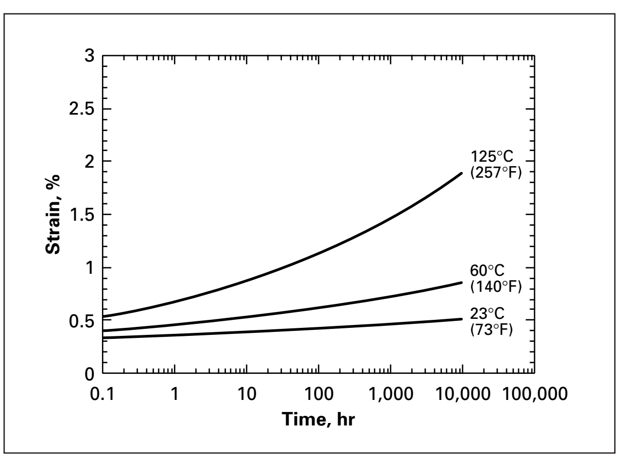


Figure 36. Rynite® 530 Flexural Creep at 27.6 MPa (4,000 psi) Stress

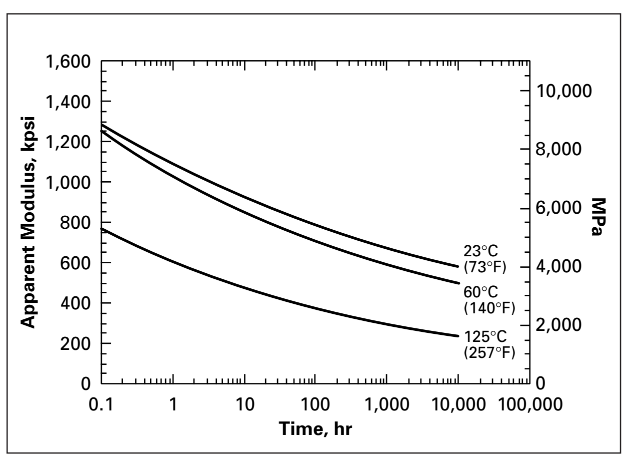


Figure 37. Rynite® 545 Flexural Creep at 27.6 MPa (4,000 psi) Stress

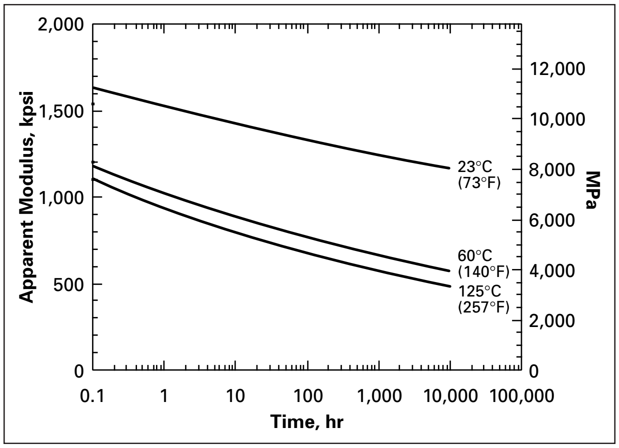


Figure 40. Rynite® 555 Flexural Creep at 27.6 MPa (4,000 psi) Stress

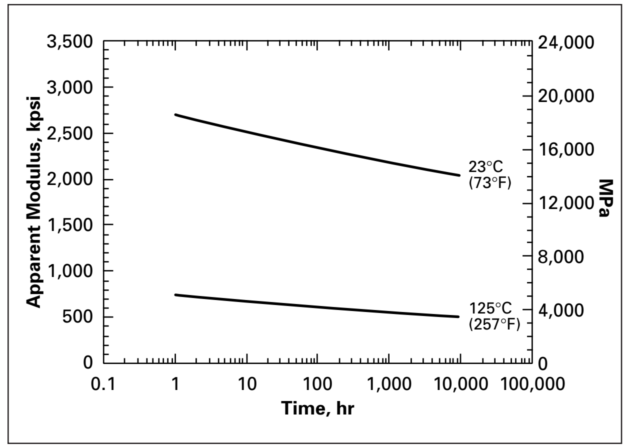


Figure 38. Rynite® 555 Flexural Creep at 6.9 MPa (1,000 psi) Stress

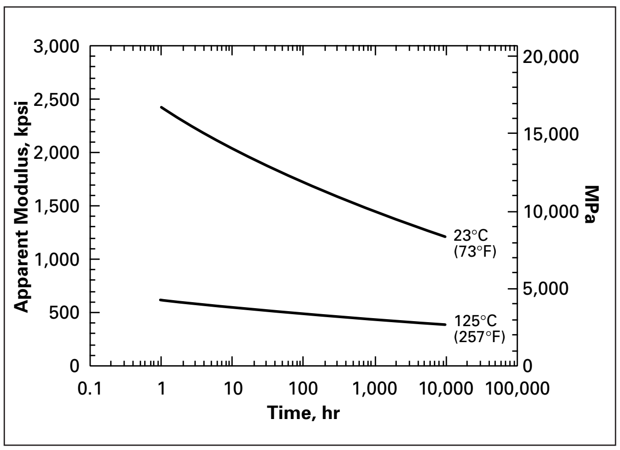


Figure 41. Rynite® 935 Flexural Creep at 6.9 MPa (1,000 psi) Stress

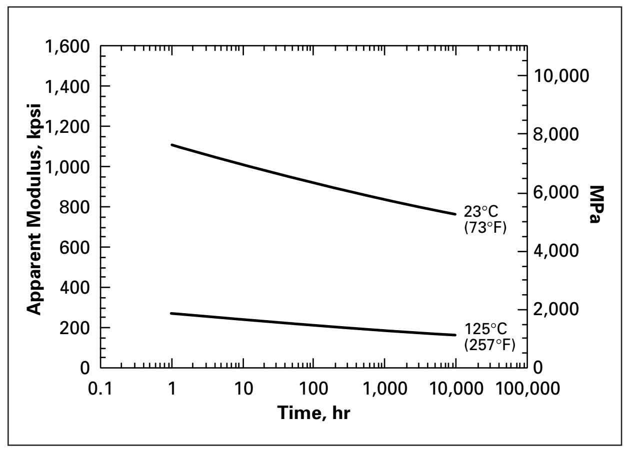


Figure 39. Rynite® 555 Flexural Creep at 13.8 MPa (2,000 psi) Stress

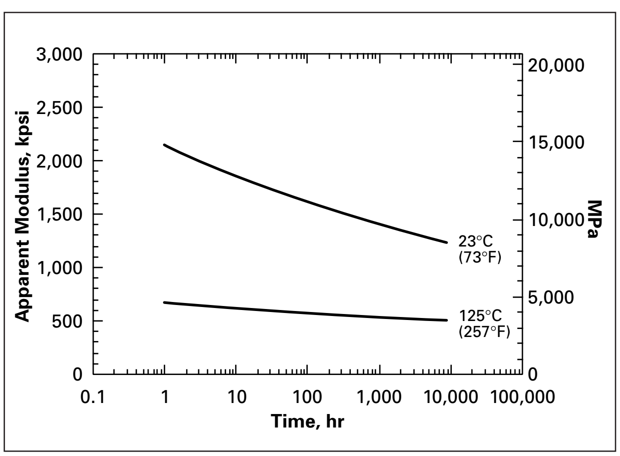


Figure 42. Rynite® 935 Flexural Creep at 13.8 MPa (2,000 psi) Stress

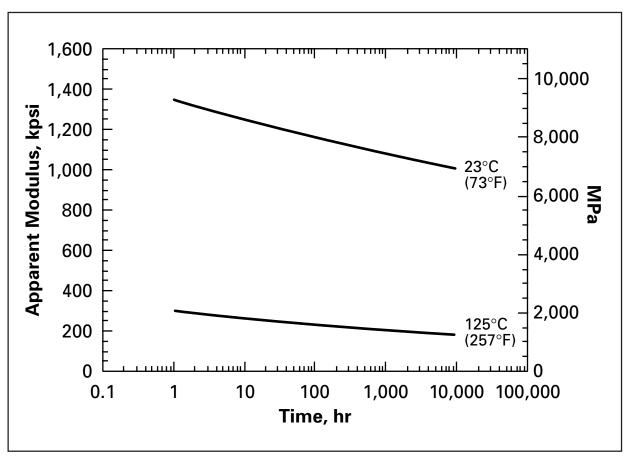


Figure 43. Rynite® 935 Flexural Creep at 27.6 MPa (4,000 psi) Stress

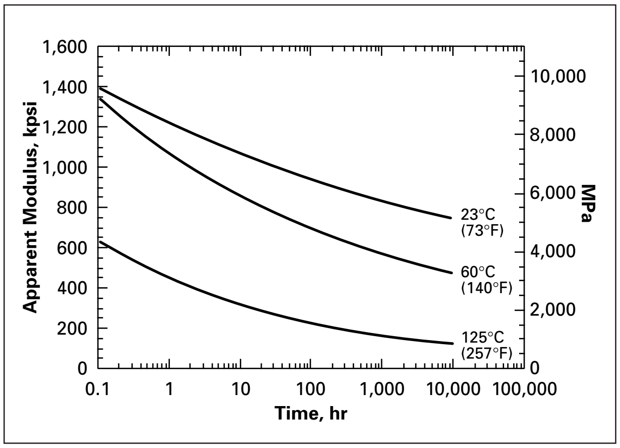


Figure 44. Rynite® 940 Flexural Creep at 27.6 MPa (4,000 psi) Stress

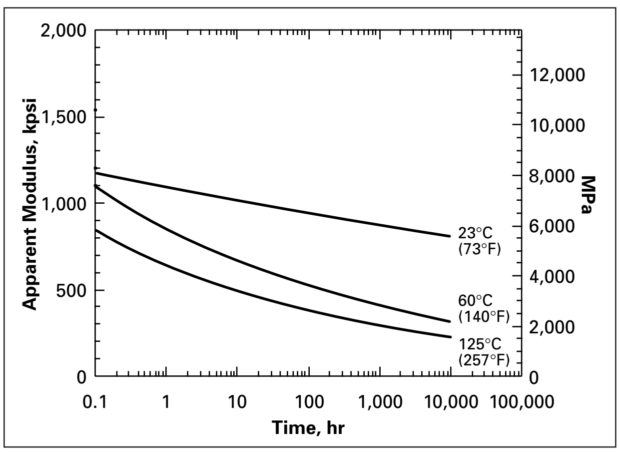


Figure 45. Rynite® 415HP Flexural Creep at 27.6 MPa (4,000 psi) Stress

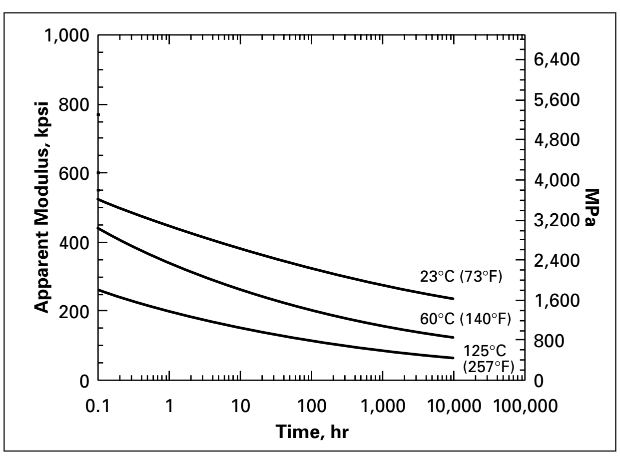


Figure 46. Rynite® SST 35 Flexural Creep at 27.6 MPa (4,000 psi) Stress

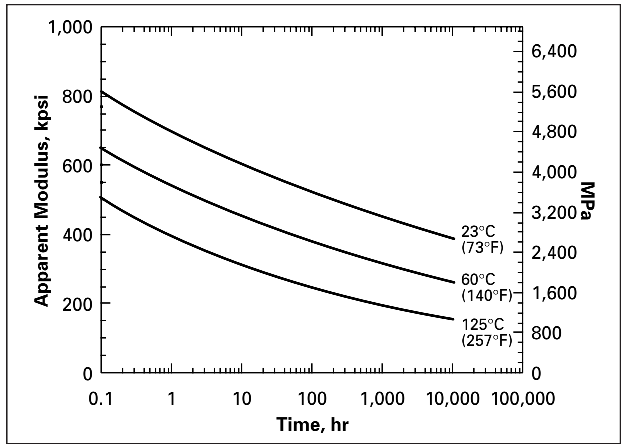


Figure 47. Rynite® FR515 Flexural Creep at 27.6 MPa (4,000 psi) Stress

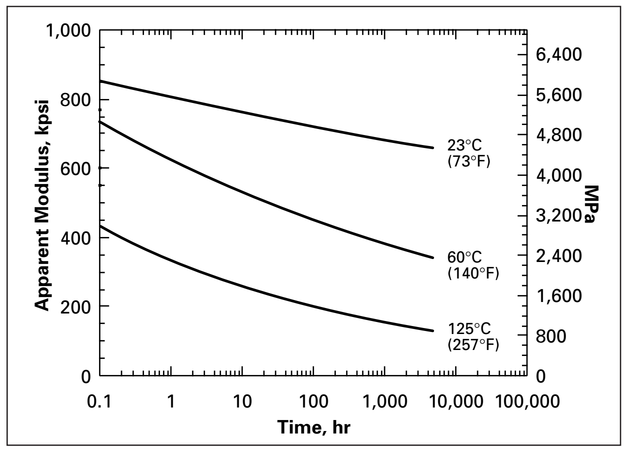


Figure 48. Rynite® FR530 Flexural Creep at 27.6 MPa (4,000 psi) Stress

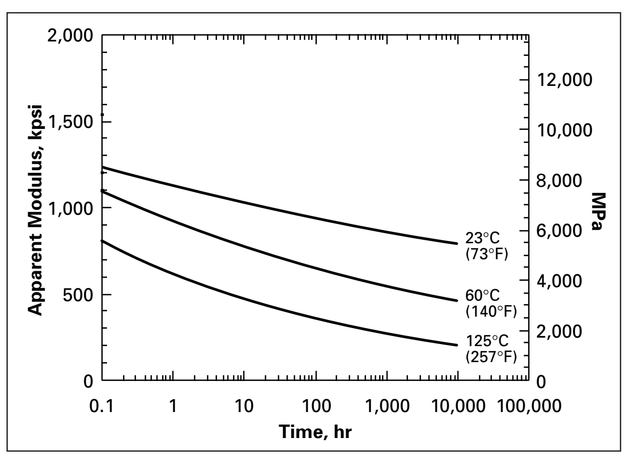


Figure 49. Rynite® FR943 Flexural Creep at 27.6 MPa (4,000 psi) Stress

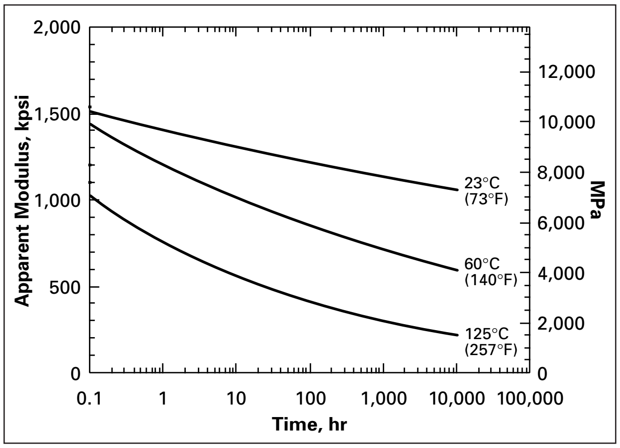
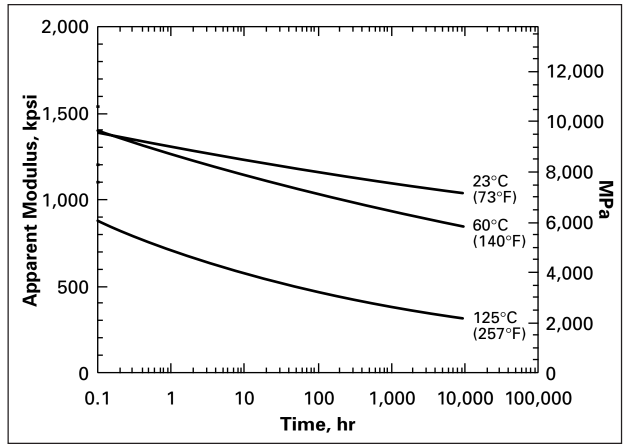


Figure 50. Rynite® FR946 Flexural Creep at 27.6 MPa (4,000 psi) Stress



Fatigue Resistance

Fatigue failure can occur in materials at stress levels below their ultimate tensile strength when they are cyclically stressed. Fatigue endurance is the cyclical stress level at which test specimens will not break up to one million cycles. Fatigue endurance is used to evaluate the life expectancy of parts subjected to cyclical stress. However, actual or simulated end-use testing of parts (at the required stress level, temperature, and environment, etc.) is the preferred way of evaluating the fatigue performance of a material for a specific application.

Rynite® PET thermoplastic polyester resin fatigue resistance properties are shown in **Figures 51** through **55**. These flexural fatigue data were determined according to ASTM D671.

Figure 51. Flexural Fatigue at 23°C (73°F)—Rynite® 530, Rynite® 545, Rynite® 555

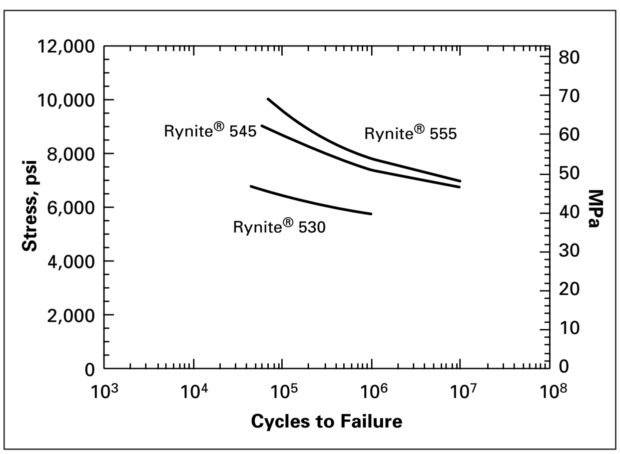


Figure 52. Flexural Fatigue at 23°C (73°F)—Rynite® 935, Rynite® 940

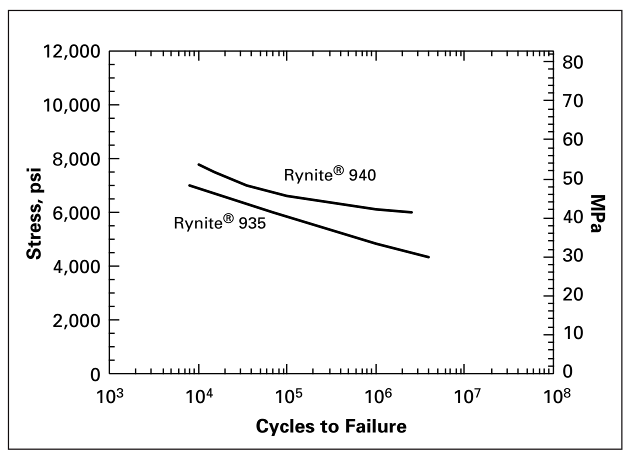


Figure 53. Flexural Fatigue at 23°C (73°F)— Rynite® 408, Rynite® 415HP, Rynite® SST 35

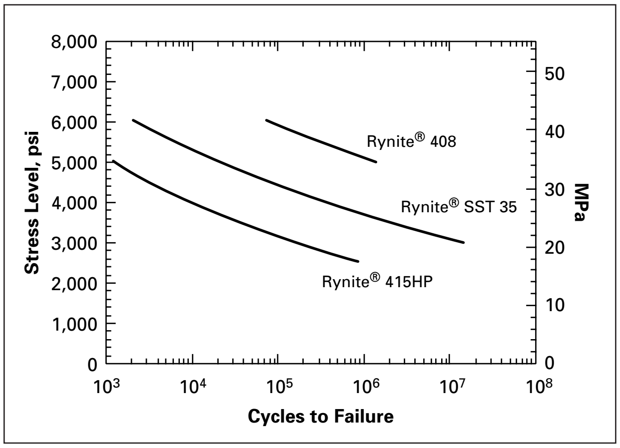


Figure 54. Flexural Fatigue at 23°C (73°F)— Rynite® FR515, Rynite® FR530, Rynite® FR543

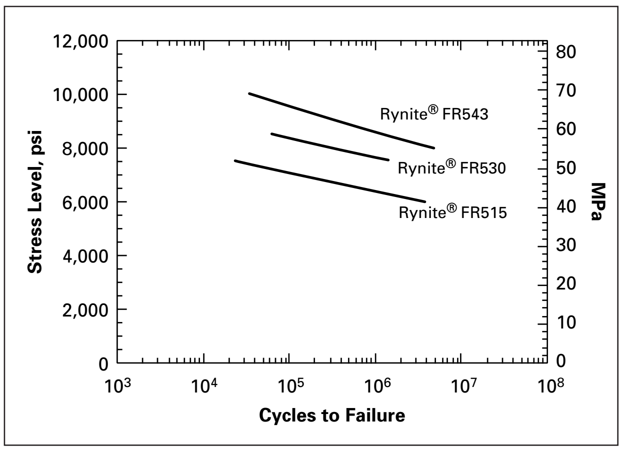
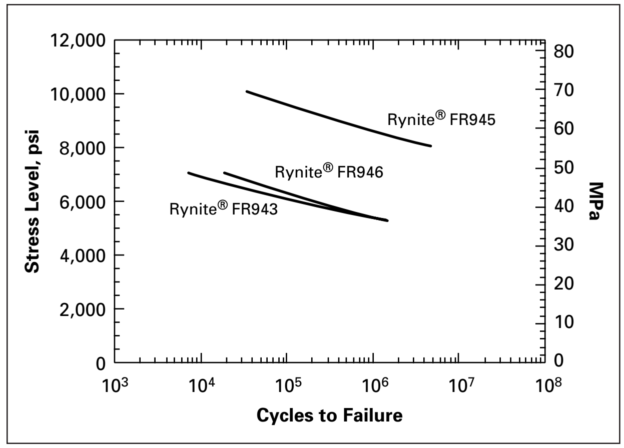


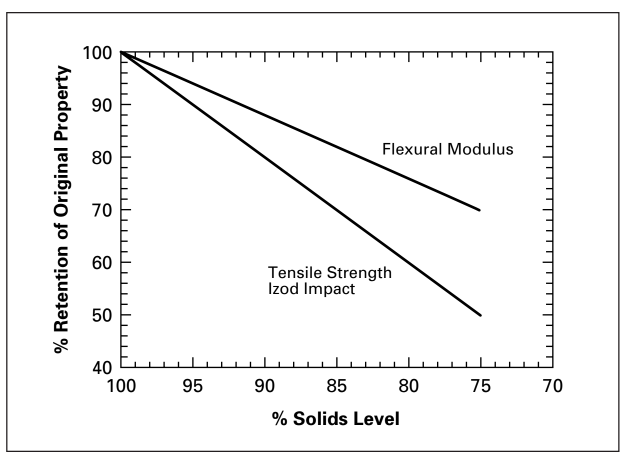
Figure 55. Flexural Fatigue at 23°C (73°F)— Rynite® FR943, Rynite® FR945, Rynite® FR946



Effect of Foaming

Rynite® PET thermoplastic polyester resins can be foamed with commercial foaming agents to reduce weight in very thick parts and reduce sinks under bosses and ribs. The amount of property loss is directly related to solids reduction and a solids reduction of 25% is the general limit. The tensile strength, izod impact, and flexural modulus of Rynite® 530, Rynite® 545, Rynite® 935, and Rynite® 940 as a function of solids level are shown in **Figure 56**. The 100% solids level refers to Rynite® PET without foaming agent.

Figure 56. Properties after Foaming Rynite® 530, Rynite® 545, Rynite® 935, Rynite® 940



Effect of Fiber Orientation

The properties of all glass-reinforced plastics are affected by fiber orientation. The data in **Table 3** lists the effect of glass fiber orientation on tensile strength, flexural modulus, and izod impact for several Rynite® PET thermoplastic polyester resins. These data were determined on test specimens machined from plaques as shown in **Figure 57**.

Figure 57. Preparation of Tensile Specimens

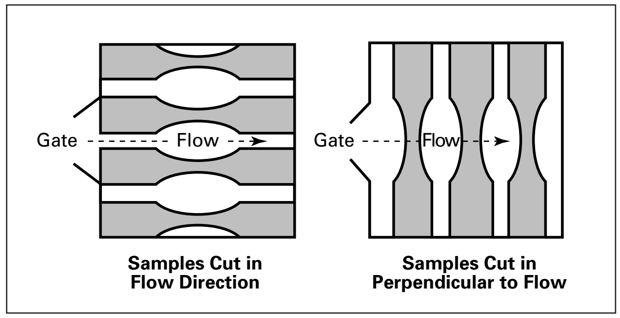


Table 3
Property Reduction (%) Due to Fiber Orientation

Property	Rynite® 530	Rynite® 545	Rynite® 555	Rynite® 935	Rynite® FR530
Tensile Strength Perpendicular to flow versus flow direction	32	32	35	20	41
Flexural Modulus Perpendicular to flow versus flow direction	43	51	51	—	45
Izod Impact Perpendicular to flow versus flow direction	53	49	58	—	59

Properties from Machined versus Molded Samples

The properties of glass-reinforced plastics are substantially different if the part is machined versus being molded. The difference is particularly important on the izod impact. The data in **Table 4** lists the reduction on tensile strength, flexural modulus, and izod impact of test bars machined in the flow direction versus molded test bars.

Table 4
Property Reduction (%), Machined versus Molded Parts

Property	Rynite® 530	Rynite® 545	Rynite® 555	Rynite® FR530
Tensile Strength machined in flow direction versus molded	24	30	36	34
Flexural Modulus machined in flow direction versus molded	3	9	14	3
Izod Impact machined in flow direction versus molded	45	56	53	9

Chapter 3

Thermal Properties

Thermal Characteristics

This section provides additional thermal data from what is found in the typical properties table (**Table 2**) in Chapter 1 of this Design Guide.

Thermal Conductivity

Thermal conductivity is a measure of the rate of heat transfer through a material. When compared to metals, plastics are good insulators and poor conductors of heat. As shown in **Table 5**, the thermal conductivity of Rynite® PET compositions is constant over a wide range of temperatures. Thermal conductivity is affected by the amount and type of fillers used.

Specific Heat/Heat Capacity

Heat capacity is the amount of heat absorbed by a substance over a given temperature range and the units are J/°C. Specific heat is the heat capacity per gram of substance and has units J/g°C or J/kg K. Specific heat relative to water (a dimensionless number) is the ratio of the amount of heat required to warm 1 g of a substance through 1°C to the amount of heat similarly required for water.

Table 6 shows the effect of temperature on the specific heat of several Rynite® PET compositions. This data is collected by starting at the melt temperature and cooling the sample. The sharp rise in specific heat between 200 and 210°C (392 and 410°F) is caused by the polymer freezing between these temperatures. The specific heat of all Rynite® PET compositions at room temperature is essentially the same while, in the melt, the specific heat increases as glass level decreases.

Table 5
Thermal Conductivity versus Temperature

Temperature, °C (°F)	Rynite® 555, W/m K	Rynite® SST 35, W/m K	Rynite® FR515, W/m K	Rynite® FR530, W/m K
280 (536)	0.37	0.29	0.21	0.27
260 (500)	0.41	0.27	0.23	0.28
240 (464)	—	0.28	0.25	0.29
220 (428)	0.42	0.30	0.25	0.31
200 (392)	0.44	0.29	0.25	0.30
180 (356)	0.42	0.28	0.24	0.30
160 (320)	0.42	0.28	0.23	0.31
140 (284)	0.41	—	0.23	0.29
120 (248)	0.40	0.29	0.24	0.29
100 (212)	0.39	0.29	0.23	0.28
80 (176)	0.38	—	0.23	0.29
60 (140)	0.38	0.28	0.23	0.29
40 (104)	—	—	0.23	0.29

Table 6
Specific Heat versus Temperature

Temperature, °C (°F)	Rynite® 530, J/kg K	Rynite® 555, J/kg K	Rynite® SST 35, J/kg K	Rynite® FR515, J/kg K	Rynite® FR530, J/kg K
290 (554)	—	1430	—	—	—
280 (536)	1600	1420	—	1640	1340
270 (518)	1600	1420	1720	1640	1340
260 (500)	1600	1340	1710	1640	1350
250 (482)	1600	1320	1700	1630	1350
240 (464)	1600	1290	1690	1610	1350
230 (446)	1590	1260	1670	1590	1350
220 (428)	1590	1240	1660	1590	1350
210 (410)	1610	1240	1670	3360	2260
200 (392)	2900	2820	3320	2280	1840
190 (374)	1880	1340	1900	1710	1450
180 (356)	1600	1240	1700	1580	1380
170 (338)	1490	1210	1630	1520	1340
160 (320)	1430	1180	1580	1460	1310
150 (302)	1360	1160	1540	1420	1280
140 (284)	1330	1140	1510	1380	1250
130 (266)	1290	1130	1480	1350	1230
120 (248)	1260	1120	1460	1320	1210
110 (230)	1230	1100	1430	1280	1190
100 (212)	1200	1090	1400	1250	1170
90 (194)	1160	1070	1370	1210	1140
80 (176)	1100	1050	1340	1180	1120
70 (158)	1040	1030	1300	1160	1140
60 (140)	1010	1010	1270	1140	1130

Chapter 4

Electrical Properties and Flammability

Dielectric Strength

Dielectric strength is the maximum voltage a dielectric material can tolerate without breakdown. Higher dielectric strengths indicate a greater resistance of a material to dielectric failures. Over the temperature range of 23–150°C (73–300°F) Rynite® PET thermoplastic polyester resins have dielectric strengths between 7 and 30 kV/mm (200 and 750 V/mil).

Several factors affect the dielectric strength of Rynite® PET thermoplastic polyester resins including composition of the resin, voltage rate, test temperature, sample thickness, and processing.

Table 7 shows the effect of varying the applied voltage rate on Rynite® 530 and Rynite® FR530 with higher voltage rates giving higher values. The single point data listed in Chapter 1 was measured at a voltage rate of 500 V/sec. In general, carbon black pigments lower the dielectric strength of resins. **Table 8** shows the effect of carbon black as a pigment on the dielectric strength of Rynite® 935 and 530. The dielectric strength values measured on actual parts may be lower than those measured on test specimens, due to the presence of imperfections such as voids, weldlines, and bubbles.

Table 7
Dielectric Strength versus Voltage Rate

Resin	Thickness	Unit	Voltage Rate		
			500 V/sec	2,000 V/sec	5,000 V/sec
Rynite® 530 NC010					
23°C	**3.2 mm**	**kV/mm**	**20.5**	**24.0**	**25.5**
73°F	0.125 in	V/mil	520	615	650
95°C	**3.2 mm**	**kV/mm**	**16.5**	**22.0**	**24.5**
203°F	0.125 in	V/mil	420	560	620
Rynite® FR530 NC010					
23°C	**3.2 mm**	**kV/mm**	**18.0**	**20.5**	**22.0**
73°F	0.125 in	V/mil	460	520	560
95°C	**3.2 mm**	**kV/mm**	**18.0**	**22.0**	**24.0**
203°F	0.125 in	V/mil	460	560	615

ASTM D149, short-time in oil

Table 8
Dielectric Strength—Natural versus Carbon Black

Temperature	Thickness	Unit	935 NC010	935 BK505	530 NC010	530 BK503
23°C	**1.57 mm**	**kV/mm**	**29.5**	**25.5**	**25.5**	**20.5**
73°F	0.062 in	V/mil	750	650	650	520
95°C	**1.57 mm**	**kV/mm**	**25.5**	**20.5**	**22.5**	**17.0**
203°F	0.062 in	V/mil	650	520	570	430
150°C	**1.57 mm**	**kV/mm**	**14.5**	**14.5**	**15.5**	**15.5**
300°F	0.062 in	V/mil	375	375	395	395
23°C	**3.2 mm**	**kV/mm**	**23.5**	**19.5**	**20.5**	**15.0**
73°F	0.125 in	V/mil	595	495	520	380
95°C	**3.2 mm**	**kV/mm**	**19.5**	**13.5**	**16.5**	**14.0**
203°F	0.125 in	V/mil	495	340	420	355
150°C	**3.2 mm**	**kV/mm**	**12.0**	**11.0**	**12.0**	**12.0**
300°F	0.125 in	V/mil	300	280	300	300

ASTM D149, short-time in oil, 500 V/sec

Ignition Properties

Self-ignition temperature is the lowest initial temperature of air passing around a specimen at which, in the absence of an ignition source, the self-heating properties of the specimen lead to ignition or ignition occurs by itself, as indicated by an explosion, flame, or sustained glow.

Flash ignition temperature is the lowest initial temperature of air passing around a specimen at which a sufficient amount of combustible gas is evolved to be ignited by a small external pilot flame (**Table 9**).

Table 9
Ignition Temperature

Resin	Self-Ignition Temperature	Flash Ignition Temperature
FR515	430°C	340°C
FR530	—	370°C

Combustibility

The combustibility of Rynite® PET thermoplastic polyester resins has been measured by the MVSS (Motor Vehicle Safety Standard) 302 rating, the FAR-25-853B vertical burn test, and the IEC glow wire test. MVSS 302 ratings are shown in **Table 10**. No Rynite® PET thermoplastic polyester resins pass the entire FAR-25-853B test for panel surfaces in airplanes. The flame-retardant grades pass the heat release portion, but fail the smoke generation portion, while other compositions pass the smoke test, but fail the heat release test. All Rynite® PET thermoplastic polyester resins may be used in airplanes as small components such as connectors, sockets, plugs, and brackets. The data in **Table 11** shows the results of the IEC glow wire test.

Table 10
MVSS 302 Ratings

Resin	Thickness, mm (in)	MVSS 302 Rating	Burning Rate, mm/min (in/min)
Rynite® 415HP	1.6 (0.062)	B	<38.1 (<1.5)
Rynite® 408	1.6 (0.062)	B	<19.0 (<0.75)
Rynite® SST 35	1.6 (0.062)	B	<19.0 (<0.75)
Rynite® 530	1.6 (0.062)	B	<19.0 (<0.75)
Rynite® 545	1.6 (0.062)	B	<19.0 (<0.75)
Rynite® 555	1.6 (0.062)	B	<19.0 (<0.75)
Rynite® 935	1.6 (0.062)	B	<19.0 (<0.75)
Rynite® 940	1.6 (0.062)	B	<19.0 (<0.75)

Table 11
Glow Wire Test/Extinction Time ≤30 sec

Resin	Test Standard	1 mm (0.040 in)	2 mm (0.080 in)	3 mm (0.120 in)	6.4 mm (0.25 in)
Rynite® 530	VDC/IEC	650	750	750	960
Rynite® 545	VDC/IEC	750	750	850	960
Rynite® FR530	VDC/IEC	960	960	960	—

Chapter 5

Environmental

Temperature

The effect of temperature on the properties of the Rynite® PET thermoplastic polyester resins is given in **Figures 58** through **70**. These data were determined by exposing test specimens in an air oven at various temperatures. The change in properties with time and temperature was measured. Oils, greases, water, etc., may have a different effect on the properties of the resins at elevated temperatures. See Chemical Resistance section.

Caution: Exposure of the Rynite® PET thermoplastic polyester resins—particularly natural and light colors—to high temperatures in air may result in discoloration, depending upon conditions.

Rynite® PET thermoplastic polyester resins stabilized to minimize discoloration at elevated temperatures are available.

Figure 58. Effect of Air Oven Aging on Tensile Strength—Rynite® 530

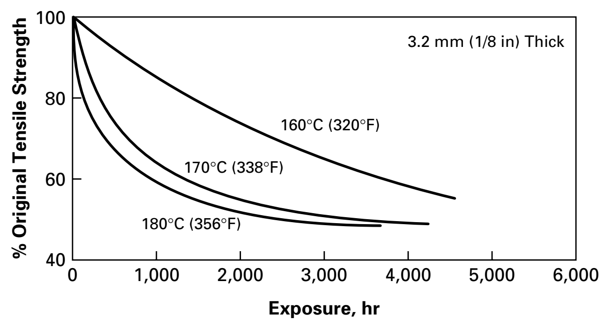


Figure 59. Effect of Air Oven Aging on Izod Impact—Rynite® 530

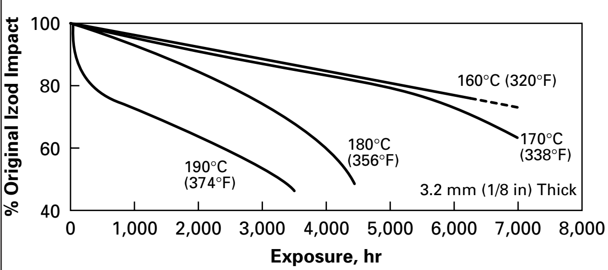


Figure 60. Effect of Air Oven Aging on Tensile Strength—Rynite® 545

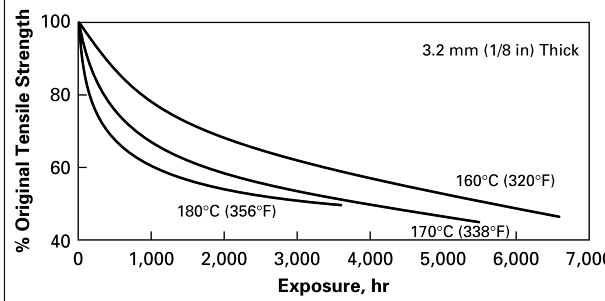


Figure 61. Effect of Air Oven Aging on Izod Impact—Rynite® 545

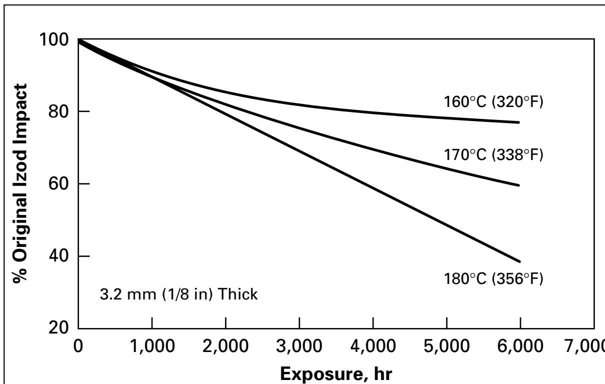


Figure 62. Effect of Air Oven Aging on Tensile Strength—Rynite® 555

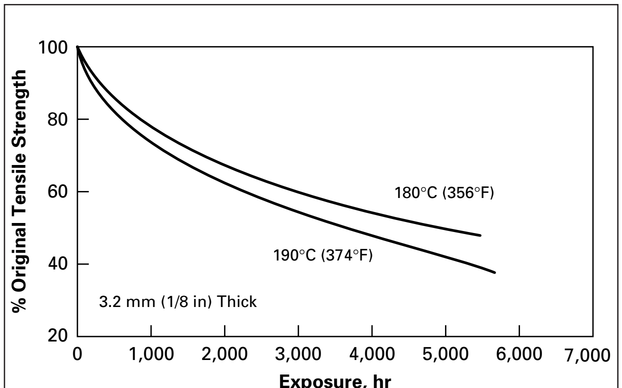


Figure 63. Effect of Air Oven Aging on Tensile Strength—Rynite® 935

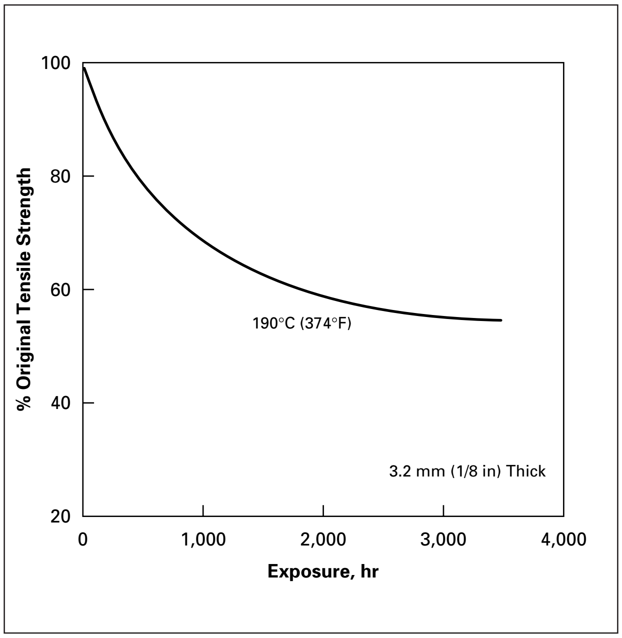


Figure 64. Effect of Air Oven Aging on Tensile Strength—Rynite® 408

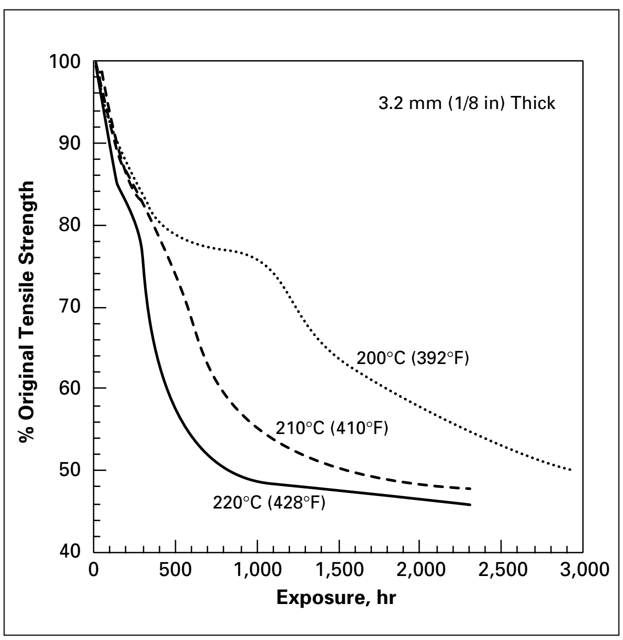


Figure 65. Effect of Air Oven Aging on Tensile Strength—Rynite® SST 35

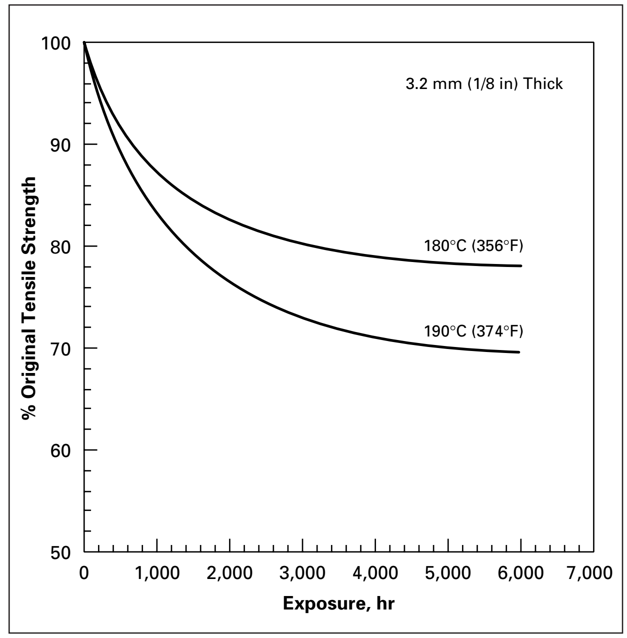


Figure 66. Effect of Air Oven Aging on Izod Impact—Rynite® FR530

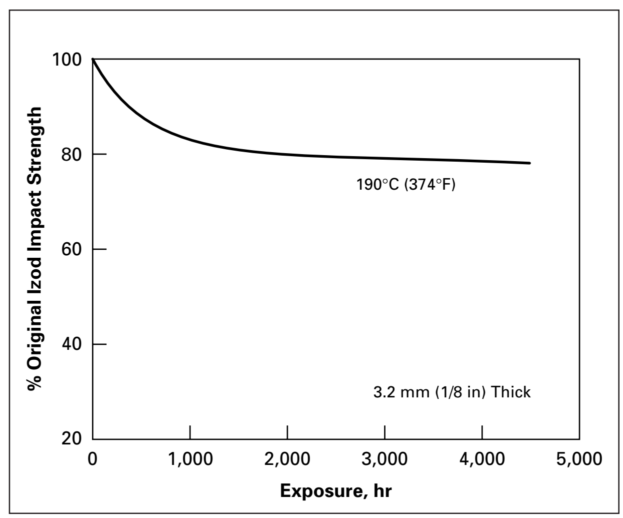


Figure 67. Effect of Air Oven Aging on Tensile Strength—Rynite® FR530

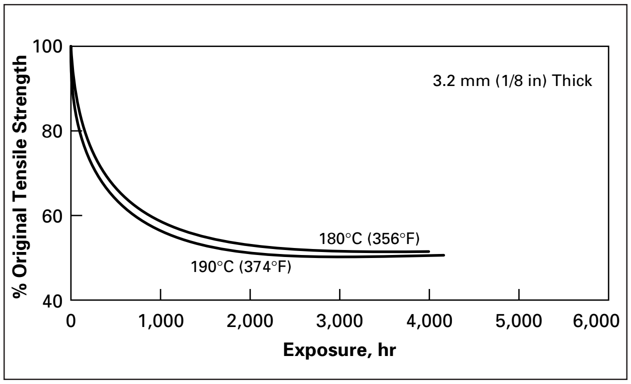


Figure 68. Effect of Air Oven Aging on Tensile Strength—Rynite® FR543

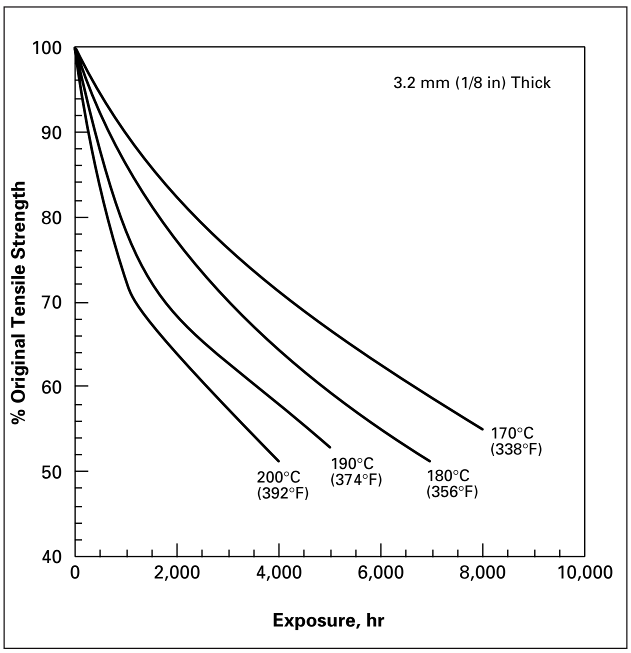


Figure 69. Effect of Air Oven Aging on Tensile Strength—Rynite® FR943

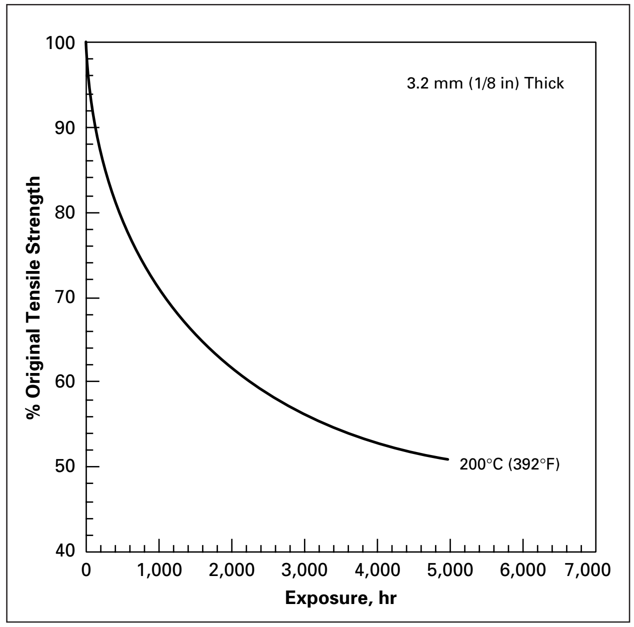
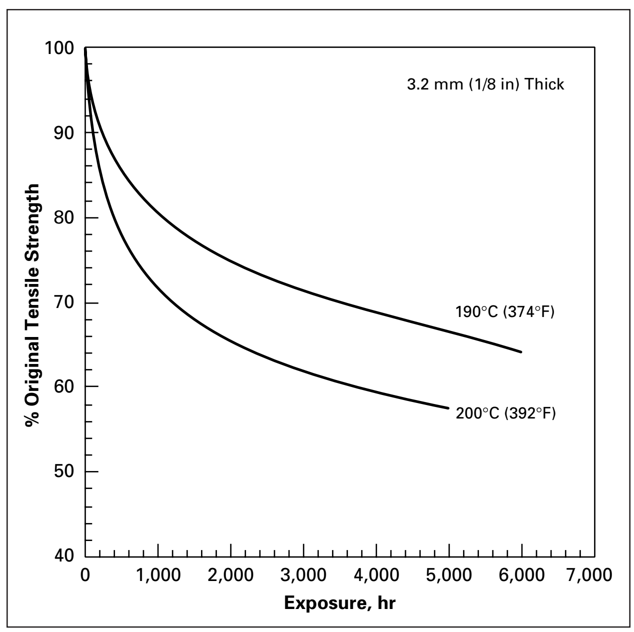


Figure 70. Effect of Air Oven Aging on Tensile Strength—Rynite® FR945



Weathering

Introduction

Rynite® PET thermoplastic polyester resins rank high among plastic engineering materials in their resistance to outdoor weathering. The effect of weathering on the properties of the Rynite® PET thermoplastic polyester resins has been determined by various methods, including accelerated carbon arc X-W Weather-O-Meter exposure, natural outdoor weathering in Arizona and Florida, and accelerated outdoor weathering in Arizona. The results obtained on test bars exposed in these environments indicate in general that the Rynite® PET thermoplastic polyester resins exhibit good property retention. Overall performance is improved, especially impact, by the addition of carbon black (>0.3% by weight) to the resin.

X-W Weather-O-Meter

In the X-W Weather-O-Meter, the test specimens are exposed to simulated sunlight by filtering carbon arc light through Corex D filters. During this exposure, the test samples are sprayed with 32°C (90°F) water for 18 min, which is then followed by a water evaporation cycle at 63°C (145°F) for 102 min. The whole 2-hr cycle is then repeated for the number of hours listed in the various tables. There is no precise correlation between outdoor weathering and the accelerated X-W Weather-O-Meter tests. However, it is estimated that 400 to 1,000 hr in the X-W Weather-O-Meter is equivalent to one year of outdoor weathering in Florida.

General-Purpose Resins

After 10,000 hr in the X-W Weather-O-Meter:

- Rynite® 530 NC010 and Rynite® 545 NC010 retained over 70% of their initial tensile strength and 55% of their original elongation properties.
- Pigmented Rynite® 530 resins retained higher tensile strength and elongation than the Rynite® 530 natural resin. For example, the Rynite® 530 black (BK503), white (WT501), gray (GY5054), and blue (BL503) retain over 87% of their original tensile strength and 75% of their original elongation properties, **Figures 71** and **72**.
- The Rynite® 530 resins listed above retained over 83% of their original Izod impact properties.
- The surface of the test samples exhibited an "etched," rough appearance, i.e., the surface gloss had been significantly reduced and glass fibers were exposed. There was a slight yellowing of the white (WT501) composition.

Figure 71. Percent Retention of Original Tensile Strength After Exposure in X-W Weather-O-Meter

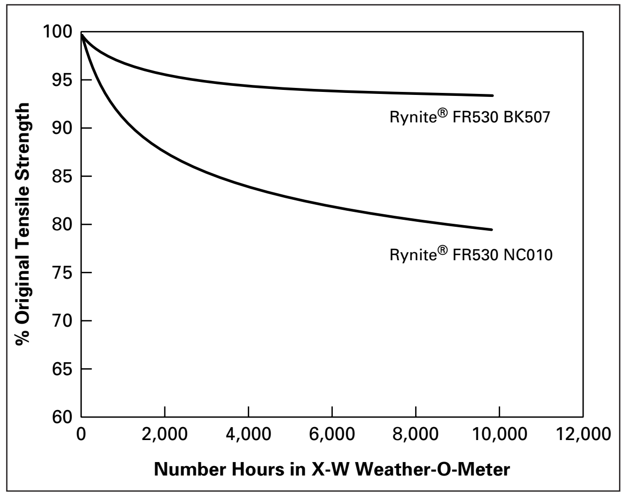
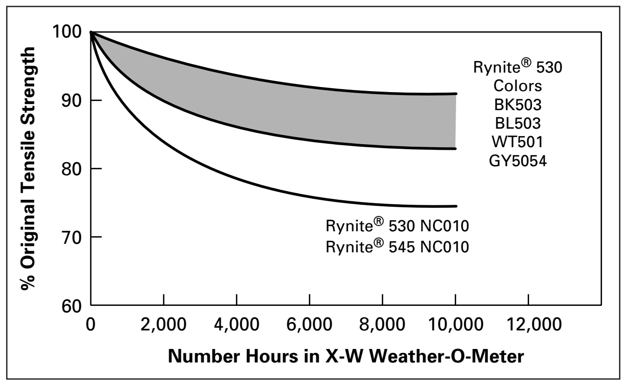


Figure 72. Percent Retention of Original Tensile Strength After Exposure in X-W Weather-O-Meter



Toughened Resins

After 5,000 hr of exposure in the X-W Weather-O-Meter:

- Rynite® PET thermoplastic polyester resins modified for improved toughness retained over 85% of their original tensile properties and 80% of their original elongation at break properties.
- The surface of the test bars was "etched," but not chalked.

Flame-Retardant Grades

After 10,000 hr of exposure in the X-W Weather-O-Meter:

- Rynite® FR530 BK503 black retained 94% of its original tensile strength and 71% of its original elongation at break.
- Rynite® FR530 NC010 natural retained 80% of its original tensile strength and 59% of its original elongation at break.

Outdoor Weathering 45° South

General-Purpose Resins

Rynite® 530 NC010 and BK503 and Rynite® 545 NC010 and BK504 resins have been exposed outdoors in Florida and Arizona facing 45° South for five years. The data determined on these exposed samples indicate that the resins have retained over 69% of their initial tensile strength and over 46% of their initial elongation. As expected, the compositions containing carbon black have a higher property retention (**Tables 13** and **14**). After five years, all the test samples were slightly "etched."

Low Warp Resins

After five years of exposure in Arizona, Rynite® 935 BK505 retained 99% of original tensile strength and 82% of original elongation (**Table 14**).

Accelerated Natural Weathering in Arizona

General-Purpose Resins

After 500,000 Langleys of exposure in the equatorially mounted mirror assisted (EMMA) and EMMA with water (EMMAQUA) environments, Rynite® 530 NC010 and BK503 and Rynite® 545 NC010 and BK504 resins retained over 90% of their original tensile strength and 73% of their original elongation properties. The EMMA and EMMAQUA environments have similar effects on the properties of the Rynite® 530 and Rynite® 545 resins (**Table 15**).

Test specimens had reduced gloss levels after exposure. On the average, samples exposed in Arizona received approximately 150,000 Langleys of sunlight per year. These tests correspond to about three and one-third years of natural weathering in Arizona.

Table 13
Outdoor Weathering Florida 45°South—% Retention of Original Physical Properties

Exposure: Florida 45°South—Yr	Rynite® 530 NC010	Rynite® 530 BK503	Rynite® 545 NC010	Rynite® 545 BK504
Tensile Strength				
0	100	100	100	100
0.5	98	100	89	88
1	92	100	84	90
2	82	93	75	91
3	76	98	72	91
5	77	100	69	92
Elongation				
0	100	100	100	100
0.5	85	87	77	67
1	77	91	68	78
2	69	91	73	89
3	58	87	50	78
5	46	87	50	72

Table 14
Outdoor Weathering Arizona 45°South—% Retention of Original Physical Properties

Exposure: Arizona 45°South Yr	Rynite® 530 NC010	Rynite® 530 BK503	Rynite® 545 NC010	Rynite® 545 BK504	Rynite® 935 BK505
Tensile Strength					
0	100	100	100	100	100
0.5	100	98	98	94	100
1	98	100	88	97	100
2	90	98	87	94	100
3	87	98	82	90	97.5
5	80	97	76	90	99
Elongation					
0	100	100	100	100	100
0.5	85	91	82	83	100
1	88	96	77	94	94
2	77	96	73	89	94
3	73	83	68	78	76
5	54	70	50	78	82

Table 15
Accelerated Natural Arizona Weathering—% Retention of Original Physical Properties

Exposure	Rynite® 530 NC010	Rynite® 530 BK503	Rynite® 545 NC010	Rynite® 545 BK504
EMMA—500,000 Langleys*				
Tensile Strength	100	100	92	93
Elongation	85	87	73	89
EMMAQUA—500,000 Langleys*				
Tensile Strength	100	100	92	93
Elongation	81	87	73	94

EMMA = Equatorially mounted mirror assisted
EMMAQUA = EMMA assisted with water
*150,000 Langleys ≅ One year

Chemical Resistance

Rynite® PET thermoplastic polyester resins exhibit excellent resistance to a wide variety of chemicals. **Tables 17** and **18** detail the effects of various automotive-related chemicals, organic solvents, acids, bases, salt solutions, and water on the properties of Rynite® 530 and Rynite® 545 resins after exposure at various times and temperatures. These data are based on unstressed test bars that were molded via recommended molding conditions, e.g., hot >93°C (200°F) molds. The resistance of Rynite® PET thermoplastic polyester resins to certain chemicals (e.g., chlorinated hydrocarbons) at elevated temperatures depends on the surface crystallinity of the molded part. Annealed parts or parts molded in hot molds >93°C (200°F) will exhibit good resistance, whereas parts molded in cold molds may surface craze. We strongly recommend end-use testing be carried out on actual parts (as opposed to test bars) to determine the suitability of Rynite® PET thermoplastic polyester resins in any application.

All thermoplastic polyester resins will hydrolyze in hot water. The hydrolysis results in polymer degradation and a decrease in the physical properties of the resin. The rate of hydrolysis depends on exposure conditions; primarily time, temperature, and the composition of the specific polyester resin. We do not recommend that parts made from Rynite® PET thermoplastic polyester resins be used in an environment where there is continuous exposure to water at temperatures above 50°C (122°F) (**Table 16**).

Table 16
Hydrolysis Resistance of Rynite® 530 at 100% RH; Times to Reach One-Half of Initial Property Value

Temperature	Time (Weeks)
Tensile Strength	
85°C (185°F)	4
70°C (160°F)	22
55°C (130°F)	100
40°C (105°F)	>104
Unnotched Impact	
85°C (185°F)	1
70°C (160°F)	6
55°C (130°F)	38
40°C (105°F)	60

Due to excessive degradation, we recommend that the maximum continuous exposure temperature of parts made from Rynite® PET thermoplastic polyester resins to oil be 121°C (250°F).

Tables 19 and **20** list the effect of various solvents used in cleaning electrical/electronic parts.

Table 17
Rynite® PET Solvent Resistance*

Chemical Media	Temperature, °C (°F)	Days of Immersion	% Retention of Original Tensile Strength	Weight Gain, %	Dimensional Change, %
Automotive-Related Environments					
Diesel Fuel	23 (73)	21	90–95	1	0
Diesel Fuel + 15% Ethanol	121 (250)	2 7 14	60–70 20–30 15–20	2–2.5 2 2	— — —
Diesel Fuel/Unleaded Gasoline (50/50)	23 (73)	21	95–99	1	0
Unleaded Gasoline	23 (73) 42 (108) 60 (140)	21 84 84	100 100 90	0.1 0.1 0.5	— 0.01 0.1
Unleaded Gasoline/Methanol (85/15)	23 (73) 60 (140)	21 21 84	90–95 70 45–50	1 1.8 2.3	0.04 0.1 0.2
Unleaded Gasoline/Ethanol (85/15)	23 (73)	21	85–90	1	0.01
Unleaded Gasoline + 5% Methanol + 2.5% Mixed Alcohols	42 (108)	28 84	90 73	1.5 2.9	0.1 0.2
Unleaded Gasoline + 5% Methanol + 3.2% Ethanol	42 (108)	28 84	86 75	1.9 3.1	0.1 0.2
Unleaded Gasoline + 5% Methanol + 4.1% Propanol	42 (108)	28 84	92 82	1.2 2.4	0.1 —
Unleaded Gasoline + 5% Methanol + 4.2% Mixed Alcohols	42 (108)	28 84	88 79	1.5 2.7	0.1 0.2
Unleaded Gasoline + 5% Methanol + 5% Butanol	42 (108)	28	100	1.2	0.1
Leaded Gasoline	23 (73)	7	90–95	1	0.03
Ford Motor Oil	121 (250)	28 112	95–99 15	— —	— —
Shell Motor Oil	121 (250)	14 28 84	90–95 55–65 15	— — —	— — —
Synthetic Motor Oil	150 (300)	21 42	70 45	— —	— —
Omnilube 300	93 (200)	290	99	—	—
Turbo 33	93 (200)	290	99	—	—
Rotron Diester Oil	93 (200)	290	99	—	—

*Data based on Rynite® 530 and Rynite® 545

(continued)

Table 17
Rynite® PET Solvent Resistance* *(continued)*

Chemical Media	Temperature, °C (°F)	Days of Immersion	% Retention of Original Tensile Strength	Weight Gain, %	Dimensional Change, %
Automotive-Related Environments (continued)					
Dextron Transmission Fluid	121 (250)	28	95–99	—	—
	150 (300)	21	20–25	—	—
GM Power Steering Fluid	23 (73)	21	97–100	0	0
	121 (250)	14	85–90	0.1	—
		90	50	0.22	0.08
Delco Supreme #1 Brake Fluid	23 (73)	21	95	0.15	0.01
	66 (150)	28	80–90	—	—
	121 (250)	14	30	—	—
Quaker State Lithium-Based Grease	23 (73)	21	95–100	1	0.01
Kendal 3 Star 80W160 Gear Lubricant	23 (73)	21	90–96	1	—
Permatex Hydraulic Jack Oil	23 (73)	21	94–100	0.15	0.01
Antifreeze (50%)	23 (73)	21	90–95	1	0.1
Ethylene Glycol (100%)	23 (73)	21	95–99	1	0.01
"Optikleen" Windshield Washer Solvent (100%)	23 (73)	21	90–95	1	0.02
"Optikleen"/Water (50/50)	23 (73)	21	90–95	1	0.01
		90	85	1	0.01
Organic Solvents					
Acetone	23 (73)	21	70–80	5	0.1
Benzyl Alcohol	23 (73)	21	95	0.04	0
Ethanol	23 (73)	21	98–100	0	0.01
Ethyl Acetate	23 (73)	21	80–90	5	0.04
Ethyl Ether	23 (73)	21	85–95	0.15	0.01
Freon® F113	23 (73)	21	91–99	1	0.01
Iso-Octane	23 (73)	21	99	0	0.01
		364	99	0.04	0.01
Isopropanol	23 (73)	21	95–99	0.1	0
Methanol	23 (73)	21	95–96	1	0.01
Methylene Chloride	23 (73)	21	45–50	8–10	0.3
Methyl Ethyl Ketone (MEK)	23 (73)	21	80–92	0.7	0.07
Nitromethane	23 (73)	21	70	4	0.12
Toluene	23 (73)	21	95–98	0.5	0.01

*Data based on Rynite® 530 and Rynite® 545

(continued)

Table 17
Rynite® PET Solvent Resistance* *(continued)*

Chemical Media	Temperature, °C (°F)	Days of Immersion	% Retention of Original Tensile Strength	Weight Gain, %	Dimensional Change, %
Acids					
Acetic Acid (100%)	23 (73)	21	85–95	1	0.04
Hydrochloric Acid (10%)	23 (73)	21	92–96	1	0.01
Sulfuric Acid (10%)	23 (73)	21	91–96	1	0.02
Sulfuric Acid (Battery)	23 (73)	3	90–95	1	0.01
Bases					
Ammonium Hydroxide (10%)	23 (73)	21	85–93	0.3	0.02
Sodium Hydroxide (10%)	23 (73)	21	0–47	5	0.02
Other Solvents					
Bleach, "Clorox" (100%)	23 (73)	21	90–95	0.1	0.07
Calcium Chloride (10%)	23 (73)	21	85–95	0.25	0
Hydrogen Peroxide (30%)	23 (73)	21	90	0.25	0.02
Sodium Choride	23 (73)	21	90–95	0.31	0
1,1,1-Trichloroethane	23 (73)	21	90	0.3	0
WD-40	23 (73)	21	90	0.05	0.01
Zinc Chloride (10%)	23 (73)	21	91–96	1	0.01
Zinc Chloride (50%)	23 (73)	8	90–95	1	0.01

*Data based on Rynite® 530 and Rynite® 545

Table 18
Rynite® 545 Immersed for One Year at 23°C (73°F)

	% Retention of Initial Tensile Strength	Weight Gain, %	Dimensional Change, %
Water	92	0.47	0.07
Methanol	87	0.6	0.07
Ethanol	97	0.13	0.02
Iso-Octane	100	0.04	0.01
Regular Gasoline	99	0.08	0.03
Toluene	90	0.99	0.05
Toluene 85% Volume Methanol 15% Volume	61	3.14	0.24
White Gasoline 85% Volume Methanol 15% Volume	84	1.06	0.09
Unleaded Gasoline 85% Volume Methanol 15% Volume	83	0.96	0.09
Unleaded Gasoline 85% Volume Ethanol 15% Volume	93	0.28	0.03

Table 19
Effect of Cleaning Solvents on Rynite® FR530

	Freon®					
Plastic	**TM**	**TES**	**TMS**	**TMC**	**Methyl Chloroform**	**Trichloro-ethylene**
0.78 mm (0.031 in)						
Unstressed	0	0	0	1	1	1
Stressed	0	0	0	1	1	1
1.56 mm (0.062 in)						
Unstressed	0	0	0	1	1	1
Stressed	0	0	0	1	1	1

Effect Key:
0 = No visible effect
1 = Very slight effect
2 = Compatibility should be tested
3 = Probably not suitable
4 = Disintegrated or dissolved

- All test pieces exposed to solvent at the boiling point for 5 min.
- Immediately on removal from the solvent, the pieces were tested by bending, scraping, twisting, and visual observation to determine if any change or damage had occurred.
- All test pieces were of the thickness indicated × 12.5 mm (0.50 in) wide × 125 mm (5 in) long.
- 0.78 mm (0.031 in) stressed specimens were bent through a 180° angle for exposure testing. The 1.56 mm (0.062 in) stressed pieces were bent through an 80° angle. In both cases specimens were bent as far as possible without initiating fracture.

Table 20
Detailed Compatibility of Rynite® FR530 with Solvents

Condition	Solvent	Comments	Effect Key
0.78 mm [0.032 in] thick specimens			
Unstressed	Freon® TF	No change	0
Stressed	Freon® TF	No change	0
Unstressed	Freon® TES	No change	0
Stressed	Freon® TES	No change	0
Unstressed	Freon® TMS	No change	0
Stressed	Freon® TMS	No change	0
Unstressed	Freon® TMC	No change	1
Stressed	Freon® TMC	No change	1
Unstressed	Methyl Chloroform	Slightly easier to flex; lost some of its glossiness	1
Stressed	Methyl Chloroform	Slightly easier to flex; lost some of its glossiness	1
Unstressed	Trichloroethylene	Easier to flex; bleached out	1
Stressed	Trichloroethylene	Easier to flex; bleached out	1
1.56 mm [0.062 in] thick specimens			
Unstressed	Freon® TF	No change	0
Stressed	Freon® TF	No change	0
Unstressed	Freon® TES	No change	0
Stressed	Freon® TES	No change	0
Unstressed	Freon® TMS	No change	0
Stressed	Freon® TMS	No change	0
Unstressed	Freon® TMC	No change	1
Stressed	Freon® TMC	No change	1
Unstressed	Methyl Chloroform	Lost its glossiness	1
Stressed	Methyl Chloroform	Lost its glossiness	1
Unstressed	Trichloroethylene	Slightly easier to flex and bleached out	1
Stressed	Trichloroethylene	Slightly easier to flex and bleached out	1

Note: See Table 19 for details on tests.

Chapter 6

Government and Agency Approvals

Underwriters' Laboratories Ratings

Table 22 lists the UL ratings for the Rynite® PET thermoplastic polyester resins. For the latest on data, contact your nearest DuPont sales office.

Military Specification MIL-M-24519

Rynite® FR530 is listed in the Qualified Products List (QPL 24519-27).

Food and Drug Administration (FDA)

Rynite® PET thermoplastic polyester resins are not FDA compliant and should NOT be used in applications where FDA compliance is required.

National Sanitation Foundation (NSF)

There are currently no Rynite® PET thermoplastic polyester resins listed by DuPont for use in applications where NSF approval is required.

ASTM D5927-96

Table 21 shows the ASTM callouts for various PET resins. All Rynite® PET thermoplastic polyester resins meet these guidelines. Under this system, the Rynite® 530 callout would be D5927-96 TPES021G30.

Table 21
TPES Detail Requirements for Thermoplastic Polyester[a]

Group	Description	Class	Description	Grade	Description[b]	Flow Rate, ISO 1133, g/10 min	Density, ISO 1183, g/cm³	Tensile Strength, ISO 527-1, -2,[c] Min., MPa	Flexural Modulus, ISO 178,[d] Min., GPa	Izod Impact Resistance, ISO 180,[e] Min., kJ/m²	Deflection Temp. at 1.8 MPa, ISO 75-1, -2,[f] Min., °C
02	Polyethylene terephthalate (PET)	1	Unmodified	10		<20.0 285/2.16[g]	1.26–1.43	50	2.0	2.8	60
				G15	15% Glass	—	1.26–1.52	75	4.0	4.0	180
				G20	20% Glass	—	1.43–1.60	80	6.0	5.0	190
				G30	30% Glass	—	1.46–1.65	115	8.0	5.0	200
				G40	40% Glass	—	1.59–1.73	120	11.0	5.0	200
				G45	45% Glass	—	1.64–1.85	120	12.0	5.0	210
				G55	55% Glass	—	1.76–1.86	160	12.0	5.0	220
				G00	Other	—	—	—	—	—	—
				R15	15% Filler	—	1.35–1.45	85	3.5	3.0	150
				R35	35% Filler	—	1.53–1.65	75	7.5	4.0	165
				R40	40% Filler	—	1.54–1.70	90	7.0	4.0	195
				R45	45% Filler	—	1.65–1.75	145	12.0	8.0	225
				R00	Other	—	—	—	—	—	—
		2	Impact modified	G15	15% Glass	—	1.35–1.45	60	3.0	5	170
				G30	30% Glass	—	1.46–1.56	100	7.0	10	205
				G35	35% Glass	—	1.49–1.59	85	6.0	15	200
				G00	Other	—	—	—	—	—	—
		3	Flame-retardant	G15	15% Glass	—	1.50–1.67	70	4.5	3.5	175
				G20	20% Glass	—	1.56–1.70	80	5.5	4.5	190
				G30	30% Glass	—	1.62–1.78	95	9.0	4.0	200
				G40	40% Glass	—	1.71–1.83	100	11.5	6.0	200
				G45	45% Glass	—	1.75–1.85	140	12.0	10	215
				G00	Other	—	—	—	—	—	—
				R45	45% Filler	—	1.70–1.91	100	11.0	4.0	205
				R00	Other	—	—	—	—	—	—

[a] Data on 4-mm test specimens are limited, and the minimum values may be changed in a later revision after a statistical data base of sufficient size is generated.

[b] No descriptions are listed unless needed to describe a special grade under the class. All other grades are listed by requirement.

[c] Tensile strength shall be determined using a Type 1A tensile specimen as described in ISO 527-2:1993. The crosshead speed shall be 50 mm/min ±10% for unreinforced materials and 5 mm/min ±20% for reinforced grades.

[d] Flexural modulus shall be determined on a specimen 80 ± 2 mm by 10 ± 0.2 mm by 4 ± 0.2 mm at a test speed of 2 mm/min ± 20%.

[e] Izod shall be determined on a specimen 80 ± 2 mm by 10 ± 0.2 mm by 4 ± 0.2 mm as described in ISO 180:1993, method 1A.

[f] Deflection temperature shall be determined on an unannealed specimen 80 ± 2 mm by 10 ± 0.2 mm by 4 ± 0.2 mm as described in ISO 75-2:1993, method Af.

[g] Moisture content of the specimen shall be below 0.005%.

Table 22
Underwriters Laboratories Yellow Card Ratings

Material Designation	Color	Minimum Thickness mm	Minimum Thickness in	UL94 Flame Class	Temperature Index, °C Electrical	Temperature Index, °C Mechanical With Impact	Temperature Index, °C Mechanical Without Impact	Hot Wire Ignition	High Current Arc Ignition	High Voltage Track Rate	IEC Track (CTI)
Rynite® 408	All	0.75	0.029	94HB	140	140	140	1	2	—	—
		1.50	0.060	94HB	140	140	140	1	2	—	—
		3.00	0.120	94HB	140	140	140	0	2	0	2
Rynite® 415HP	All	0.81	0.032	94HB	140	120	140	3	1	—	—
		1.50	0.060	94HB	140	120	140	2	1	—	—
		3.00	0.120	94HB	140	120	140	0	1	2	2
Rynite® 520 (f1)	NC, BK,	0.79	0.031	94HB	140	140	140	3	1	2	—
	GY	1.50	0.060	94HB	140	140	140	1	2	2	—
		3.00	0.120	94HB	140	140	140	0	1	3	3
Rynite® 530 (f1)	All	0.81	0.032	94HB	140	140	140	2	1	—	—
		1.50	0.060	94HB	140	140	140	1	1	—	—
		3.00	0.120	94HB	140	140	140	0	1	2	2
		6.00	0.250	94HB	140	140	140	0	1	—	—
Rynite® 545 (f1)	All	0.81	0.032	94HB	140	140	140	2	1	—	—
		1.50	0.060	94HB	140	140	140	1	1	—	—
		3.00	0.120	94HB	140	140	140	0	1	1	2
Rynite® 555	All	0.81	0.032	94HB	140	140	140	2	1	1	—
		1.50	0.060	94HB	140	140	140	1	1	1	—
		3.00	0.120	94HB	140	140	140	0	1	1	3
Rynite® 935 (f1)	NC, BK	0.79	0.030	94HB	140	140	140	2	1	1	—
		1.50	0.060	94HB	140	140	140	1	1	1	—
		3.00	0.120	94HB	140	140	140	0	1	1	2
Rynite® 940	BK	0.75	0.030	94HB	75	75	75	—	—	—	—
Rynite® SST 35	NC, BK	0.81	0.032	94HB	150	150	150	3	0	—	—
		1.50	0.060	94HB	150	150	150	2	0	—	—
		3.00	0.120	94HB	150	150	150	1	0	3	1
Rynite® FR515	All	0.86	0.034	94V-0	140	140	140	0	0	—	—
		1.50	0.060	94V-0	140	140	140	0	0	—	—
	NC, BK	1.50	0.060	94V-0 94-5VA	140	140	140	0	0	—	—
	All	3.00	0.120	94V-0	140	140	140	0	1	4	3
	NC, BK	3.00	0.120	94V-0 94-5VA	140	140	140	0	1	4	3
Rynite® FR330	All	0.81	0.032	94V-0	140	140	140	—	—	—	—
		1.50	0.060	94V-0	140	140	140	—	—	—	—
	NC, BK	1.50	0.060	94V-0 94-5VA	140	140	140	—	—	—	—
	All	3.00	0.120	94V-0	140	140	140	0	1	3	3
	NC, BK	3.00	0.120	94V-0 94-5VA	140	140	140	0	1	3	3
Rynite® FR530 (f1)	BK, NC	0.35	0.014	94V-0	—	—	—	3	1	—	—
		0.81	0.032	94V-0	150	150	150	2	1	1	—
		1.50	0.060	94V-0 94-5VA	150	150	150	0	1	1	—
	NC, BK	1.50	0.060	94V-0	150	150	150	0	1	1	—
	All	2.00	0.080	94V-0 94-5VA	150	150	150	0	1	1	—
		3.00	0.120	94V-0	150	150	150	0	1	1	2
		3.00	0.120	94V-0 94-5VA	150	150	150	0	1	1	2
Rynite® FR543	NC, BK	0.81	0.032	94V-0	155	155	155	0	1	1	—
		1.50	0.060	94V-0 94-5VA	155	155	155	0	1	1	—
		3.00	0.120	94V-0 94-5VA	155	155	155	0	1	1	3

(continued)

Table 22
Underwriters Laboratories Yellow Card Ratings *(continued)*

Material Designation	Color	Minimum Thickness		UL94 Flame Class	Temperature Index, °C			Hot Wire Ignition	High Current Arc Ignition	High Voltage Track Rate	IEC Track (CTI)
						Mechanical					
		mm	in		Electrical	With Impact	Without Impact				
Rynite® FR943	NC, BK	0.35	0.014	94V-0	75	75	75	—	—	—	—
	NC, BK,	0.81	0.032	94V-0	155	155	155	2	4	—	—
	GY	1.50	0.060	94V-0	155	155	155	2	4	—	—
		2.30	0.090	94-5VA	155	155	155	—	—	—	—
		3.00	0.120	94V-0	155	155	155	0	4	1	2
Rynite® FR945	All	0.81	0.032	94V-0	150	150	150	2	2	—	—
		1.50	0.060	94V-0 94-5VA	150	150	150	0	2	—	—
		2.30	0.090	94V-0 94-5VA	150	150	150	0	2	—	—
		3.00	0.120	94V-0 94-5VA	150	150	150	0	1	1	2
Rynite® FR946	GN, BK	0.81	0.032	94V-0	150	140	140	0	3	—	—
	GY, NC,	1.50	0.060	94V-0	150	150	150	0	3	—	—
	BL	3.00	0.120	94V-0	150	150	150	0	3	1	3
	NC, BK	3.00	0.120	94-5VA	150	150	150	0	3	1	3

Hot-Wire Ignition (HWI)—

Mean Ignition Time	Assigned PLC
120 ≤ IT	0
60 ≤ IT < 120	1
30 ≤ IT < 60	2
15 ≤ IT < 30	3
7 ≤ IT < 15	4
0 ≤ IT < 7	5

High Current Arc Ignition (HAI)—

Mean Number of Arcs to Cause Ignition (NA)	Assigned PLC
120 ≤ NA	0
60 ≤ NA < 120	1
30 ≤ NA < 60	2
15 ≤ NA < 30	3
0 ≤ NA < 15	4

High Voltage Arc Tracking Rate (HVTR)—

Tracking Rate (mm/min)	Assigned PLC
0 < TR ≤	0
10 < TR ≤ 10	1
25 < TR ≤ 25	2
80 < TR ≤ 80	3
150 < TR 150	4

Comparative Track Index (CTI)—

Tracking Index (V)	Assigned PLC
600 ≤ TI	0
400 ≤ TI < 600	1
250 ≤ TI < 400	2
175 ≤ TI < 250	3
100 ≤ TI < 175	4
0 ≤ TI < 100	5

Chapter 7

Applications

General Decorating Techniques

Often, it is desirable to decorate parts injection molded from Rynite® PET thermoplastic polyester resins in post-molding operations. Below is a brief summary of several techniques. This information is intended as only a guide. Please consult the specific equipment or material suppliers for each technique for details.

Hot Stamping

Hot stamping has been used in a number of applications. A good clean polymer surface is usually needed, and no one set of operating conditions can be recommended. Die pressures, temperatures, and dwell times must be individually determined for each application; however, die temperatures of 215–245°C (420–473°F), dwell times of 0.2–2.0 sec, and pressures of 13–45 psi are common. In some applications, the temperature of the part and surface moisture content (time out of the mold) may also be important.

Inks

Many solvent-soluble inks can be used with Rynite® PET thermoplastic polyester resins. Flame, infrared, and oven baking "fixing" can also be used.

Painting

Cleaning the surface of molded parts to remove dirt, oil, dust, mold release, or other contaminants is important to achieving good paint adhesion. Parts may be wiped clean with alcohol, toluene, or other typical solvents and washes used to prepare a part surface prior to painting.

The excellent solvent resistance and the high heat distortion temperature of Rynite® PET thermoplastic polyester resins result in a broad flexibility when choosing a primer/topcoat system, including those that require high bake temperatures. The key to good paint adhesion and durability is the choice of primer.

Adhesion

Parts or stock shapes such as plaques of Rynite® PET thermoplastic polyester resin can be bonded to each other by the use of commercially available adhesives. A list of adhesives that have been tested with successful results in bonding Rynite® PET to Rynite® PET are listed in **Table 23**. For best results, surfaces should be cleaned with a solvent such as acetone prior to applying the adhesive. Procedures recommended by the adhesive suppliers should be followed.

One of the many uses of adhesive bonding is the joining of plaques to form a thick section for machining* of prototypes. Polyurethane adhesives have been used successfully in this manner, and parts produced have survived severe end-use testing conditions such as automotive under hood environment.

* Plaques bonded with adhesive should be annealed, rough machined, and annealed again prior to final machining. Annealing conditions are1–2 hr at 149°C (300°F) in air.

Table 23
Adhesive Recommendations—Rynite® PET to Rynite® PET Bonding

Adhesive	Supplier
Epoxy "Arathane" 8503 (and primer) **Urethane** "Arathane" 5540 (and primer)	Ciba-Geigy Corporation Formulated Systems Group 31601 Research Park Drive Madison Heights, MI 48071 Phone: (800) 672-1027 (800) 248-1306 (313) 585-7200
Urethane "UR 2139"	H.B. Fuller 3530 Lexington Avenue North St. Paul, MN 55126 Phone: (612) 645-3401
Acrylic "3100" (Temperature limit ~100°C [248°F])	ITW Adhesive Systems 37722 Enterprise Court Farmington Hills, MI 48331 Phone: (313) 489-9344
Anaerobic "Black Max 380" (Temperature limit ~100°C [248°F] intermittent) **Cycanoacrylate** "Super Bonder" 430, 496, 414	Loctite 705 N. Mountain Road Newington, CT 06111 Phone: (203) 278-1280
Urethane "Tyrite" 7500 (on PET types) **Cyanoacrylate** "Cylok" R, G, M	Lord Corporation Industrial Adhesives Division 2000 West Grandview Blvd. P.O. Box 10038 Erie, PA 16514-0038 Phone: (814) 868-3611
Cyanocrylate "Permabond" 910	Permabond International Corp. 480 S. Dean Street Englewood, NJ 07631 Phone: (210) 868-9494
Epoxy "Scotchweld" 2214	3M Aerospace Central Aerospace Materials Department 3M Center, Bldg. 223-IN-07 St. Paul, MN 55144 Phone: (800) 235-AERO

As every end use has its own requirements for bond strength and durability, the bonded part should be tested under actual end-use conditions prior to adopting any adhesive system.

In considering an adhesive for evaluation, consider both the end-use environment and the stresses the adhesive must endure. Pay particular attention to the bond strength requirements, differences in thermal expansion and contraction between the two bonded substrates, temperature requirements, humidity resistance, chemical resistance, weatherability, and oxidation resistance.

Questions on any specific adhesive system should be directed to the manufacturer of that system.

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For Automotive Inquiries: (800) 533-1313

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(847) 735-2720

West
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