Crastin® PBT and Rynite® PET

Thermoplastic Polyester Resins

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Design information on CRASTIN® PBT and RYNITE® PET

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1. Ignition coils, lead connection piece and tray for automotive ignition system made in CRASTIN® SK605.
2. Steam iron skirt made of RYNITE®.
3. Spotlights in CRASTIN® SK603.
4. Lamp sockets in a variety of shapes made in RYNITE® 9087F.

1 – Introduction

1.1 – Foreword

CRASTIN® PBT and RYNITE® PET are DuPont's registered trademarks for its thermoplastic polyester resins.

This handbook contains material properties which can be useful for the structural design of plastic parts to be made with CRASTIN® or RYNITE®.

General design principles can be found in DuPont's "Design Handbook", Module I, where for instance subjects like snap fits, self tapping screws and gears are covered.

The data in this handbook cannot be complete and is also subject to change caused by newly defined test methods. For critical applications it is therefore recommended to verify properties with latest publications and to perform prototype testing of end-use parts.

Safety Information

DuPont supplies Material Safety Data Sheet (MSDS) information to its customers with the initial order of RYNITE® and CRASTIN® resin and on the next order after an MSDS is revised. MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures and storage information.

Environment

RYNITE® PET is based on the same polymer which is largely used for soft drink bottles with respect to its good environmental behaviour.

In following the guidelines of this manual, the amount of waste and reject parts generated will be minimised. The good melt stability of RYNITE® and CRASTIN® allows in general the recycling of properly handled production waste. If recycling is not possible, DuPont recommends, as the preferred option, incineration with energy recovery. The incinerator has to be equipped with a state of the art scrubber in order to clean the flue gases before release.

RYNITE® and CRASTIN® are not soluble in water and have practically no additives which can be extracted by water. Therefore RYNITE® and CRASTIN® represent no known risk to human health or the environment when land filled.

For any disposal, local regulations have to be observed which can vary significantly from locality to locality.

Polyethylene terephthalate and polybutylene terephthalate are mentioned on the 'green list' of the European Regulation EEC 259/93, Annex II. Thus, RYNITE® and CRASTIN® are not restricted for inter European transport of waste destined for recovery.

Introduction to DuPont's thermoplastic polyester resins

RYNITE® thermoplastic polyester resins, listed in Table 1.1, contain uniformly dispersed glass fibres or mineral/glass combinations in polyethylene terephthalate (PET) resin which has been specially formulated for rapid crystallisation during the moulding process. RYNITE® thermoplastic polyester resins have an outstanding combination of properties – high strength, stiffness, excellent dimensional stability, outstanding chemical and heat resistance, and good electrical properties.

RYNITE® resins are noted for their excellent melt flow characteristics, close moulding tolerances, and high productivity from multicavity moulding. The properties, processing characteristics and competitive price of RYNITE® resins lead to high value-in-use and lower part costs.

CRASTIN® PBT thermoplastic resins, of which the basic grades are listed in Table 1.2, are based on polybutylene terephthalate (PBT) resin, which have been specially formulated for rapid crystallisation during the moulding process and may contain uniformly dispersed glass fibres or glass beads.

As with RYNITE®, the CRASTIN® resins have an outstanding combination of properties, so that they can fulfil the demands of various applications.

The melting point of PBT resins is about 30 K lower than that of PET resins, resulting in lower melt temperatures during moulding as well as slightly lower allowable design temperatures for moulded parts.

1.2 – Standard Rynite® grades, characteristics, typical uses

General purpose grades

Standard grades	Characteristics	Typical uses
Rynite® 530	30 % glass-reinforced modified PET – outstanding balance of strength, stiffness and toughness, good electrical properties, and excellent surface appearance.	Ignition components, coil caps, relay bases, gears, sprockets, carburettor components, various pump housings, vacuum cleaner parts, furniture parts, lamp sockets.
Rynite® 536	36 % glass-reinforced modified PET – high tensile strength. Low outgassing.	Structural parts, brake booster pistons, foglamp housings, various mechanical and structural parts.
Rynite® 545	45 % glass-reinforced modified PET – greater strength and stiffness, excellent dimensional stability and creep resistance.	Lamp housings, compressor housings, fuel, air and temperature sensor housings, frames, filament spools, coil bobbins, transmission components, medical devices.
Rynite® 555	55 % glass-reinforced modified PET – superior stiffness, dimensional stability, heat resistance, and outstanding resistance to creep.	Structural support brackets, clamps, structural housings and covers, transmission components, propellors.

Low warpage grade

Rynite® 935	35 % mica / glass reinforced modified PET – low warpage, good electrical properties, high stiffness, high heat resistance.	Exterior body parts, structural housings and frames, irrigation components, electrical components.
Rynite® 940	40 % mica / glass reinforced modified PET – high stiffness, low warpage, with excellent electrical properties. Best in class adhesion to epoxy resins.	Auto ignition parts and bobbins.

Toughened grades

Rynite® 408	30 % glass-reinforced, toughened PET. High impact resistance, excellent balance of strength, stiffness and toughness	Water pump and structural housings
Rynite® 415HP	15 % glass-reinforced, toughened PET. High impact resistance and elongation at break. Modified for easy, fast processing	Electrical and electronic components, automotive housings and structural parts
Rynite® 425LW	25 % mica / glass, toughened PET. High thermal choc resistance, high flow properties, high adhesion to epoxy potting resins.	Electrical and electronic components, large components with integrated snapfits.

Flame-retardant grade

Rynite® FR530L	Flame-retardant, 30 % glass reinforced modified PET. Recognized by UL as 94 V-0 with a relative temperature index of 155° C. Outstanding balance of properties and excellent flow characteristics.	Electrical and electronic connectors and other components requiring flame-retardant characteristics. Used in applications employing vapour phase and wave soldering techniques. Also used for high temperature bobbins.
Rynite® FR945	Flame-retardant, 45 % glass / mica reinforced PET. Recognized by UL as 94 V-0 with a relative temperature index of 155° C. Very low warpage properties.	Electrical and electronic connectors and other components requiring flame-retardant characteristics. Used in applications employing vapour phase and wave soldering techniques. Also used for high temperature bobbins.

1.2 – Standard Rynite® grades, characteristics, typical uses (continued)

Special grades

	Characteristics	Typical uses
Rynite® 530CS	Modified PET with 30 % glass fibre reinforcement. High colour stability at elevated temperatures.	Toaster housings, oven handles.
Rynite® 936CS	Modified PET with 36 % glass reinforcement. Good colour stability, low warpage.	Housings, oven handles.
Rynite® FR943	Flame-retardant, 43 % glass fibre / glass flake. Recognized by UL as 94 V-0. Very low warpage and colourable.	Electrical and electronical components.

1.3 – Standard Crastin® grades, characteristics, typical uses

General purpose grades

Standard grades	Characteristics	Typical uses
Crastin® S600F10	Unreinforced PBT, high viscosity basic grade.	Moulding with thick wall sections, scissor handles, oven knobs, mechanical parts.
Crastin® S600F20	Unreinforced, medium viscosity.	General purpose resin for parts with thin walls such as automotive connectors.
Crastin® S620F20	Unreinforced, medium viscosity, fast cycling.	Connectors, zippers, oven knobs.
Crastin® SK601	10 % glass-reinforced PBT.	Parts requiring higher HDT than unreinforced PBT, iron skirts, coil formers.
Crastin® SK602	15 % glass-reinforced PBT.	Automotive connectors, housings.
Crastin® SK603	20 % glass-reinforced PBT.	Lighting fixtures, car head lamp, housings.
Crastin® SK605	30 % glass fibre reinforced PBT.	Parts demanding high strength, stiffness and HDT. Automotive structural and electrical components, lamp parts, mechanical components.

Low warpage grades

Crastin® SO653	20 % glass beads filled PBT.	Housings, levers, gears, appliances parts.
Crastin® SO655	30 % glass beads filled PBT, isotropic properties.	Parts demanding higher stiffness and HDT than S600. Housings for mechanical/electrical engineering and appliances.
Crastin® LW9020	20 % glass-reinforced blend PBT-ASA blend.	Connection boxes, connectors, housings in general where low warpage is a must.
Crastin® LW9030	30 % glass-reinforced PBT-ASA blend. Reduced warp tendancy and low shrinkage compared to SK605. High CTI.	Parts which cannot be made in GR-PBT because of warpage. Circular connectors, housings, switch components.

1.3 – Standard Crastin® grades, characteristics, typical uses (continued)

Toughened grades

Crastin® ST820	Unreinforced, impact modified PBT. Tough grade.	Parts demanding high impact resistance, housings, fasteners, mechanical parts.
Crastin® T803	20 % glass-reinforced PBT.	Parts requiring combination of stiffness and toughness such as car ignition bobbins.
Crastin® T805	30 % glass-reinforced Co-PBT. High elongation at break.	Parts demanding high elongation at break and high energy absorption capability. Encapsulation of coil formers (excellent behaviour in thermal cycling).

General purpose, Flame-retardant grades

Crastin® S650FR	Unreinforced PBT, basic grade, UL-94 V-0 at 0,8 mm.	Parts in electrical and electronic industry. Connectors.
Crastin® S680FR	Unreinforced PBT, basic grade, no blooming.	Parts with very thin walls such as connectors, capacitors housings, jonction blocks.
Crastin® SK641FR	10 % glass-reinforced PBT.	Parts of electrical and electronic industry.
Crastin® SK643FR	20 % glass-reinforced PBT.	Parts of electrical and electronic industry.
Crastin® SK645FR	30 % glass fibre reinforced PBT, UL-94 V-0 at 0,75 mm.	Parts in electrical and electronic industry. Connectors, coil formers, relay parts.
Crastin® SK655FR1	30 % glass fibre reinforced PBT, UL-94 V-0 at 0,4 mm.	Parts where high flow and low outgassing are key such as circuit breakers, relay parts, connectors.

Toughened, Flame-retardant grades

Crastin® T841FR	10 % glass-reinforced Co-PBT.	Parts in E/E industry demanding good flexibility and toughness. Connectors, housings with snap-fits.
Crastin® T843FR	20 % glass-reinforced Co-PBT.	Parts in E/E industry demanding good flexibility and toughness. Connectors, housings with snap-fits.
Crastin® T845FR	30 % glass-reinforced Co-PBT. High elongation at break. UL94 V-0 at 1,5 mm.	Parts in E/E industry demanding good flexibility and toughness. Connectors, housings with snap-fits.
Crastin® T850FR	Unreinforced, impact modified PBT. Tough grade. V-0 at 1,5 mm. CTI >600.	Parts in electrical and electronic industry. Telecom connectors.

Low warpage, Flame-retardant grades

Crastin® LW9020FR	20 % glass-reinforced PBT-ASA blend.	Parts where SK645FR cannot be used because very low warpage is required. Connectors, housings.
Crastin® LW9030FR	30 % glass-reinforced PBT-ASA blend. Reduced warp tendancy and low shrinkage compared to SK645FR or CE7931. UL94 V-0 at 1,5 mm. CTI 375 V.	Parts where SK645FR cannot be used because very low warpage is required. Connectors, housings.

2 – Summary of properties

2.1 – Properties of RYNITE® PET thermoplastic polyester resins

					Glass reinforced			Flame retardant
	Property		**Test method ISO**	**Units**	**530**	**545**	**555**	**FR530L**
MECHANICAL	Stress at break 1)		527-1/2	MPa				
		−40°C			218	242	221	193
		23°C			158	185	196	135
		93°C			83	92	96	72
		150°C			55	67	71	45
	Strain at break 1)		527-1/2	%				
		−40°C			2,5	2	1	1,9
		23°C			2,5	2	2	2
		93°C			6	5	4	3,5
		150°C			7	6	5	4
	Tensile Modulus		527-1/2	MPa	11000	16000	19500	12000
	Flexural Modulus		178	MPa				
		−40°C			10300	15200	20700	11000
		23°C			9000	13800	17900	9900
		93°C			3600	5500	9200	4600
		150°C			2700	4000	5700	2600
	Izod impact strength		180	kJ/m²				
	– notched	−30°C			10		16	9,5
		23°C			10	11	15	8,0
	Charpy impact strength			kJ/m²				
	– notched	23°C	179/1eA		11	11	12	8,5
		−30°C			11	11	12	8,5
	– unnotched	23°C	179/1eU		70	60	50	40
		−30°C			45	40	45	33
	Tensile Creep Modulus (1000 h)	23°C	899	MPa	8800	13300	15300	9700
THERMAL	Melting temperature 2)		3146C	°C	250	250	250	250
	Temperature of deflection under load 3)	1,8 MPa	75	°C	224	226	229	224
	Thermal conductivity	C-177	W/m·K		0,29	0,32	0,33	0,25
	Vicat softening temperature	B/50	306	°C	228	230	230	218
	Temperature index :	(0,8 mm)	UL 746B	°C				
	Electrical				140	140	140	150
	Mechanical w. impact				140	140	140	150
	Mechanical w/o impact				140	140	140	150

1) Testing speed 5 mm/min.
2) Melting temperature determined by different thermal analysis.
3) Deflection temperature under flexural load, annealed 30 minutes in oil at 50°C below melting point.
4) Flame-retarded resins are subject to specific UL processing and handling regulations for applications where an official UL rating is required. For more detailed information, please contact your DuPont representative.
5) Numerical flame test ratings are not intended to represent behaviour of moulded parts in real life fire conditions; each enduser must determine whether any potential flammability hazards exist with parts moulded from RYNITE®. UL yellow card available upon request.

Colour stable		Toughened		Mineral reinforced
530CS	**936CS**	**408**	**415HP**	**935**
		206	145	121
180	122	126	79	85
		70	45	44
		55	36	30
		3,0	3	2
2,5	2	3,3	5	2
		7	14	5
		7,5	14,2	5
11000	11200	9300	4700	10200
		8900	5900	11800
		8300	3600	9600
		3000	1300	3400
		2300	1100	2200
			7,7	4
9,5	3,8	12	12,5	5
10,5	5,2	14	11	6
			8	4
50	22	70	55	25
			25	20
				7700
250	250	250	250	250
227	203	220	207	200
		0,29		0,26
			206	204
		140	140	140
		140	120	140
		140	140	140

All the above information is subject to the disclaimer printed on the back page of this document.

Properties of RYNITE® PET thermoplastic polyester resins (continued)

	Property		Test method ISO	Units	Glass reinforced 530	545	555	Flame retardant FR530L
ELECTRICAL	Volume resistivity		IEC 60093	Ohm · cm	10^{15}	10^{15}		10^{15}
	Surface resistivity		IEC 60093	Ohm	10^{14}	10^{14}		10^{14}
	Relative permittivity							
		10^2 Hz	IEC 60250		4,2	4,5	4,8	4,8
		10^6 Hz			3,9	4,4	4,7	4,7
	Electric strength			kV/mm				
	1,0 mm disk	23 °C	IEC 60243-1		35	32	35	33
	Dissipation factor		IEC 60250	10^{-4}				
		10^2 Hz			130	70	70	70
		10^6 Hz			70	110	70	100
	Arc resistance		UL 746A	s	125	126	126	117
	Comparative tracking		UL 746A	PLC level*	2	2	3	2
	Index (CTI)		IEC 60112	V	250	250	200	250
FLAMMABILITY	Flammability [4), 5)]		UL-94					V-0
	0,8 mm				HB	HB	HB	at 0,35 mm
	Oxygen index		4589	%	20	20	22	33
	Glow wire flammability	2 mm	IEC 60695-2-1	°C	750	750		960 (at 1,2 mm)
		3 mm			750	850		960
MISCELLANEOUS	Density		1183	g/cm³	1,56	1,69	1,80	1,67
	Humidity absorption, 50 % RH, 23 °C		62	%	0,2	0,14	0,11	0,17
	Water absorption, saturation, 23 °C				0,78	0,62	0,59	0,77
	Hardness Rockwell		2039/2					
	scale M				100	100	100	100
	scale R				120	120	120	120
	Mould shrinkage (3,2 mm) approx.			%				
	parallel				0,2	0,2	0,2	0,2
	normal				0,9	0,8	0,7	0,9
	Coefficient of friction		ASTM D 1894					
	against self				0,18	0,17	0,27	0,18
	against steel				0,17	0,20	0,18	0,19
	Taber abrasion		ASTM D 1044	mg/1000 cycles				
	CS-17 wheel, 1000 g				30	44		38

1) Testing speed 5 mm/min.
2) Melting temperature determined by different thermal analysis.
3) Deflection temperature under flexural load, annealed 30 minutes in oil at 50 °C below melting point.
4) Flame-retarded resins are subject to specific UL processing and handling regulations for applications where an official UL rating is required. For more detailed information, please contact your DuPont representative.
5) Numerical flame test ratings are not intended to represent behaviour of moulded parts in real life fire conditions; each enduser must determine whether any potential flammability hazards exist with parts moulded from RYNITE®. UL yellow card available upon request.

Colour stable		Toughened		Mineral reinforced
530CS	**936CS**	**408**	**415HP**	**935**
		10^{15}	10^{13}	10^{15}
		10^{14}	10^{13}	10^{14}
				4,5
		3,3		4,1
				39
				300
		150		250
			95	131
		2	2	2
250		250	250	325
		HB	HB	HB
			19	
1,59	1,63	1,49	1,39	1,58
			0,25	0,13
			2,5	0,83
		70	58	75
		115	111	115
0,2	0,25	0,2	0,3	0,4
		0,7	1,0	0,8
			0,42	0,21
			0,27	0,19
			35	

*

PLC leveL			CTI
0		TI ≥	600
1	600 ≥	TI≥	400
2	400 ≥	TI≥	250
3	250 ≥	TI ≥	175
4	175 ≥	TI ≥	100
5	100 ≥	TI ≥	0

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2.2 – Properties of non-flame retardant CRASTIN® PBT grades

	Property	Test conditions	Method ISO	Units	Unreinforced		Glass reinforced			Glass beads filled
					Multi-purpose S600F10	High impact ST820	Multi-purpose SK605	Low warpage LW9030	High impact T805	Low warpage SO655
MECHANICAL	Yield stress [1]	23 °C	527-1/2	MPa	58	35	*	*	*	*
	Yield strain [1]	23 °C	527-1/2	%	3,6	9	*	*	*	*
	Stress at break [1]	23 °C	527-1/2	MPa	*	*	140	135	100	57
	Strain at break[1]	50 mm/min	527-1/2	%	>50	>50	*	*	*	*
		5 mm/min	527-1/2	%	*	*	2,6	2,8	4,2	5,8
	Tensile modulus [1]	1 mm/min	527-1/2	MPa	2700	1600	10000	9500	7000	4000
	Tensile creep modulus [1]	1 h	899	MPa	2600	–	9000	9000	6200	3600
		1000 h			1800	–	6600	7300	4000	2500
	Flexural strength[2]		178	MPa	85	67	210	190	160	95
	Ball indentation hardness[2]	H 358/30	2039-1	MPa	139	78	–	–	150	170
		H 961/30			–	–	200	175	–	–
	Izod notched impact strength[2]									
		23 °C	180/1A	kJ/m^2	6,5	58	11	10	12	4
		−30 °C			6	10	9	8	10	3
	Izod Impact strength	23 °C	180/1U	kJ/m^2	NB	NB	56	50	50	26
		−30 °C			130	215	55	50	50	25
	Charpy notched impact strength[3]									
		23 °C	179/1eA	kJ/m^2	4,2	87	12,4	10,4	14,5	4,2
		−30 °C			4	12,8	11,1	9,3	12,6	3,5
	Charpy Impact strength	23 °C	179/1eU	kJ/m^2	NB	NB	69	63	77	49
		−30 °C			NB	NB	82	66	89	50
THERMAL	Melting temperature	10 K/min	DSC	°C	225	225	225	225	206	225
	Temperature of deflection under load [4]	0,45 MPa	75	°C	160	105	220	215	205	212
		1,8 MPa			60	48	205	182	190	99
		5,0 MPa			*	*	179	*	152	*
	Coefficient of linear thermal expansion	parallel	ASTM E 831	10^{-4}/K	1,3	1,9	0,3	0,25	0,3	1,0
		normal			1,3	1,9	0,9	1,0	1,2	1,0
	Thermal conductivity		DIN 51046	W/m·K	0,25		0,28	0,26	0,28	0,28
	Vicat softening temperature[5]	50 K/h; 10 N	306	°C	216	216	221	214	205	210
		50 K/h; 50 N			175	123	213	150	191	198
	Hot ball pressure test	Plate 3 mm	VDE 0470	°C	180	–	210	180	200	190
	Temperature index		UL 746B	°C	0,75 mm	–	0,75 mm	3,0 mm	1,5 mm	0,8 mm
	electrical				130	–	130	130	140	120
	mechanical with impact				115	–	130	130	130	120
	mechanical without impact				120	–	130	130	140	120
	Stress at break	5000 h	IEC 60216	°C	130	–	165	160	155	150
		20000 h			120	–	145	145	140	135

* Properties are not applicable for this material.
1) Tensile test bar 4 mm (ISO 3167).
2) Test bar of 80 × 10 × 4 mm.
3) Test bar of 80 × 10 × 4 mm.
4) Test bar of 110 × 10 × 4 mm.
5) Specimen of ≥10 × 10 × 4 mm.

	Property	Test conditions	Method ISO	Units	Unreinforced: Multi-purpose S600F10	Unreinforced: High impact ST820	Glass reinforced: Multi-purpose SK605	Glass reinforced: Low warpage LW9030	Glass reinforced: High impact T805	Glass beads filled: Low warpage S0655
ELECTRICAL	Volume resistivity 6)		IEC 60093	ohm cm	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{15}$	$>10^{16}$	$>10^{15}$
	Surface resistivity 6)		IEC 60093	ohm	$>10^{14}$	$>10^{14}$	$>10^{14}$	$>10^{13}$	$>10^{14}$	$>10^{14}$
	Relative permittivity 7)	50 Hz	IEC 60250		3,8	–	4,4	3,8	4,4	4,6
		10^6 Hz			3,2	–	3,8	3,6	4,0	3,9
	Dissipation factor 7)	50 Hz	IEC 60250	$\times 10^{-4}$	20	–	25	30	95	136
		10^6 Hz			200	–	180	170	218	190
	Electric strength, 1 mm plate	P25/P75 7)	IEC 60243-1	kV/mm	26	–	31	36	29	25
	2 mm plate	20 s			15	–	17	21	17	17
	Electrolytical corrosion 8)		IEC 60426	rating	A1	–	A1	A1	A1	A1
	Arc resistance	4 mm plate	ASTM D495	s	160	–	124	121	116	110
	Comparative tracking index 9)	CTI	IEC 60112	rating	>600	>600	450	550	500	250
		CTI-M			350 M	>600 M	200 M	175 M	200 M	200 M
FLAMMABILITY	Flammability	0,8 mm	UL 94	rating	HB	–	HB	–	HB	HB
		1,6 mm	UL 94	rating	HB	HB	HB	HB	HB	HB
		1,6 mm	ASTM D635	cm/min	2,6	4,6	3,0	5,0	3,5	2,7
	Oxygen Index		ASTM D2863	%	22	–	19	19	19	22
	Glow wire flammability	Plate 3 mm	IEC 60695-2-1	°C	750	700	750	650	750	750
MISC.	Density 10)		1183	g/cm³	1,31	1,21	1,53	1,43	1,50	1,53
	Humidity absorption	23°C, 50% RH	62	%	0,20	–	0,13	0,24	0,14	0,12
	Water absorption	23°C, saturation	62	%	0,50	–	0,37	0,72	0,35	0,35
PROCESSING	Melt temperature			°C	240-260	240-260	240-260	230-260	230-260	240-260
	Mould temperature			°C	ca. 80	ca. 60	ca. 80	ca. 80	ca. 80	ca. 80
	Moulding shrinkage	Specimen of 100 × 100 × 2 mm	DIN 16901	%						
		parallel			1,6	2,2	0,3	0,2	0,25	1,4
		normal			1,6	2,2	1,0	0,5	0,7	1,4
	Flow length (spiral flow) at 100 MPa injection pressure	7 × 2 mm	–	mm	350	300	375	400	425	255

6) Specimen of 80 × 80 × 1 mm. According to Campus, version 1.2 (measured without sticking electrode).
7) Specimen of 80 × 80 × 1 mm, measured with silver paint.
8) Specimen of 30 × 10 × 4 mm.
9) Specimen of >15 × >15 × 4 mm.
10) Specimen of >10 × 10 × 4 mm.

Properties of flame retardant Crastin® PBT grades

					Unreinforced		Glass reinforced		
	Property	Test conditions	Method ISO	Units	Multi-purpose S650FR	High impact T850FR	Multi-purpose SK645FR	Low warpage LW9030FR	High impact T845FR
MECHANICAL	Yield stress[1)]	23 °C	527-1/2	MPa	65	47	*	*	*
	Yield strain[1)]	23 °C	527-1/2	%	3,7	3,4	*	*	*
	Stress at break[1)]	23 °C	527-1/2	MPa	58	45	140	125	110
	Strain at break[1)]	50 mm/min	527-1/2	%	9	20	*	*	*
		5 mm/min	527-1/2	%	13,0	25,0	2,5	2,2	3,7
	Tensile modulus	1 mm/min	527-1/2	MPa	2900	2400	12000	10500	8500
	Tensile creep modulus	1 h	899	MPa	2500	–	11000	9500	7800
		1000 h			1800	–	8000	7400	5200
	Flexural strength[2)]		178	MPa	100	78	215	185	170
	Ball indentation hardness[2)]	H 358/30	2039-1	MPa	150	100	–	–	153
		H 961/30			–	–	214	170	–
	Izod notched Impact strength[2)]								
		23 °C	180/1A	kJ/m²	4	11	9	8	11
		–30 °C			4	7	8	7	9
	Izod Impact strength	23 °C	180/1U	kJ/m²	45	125	40	35	44
		–30 °C			42	70	40	35	44
	Charpy notched Impact strength[3)]								
		23 °C	179/1eA	kJ/m²	4,0	12,6	9,5	8,7	10,9
		–30 °C			3,3	5,1	9,4	8,1	10
	Charpy Impact strength	23 °C	179/1eU	kJ/m²	88	NB	56	48	56
		–30 °C			67	NB	57	40	65
THERMAL	Melting temperature	10 K/min	DSC	°C	225	225	225	225	210
	Temperature of deflection under load[4)]	0,45 MPa	75	°C	160	167	220	220	205
		1,8 MPa			65	60	210	190	192
		5,0 MPa			*	*	186	130	165
	Coefficient of linear thermal expansion	parallel	ASTM E 831	10^{-4}/K	1,2	1,4	0,3	0,25	0,3
		normal			1,2	1,4	0,9	0,8	1,2
	Thermal conductivity		DIN 51046	W/m·K	0,26		0,29	0,26	0,29
	Vicat softening temperature[5)]	50 K/h; 10 N	306	°C	215	214	218	215	203
		50 K/h; 50 N			177	162	212	150	190
	Hot ball pressure test	Plate 3 mm	VDE 0470	°C	190	180	210	180	180
	Temperature index		UL 746B	°C	0,75 mm	1,5 mm	3,0 mm	3,0 mm	3,0 mm
	electrical				130	75	140	140	140
	mechanical with impact				130	75	130	130	140
	mechanical without impact				130	75	140	140	140
	Stress at break	5000 h	IEC 60216	°C	145	–	165	160	160
		20000 h			130	–	145	145	145

* Properties are not applicable for this material.
1) Tensile test bar 4 mm (ISO 3167).
2) Test bar of 80 × 10 × 4 mm.
3) Test bar of 80 × 10 × 4 mm.
4) Test bar of 110 × 10 × 4 mm.
5) Specimen of ≥10 × 10 × 4 mm.

	Property	Test conditions	Method ISO	Units	Unreinforced		Glass reinforced		
					Multi-purpose S650FR	High impact T850FR	Multi-purpose SK645FR	Low warpage LW9030FR	High impact T845FR
ELECTRICAL	Volume resistivity [6)]		IEC 60093	ohm cm	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{15}$	$>10^{16}$
	Surface resistivity [6)]		IEC 60093	ohm	$>10^{14}$	$>10^{14}$	$>10^{14}$	$>10^{13}$	$>10^{14}$
	Relative permittivity [7)]	50 Hz	IEC 60250		3,5	3,4	4,5	3,8	4,2
		10^6 Hz			3,5	3,2	3,8	3,6	4,0
	Dissipation factor [7)]	50 Hz	IEC 60250	$\times 10^{-4}$	17	10	30	30	130
		10^6 Hz			180	180	160	150	170
	Electric strength, 1 mm plate	P25/P75	IEC 60243-1	kV/mm	25	27	28	29	27
	2 mm plate	20 s			15	17	17	20	16
	Electrolytical corrosion [8)]		IEC 60426	rating	A1	A1,2	A1,2	A1, 2	A1
	Arc resistance	4 mm plate	ASTM D495	s	54	65	122	105	82
	Comparative tracking index [9)]	CTI	IEC 60112	rating	250	>600	250	375	300
		CTI-M			175 M	275 M	175 M	175 M	175 M
FLAMMABILITY	Flammability	0,8 mm	UL 94	rating	V-0	–	V-0	–	–
		1,6 mm	UL 94	rating	V-0	V-0	V-0	V-0	V-0
		1,6 mm	ASTM D635	s	<5	<5	<5	<5	<5
		1,6 mm	ASTM D635	mm	<5	<5	<5	<5	<5
	Oxygen Index		ASTM D2863	%	30	29	31	27	30
	Glow wire flammability	Plate 3 mm	IEC 60695-2-1	°C	960	960	960	960	960
MISC.	Density [10)]		1183	g/cm^3	1,47	1,40	1,69	1,56	1,69
	Humidity absorption	23°C, 50% RH	62	%	0,15	0,22	0,10	0,21	0,10
	Water absorption	23°C, saturation	62	%	0,39	0,55	0,30	0,72	0,27
PROCESSING	Melt temperature			°C	240-260	240-260	240-260	240-260	230-250
	Mould temperature			°C	ca. 80	ca. 80	ca. 80	ca. 80	ca. 80
	Moulding shrinkage	Specimen of 100 × 100 × 2 mm	DIN 16901	%					
		parallel			1,7	1,9	0,35	0,25	0,25
		normal			1,7	1,9	1,0	0,55	0,9
	Flow length (spiral flow) at 100 MPa injection pressure	7 × 2 mm	–	mm	360	370	425	380	330

6) Specimen of 80 × 80 × 1 mm. According to Campus, version 1.2 (measured without sticking electrode).
7) Specimen of 80 × 80 × 1 mm, measured with silver paint.
8) Specimen of 30 × 10 × 4 mm.
9) Specimen of >15 × >15 × 4 mm.
10) Specimen of >10 × 10 × 4 mm.

3 – Mechanical properties

3.1 – Tensile strength, stress-strain

RYNITE® thermoplastic polyester resins exhibit high strength over a wide temperature range.

Stress-strain curves of several RYNITE® grades are given in Figures 3.1.1 – 3.1.11.

If you are looking for stress-strain curves of other RYNITE® grades, please check in the newest available Campus version.

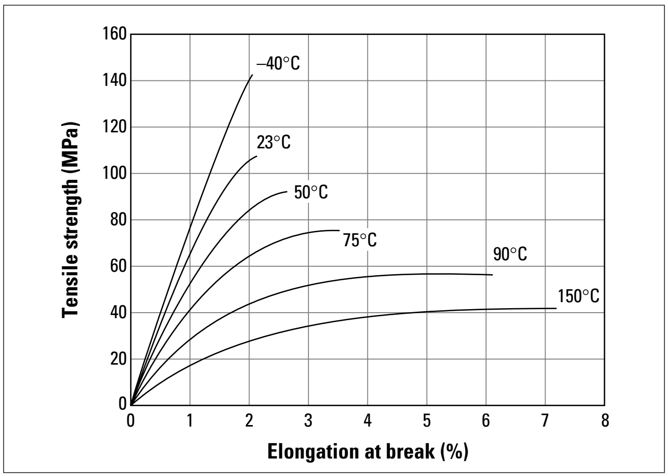


Fig 3.1.1 **Stress-strain curves for RYNITE® 520 NC010**

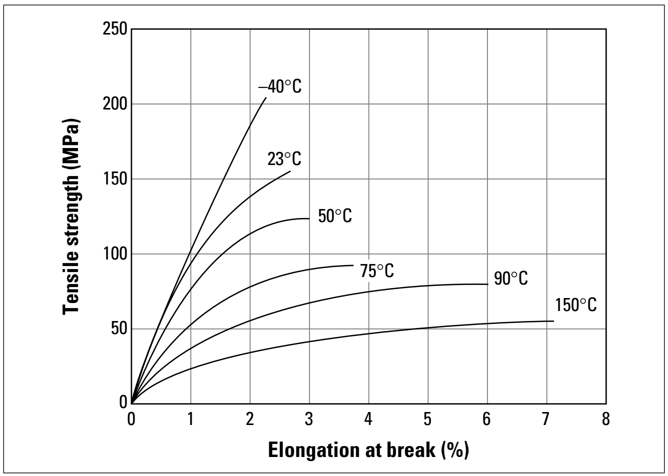


Fig 3.1.2 **Stress-strain curves for RYNITE® 530 NC010**

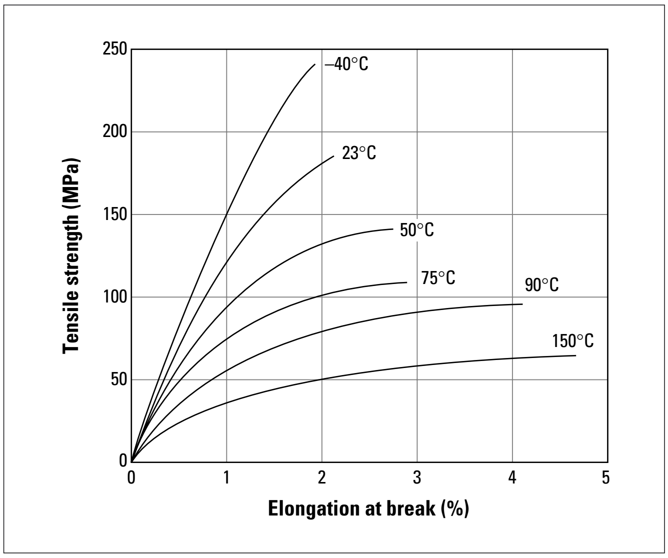


Fig 3.1.3 **Stress-strain curves for RYNITE® 545 NC010**

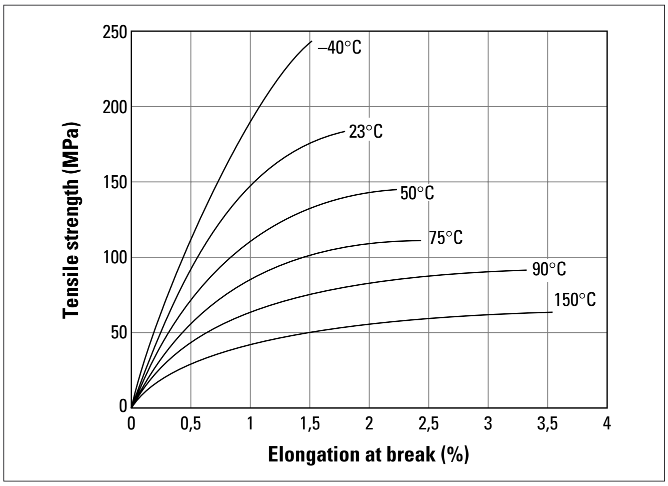


Fig 3.1.4 **Stress-strain curves for RYNITE® 555 NC010**

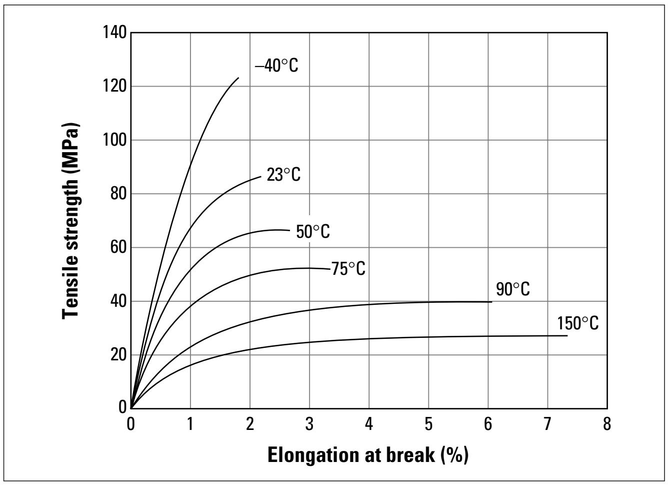


Fig 3.1.5 **Stress-strain curves for RYNITE® 935 NC010**

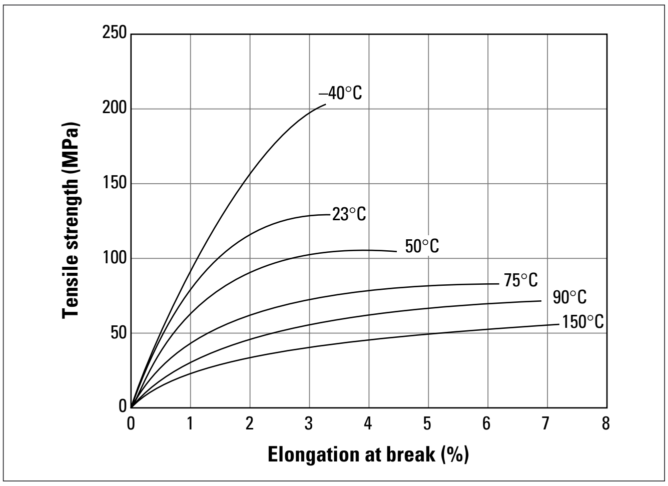


Fig 3.1.6 **Stress-strain curves for RYNITE® 408 NC010**

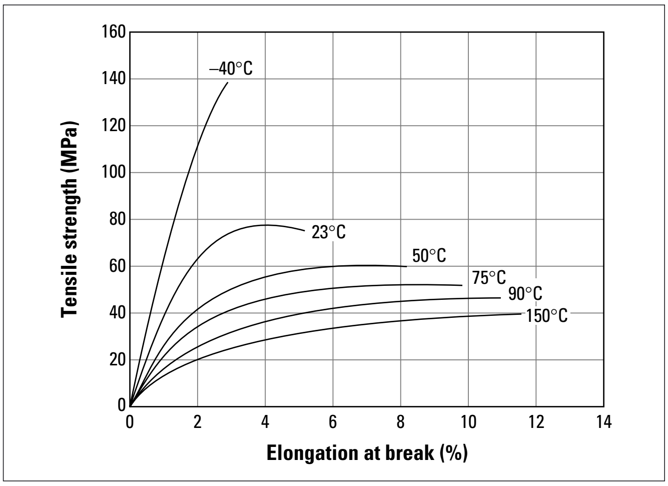


Fig 3.1.7 **Stress-strain curves for RYNITE® 415HP NC010**

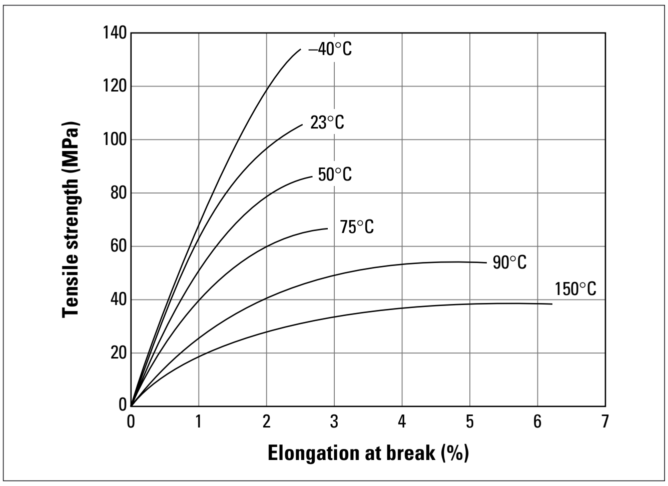


Fig 3.1.8 **Stress-strain curves for RYNITE® FR515 NC010**

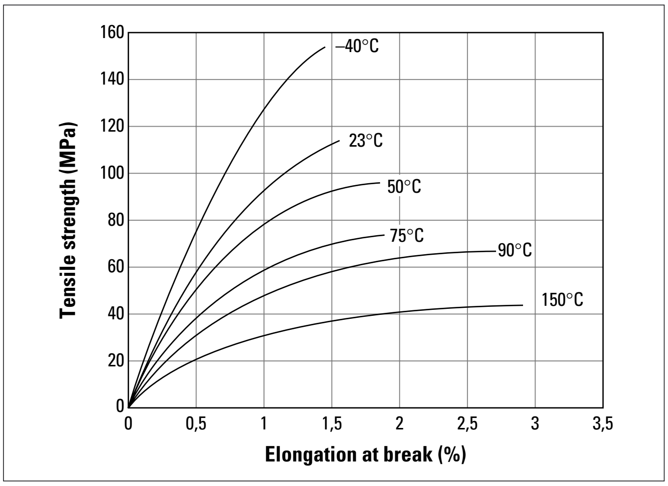


Fig 3.1.9 **Stress-strain curves for RYNITE® FR943 NC010**

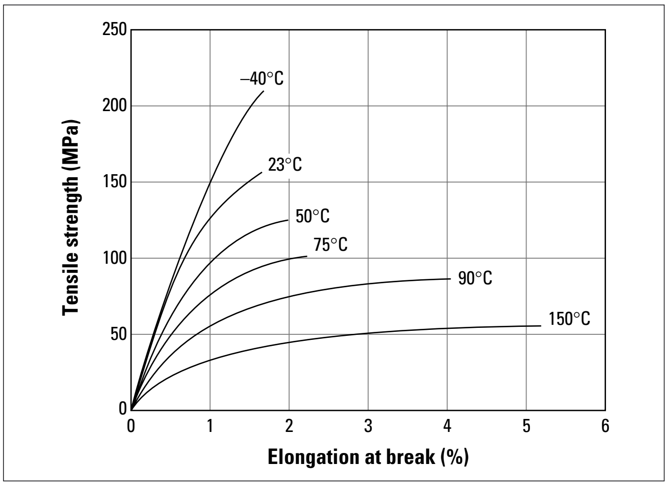


Fig 3.1.10 **Stress-strain curves for RYNITE® FR543 NC010**

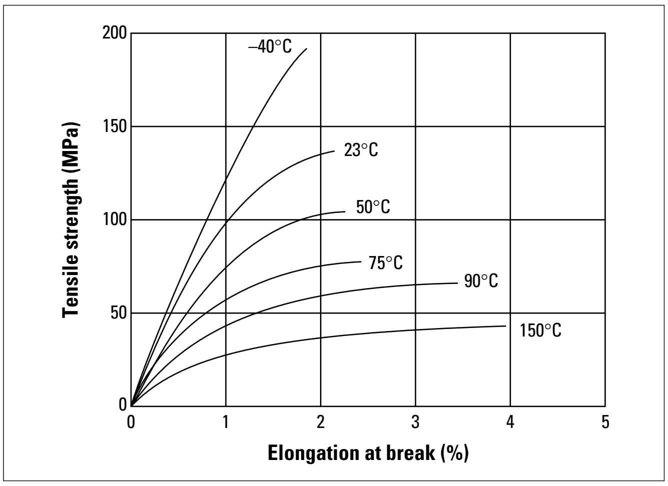


Fig 3.1.11 **Stress-strain curves for RYNITE® FR530L NC010**

CRASTIN® thermoplastic polyester resins are designed for applications within the range of intermediate strength/ stiffness to high strength/stiffness. The amount and type of reinforcement plays an important role. Stress-strain curves of several CRASTIN® grades are given in Figures 3.1.12 – 3.1.29.

If you are looking for stress-strain curves of other CRASTIN® grades, please check in the newest available Campus version.

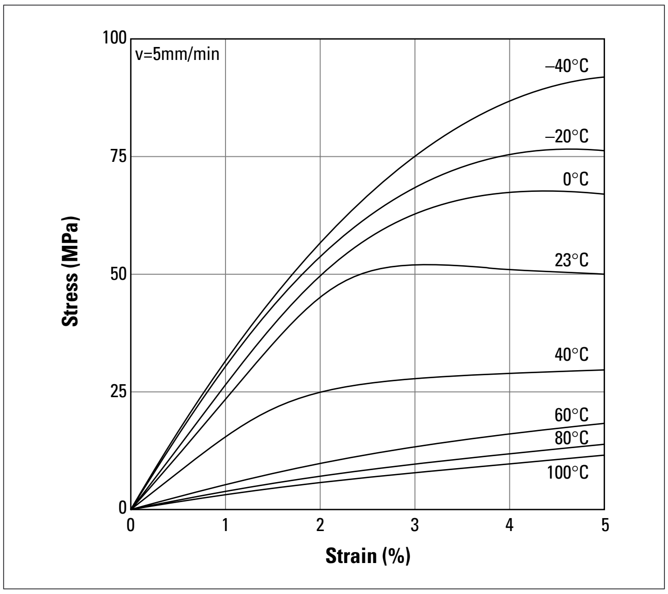


Fig 3.1.12 **Stress-strain curves for CRASTIN® S600F10**

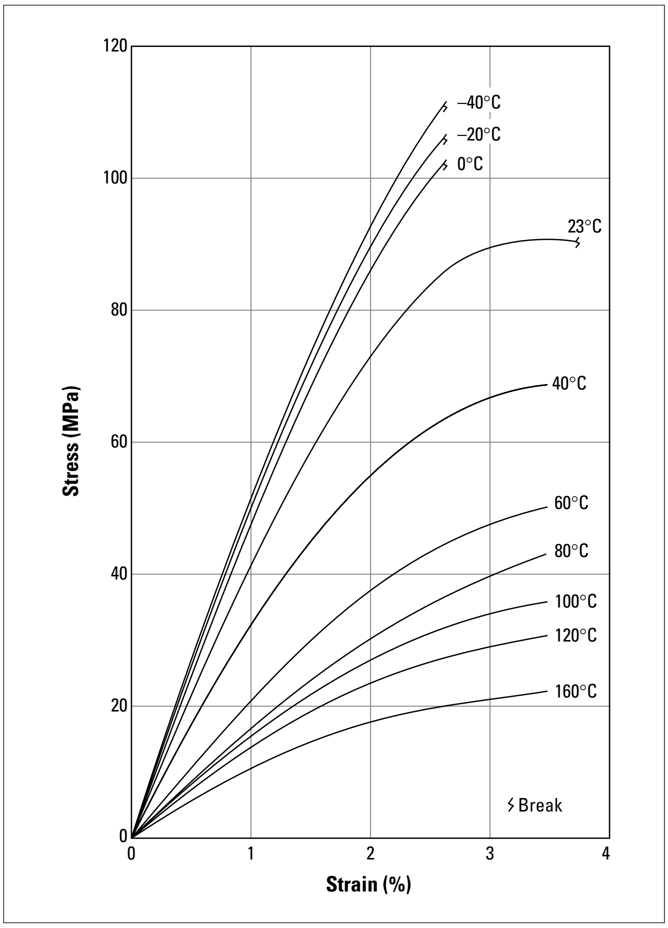


Fig 3.1.13 **Stress-strain curves for CRASTIN® SK601**

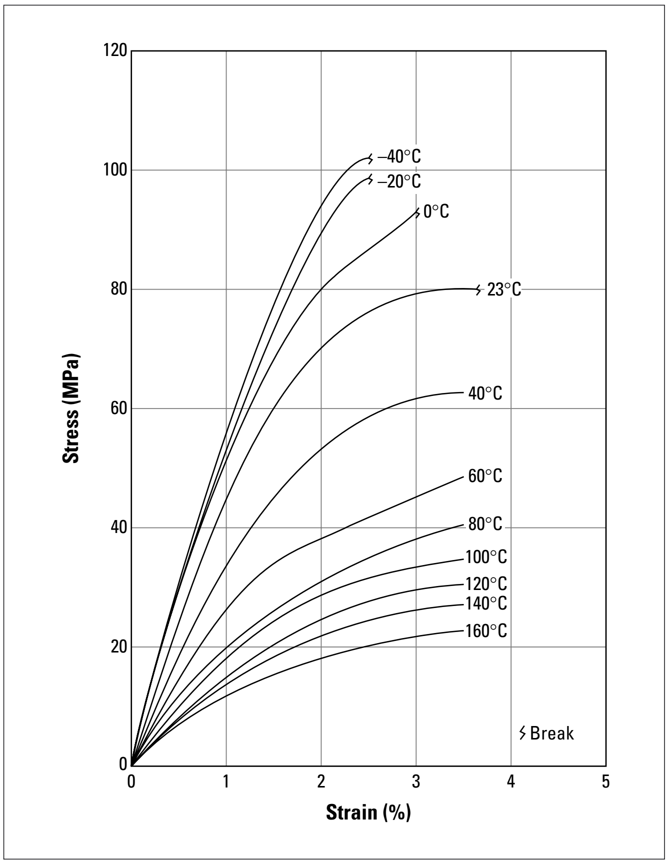


Fig 3.1.14 **Stress-strain curves for CRASTIN® SK602**

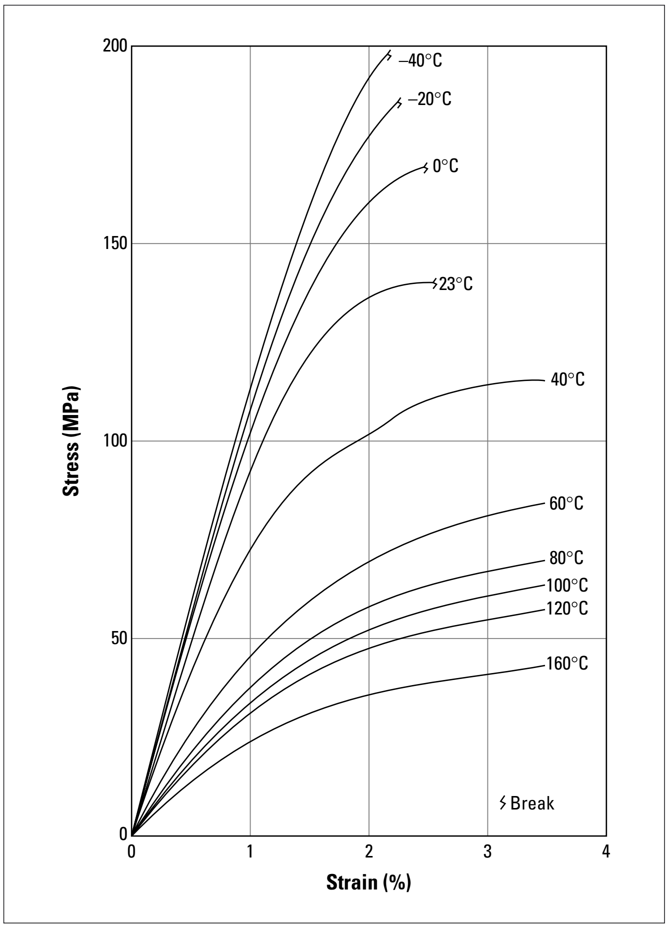


Fig 3.1.15 **Stress-strain curves for CRASTIN® SK605**

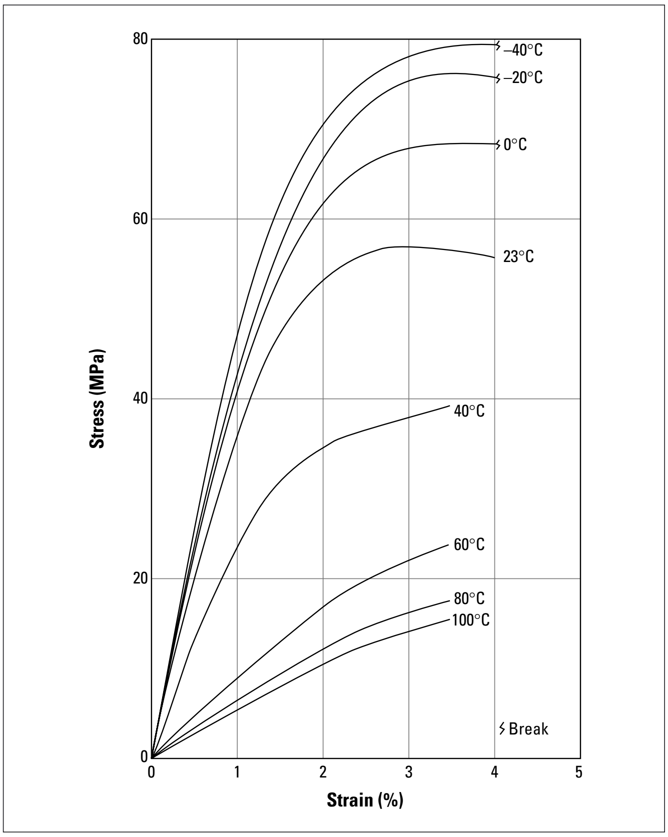


Fig 3.1.16 **Stress-strain curves for Crastin® SO655**

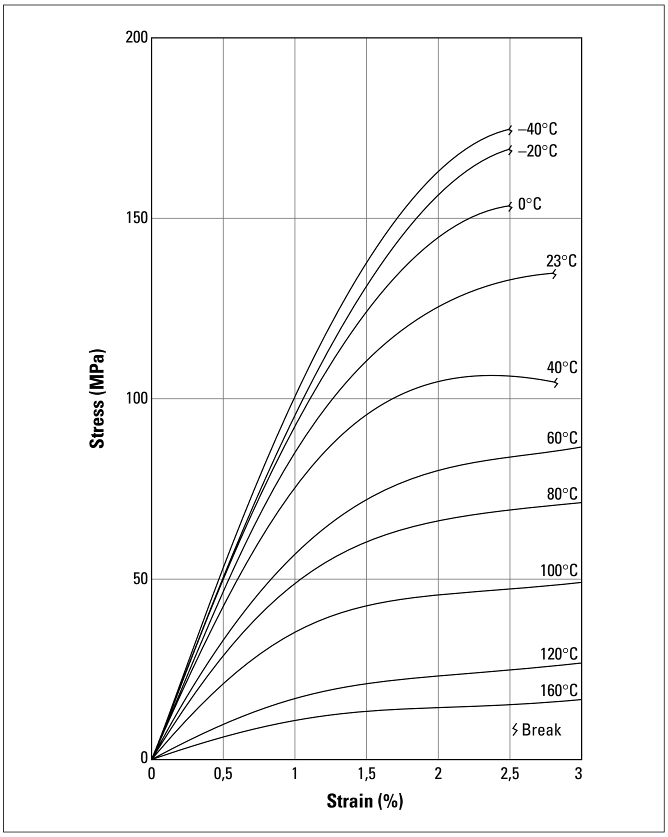


Fig 3.1.18 **Stress-strain curves for Crastin® LW9030**

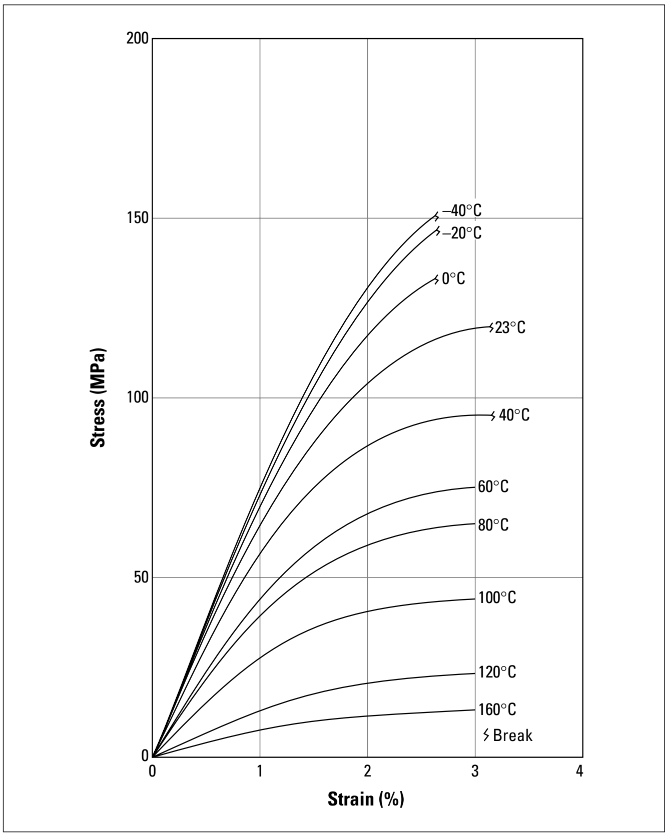


Fig 3.1.17 **Stress-strain curves for Crastin® LW9020**

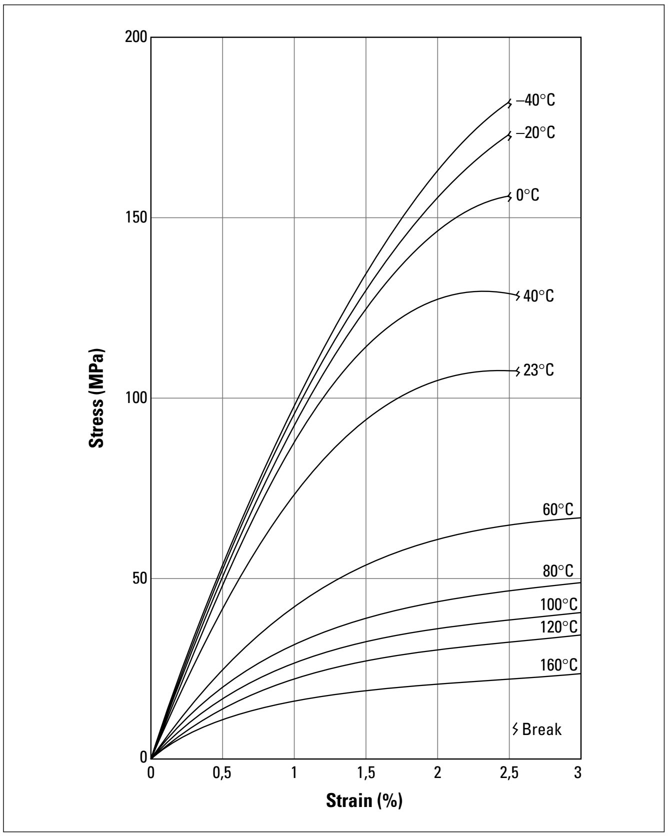


Fig 3.1.19 **Stress-strain curves for Crastin® LW9130**

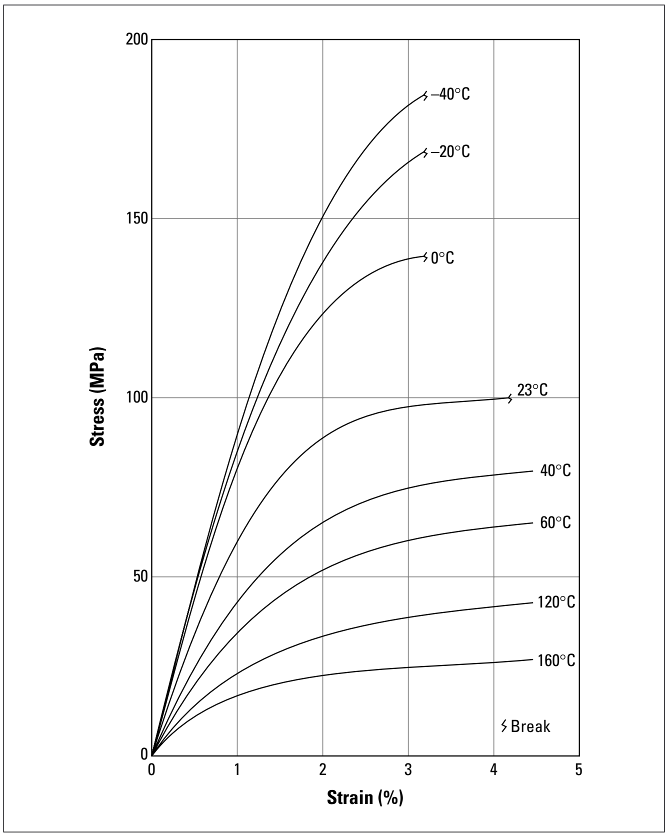


Fig 3.1.20 **Stress-strain curves for Crastin® T805**

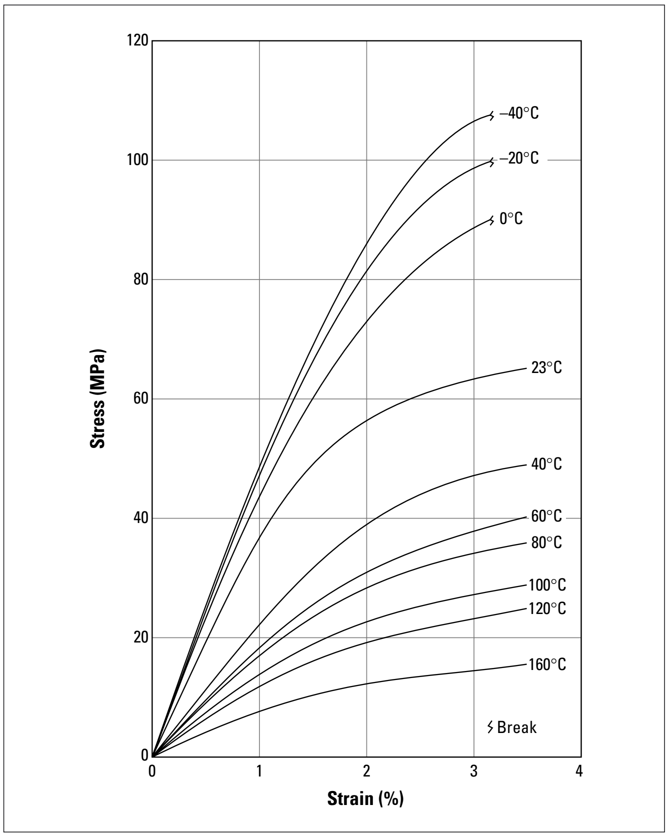


Fig 3.1.22 **Stress-strain curves for Crastin® T841FR**

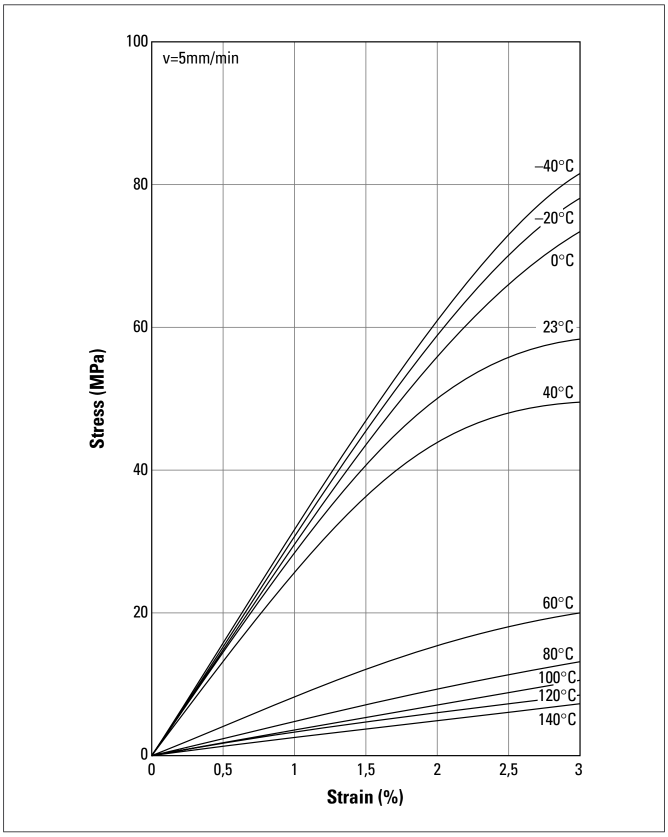


Fig 3.1.21 **Stress-strain curves for Crastin® S650FR**

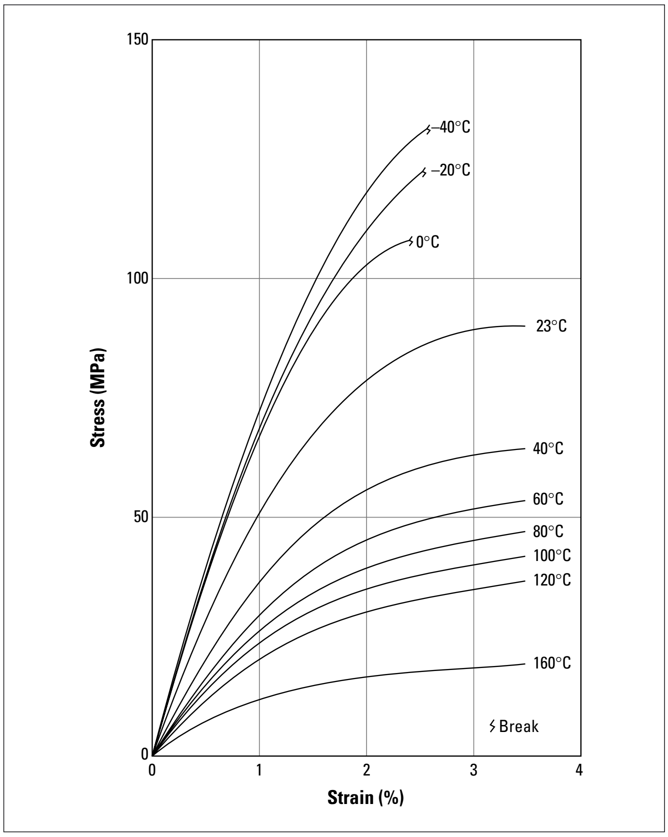


Fig 3.1.23 **Stress-strain curves for Crastin® T843FR**

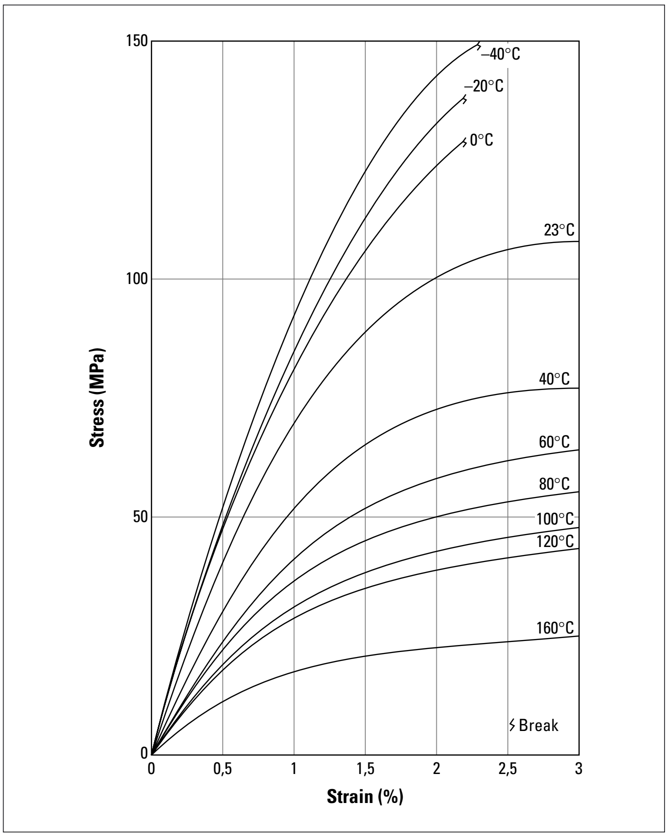


Fig 3.1.24 **Stress-strain curves for Crastin® T845FR**

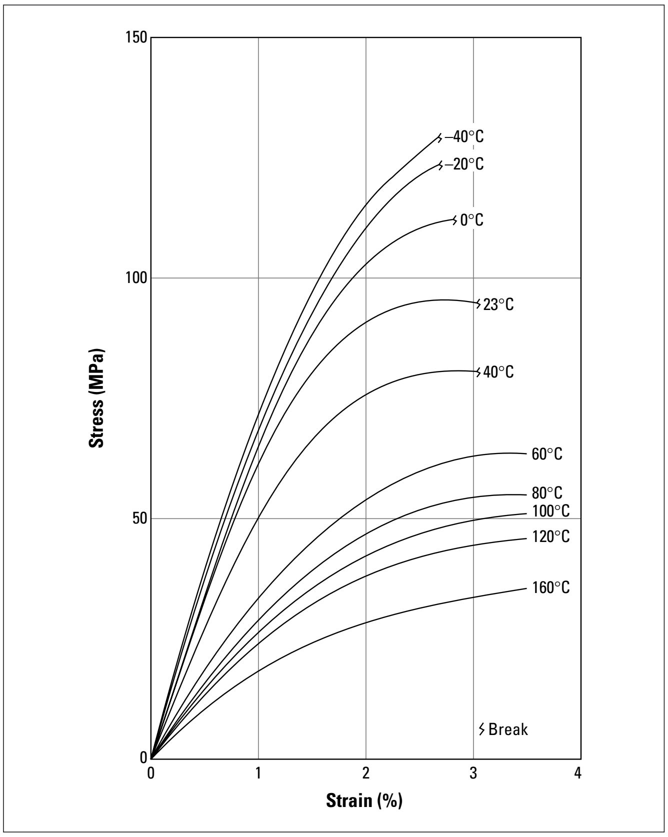


Fig 3.1.26 **Stress-strain curves for Crastin® SK642FR**

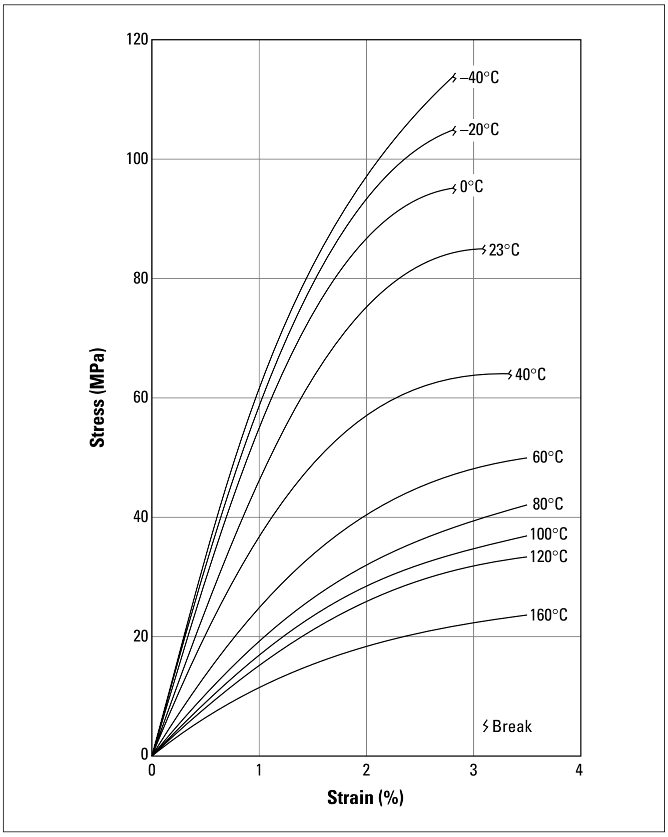


Fig 3.1.25 **Stress-strain curves for Crastin® SK641FR**

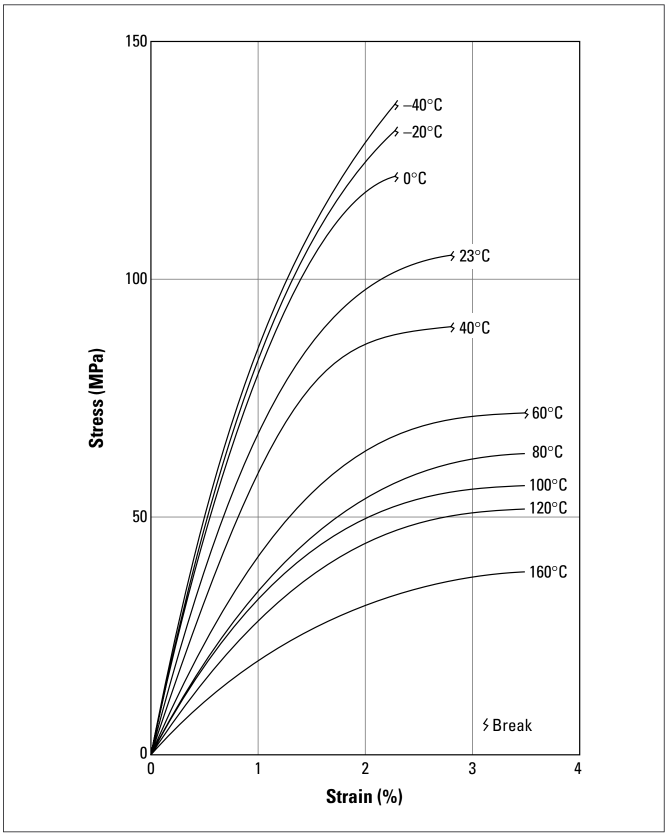


Fig 3.1.27 **Stress-strain curves for Crastin® SK643FR**

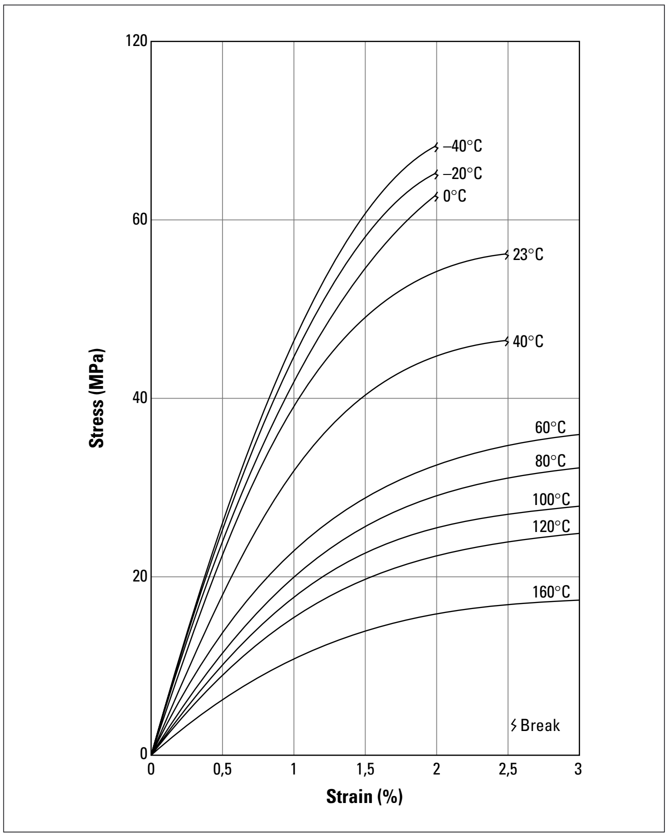


Fig 3.1.28 **Stress-strain curves for CRASTIN® SK645FR**

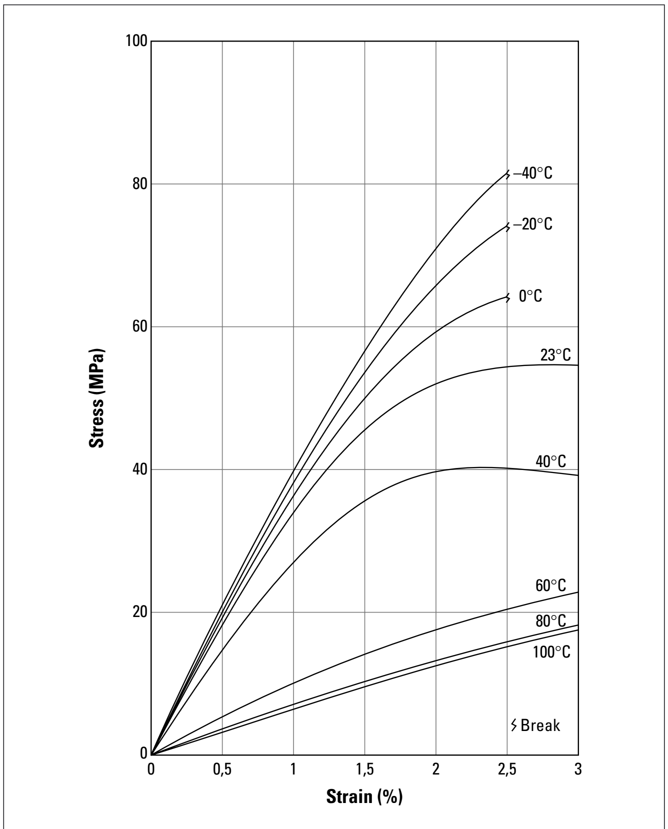


Fig 3.1.29 **Stress-strain curves for CRASTIN® HTI681FR**

The tensile strength of polyester resins is, as for many other mechanical properties, dependant on temperature. For the tensile strength of some CRASTIN® grades, see Figures 3.1.30 – 3.1.34.

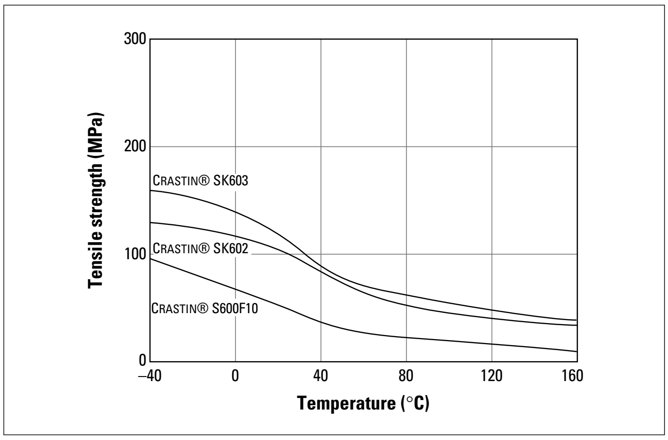


Fig 3.1.30 **Tensile strength as function of temperature for CRASTIN® S600F10, SK602 and SK603**

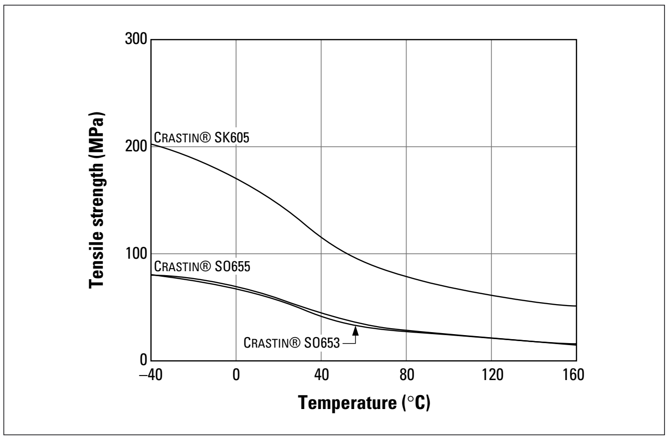


Fig 3.1.31 **Tensile strength as function of temperature for CRASTIN® SK605, SO653 and SO655**

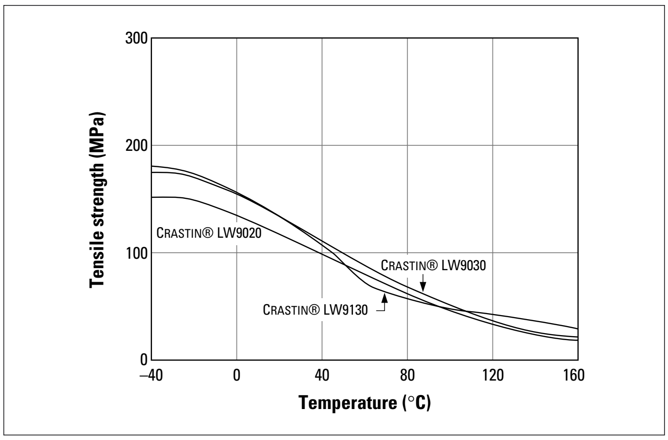


Fig 3.1.32 **Tensile strength as function of temperature for CRASTIN® LW9020, LW9030 and LW9130**

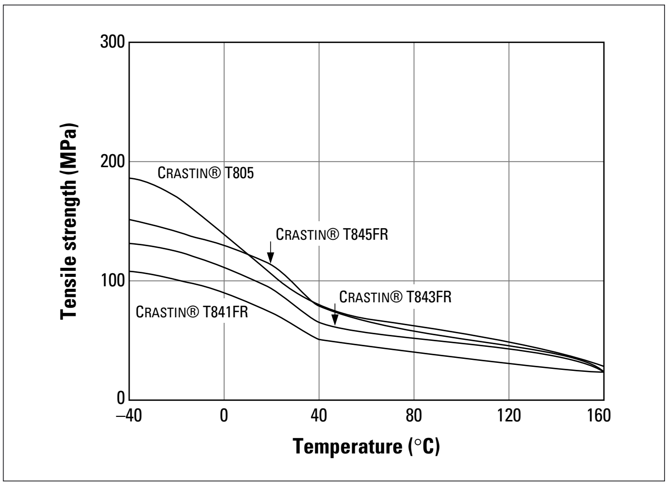


Fig 3.1.33 **Tensile strength as function of temperature for CRASTIN® T805, T845FR, T843FR and T841FR**

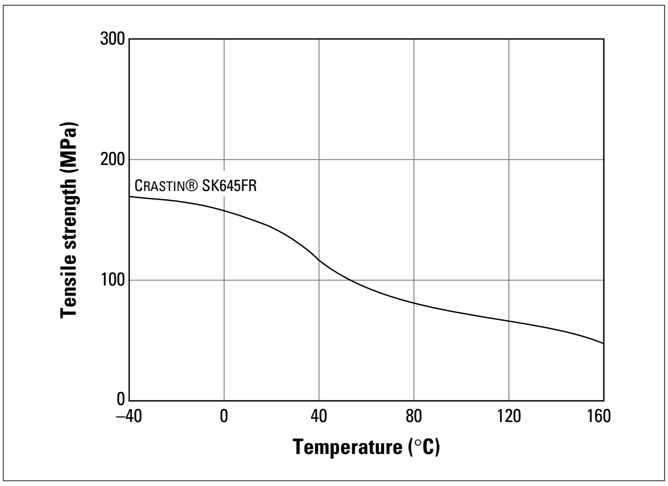


Fig 3.1.34 **Tensile strength as function of temperature for CRASTIN® SK645FR**

3.2 – Modulus of elasticity

The shear modulus of most CRASTIN® and RYNITE® grades is available in Campus.

Figures 3.2.1 to 3.2.3 show the flexural modulus (modulus of elasticity, computed from bending tests) as function of the temperature for several RYNITE® resins.

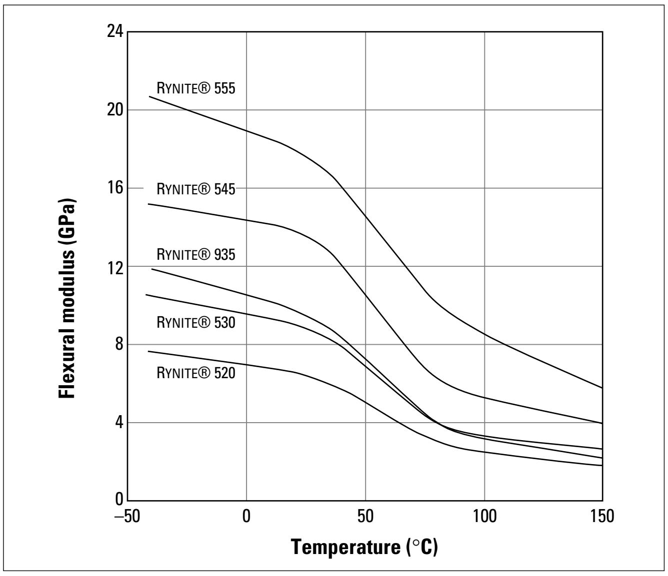


Fig 3.2.1 **Flexural modulus as function of the temperature for RYNITE® 520, 530, 545, 555 and 935**

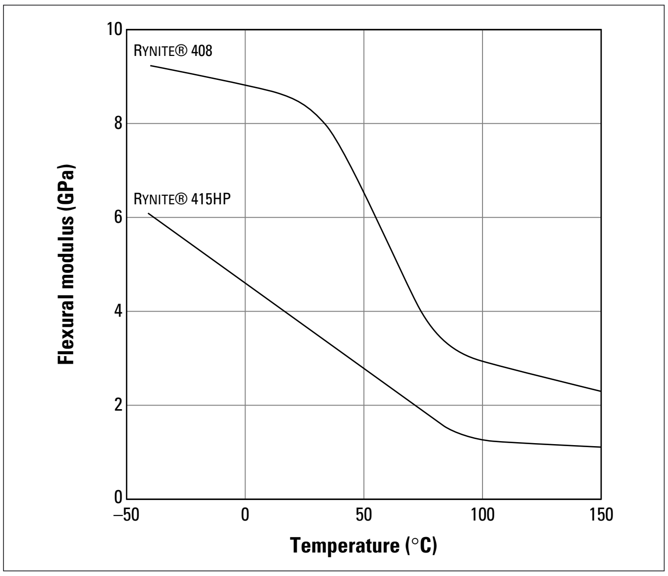


Fig 3.2.2 **Flexural modulus as function of the temperature for RYNITE® 408 and 415HP**

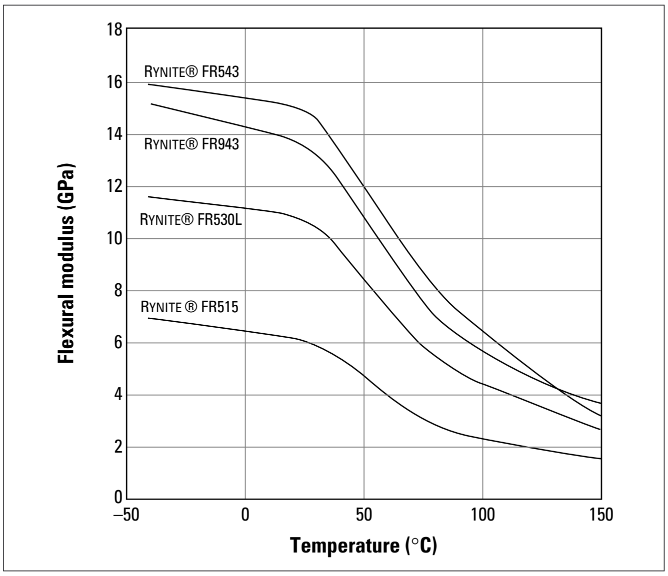


Fig 3.2.3 **Flexural modulus as function of the temperature for RYNITE® FR515, FR530L, FR543 and FR943**

In Figures 3.2.4 – 3.2.8, the modulus of elasticity is shown (as measured from tensile tests) as function of temperature for some CRASTIN® grades.

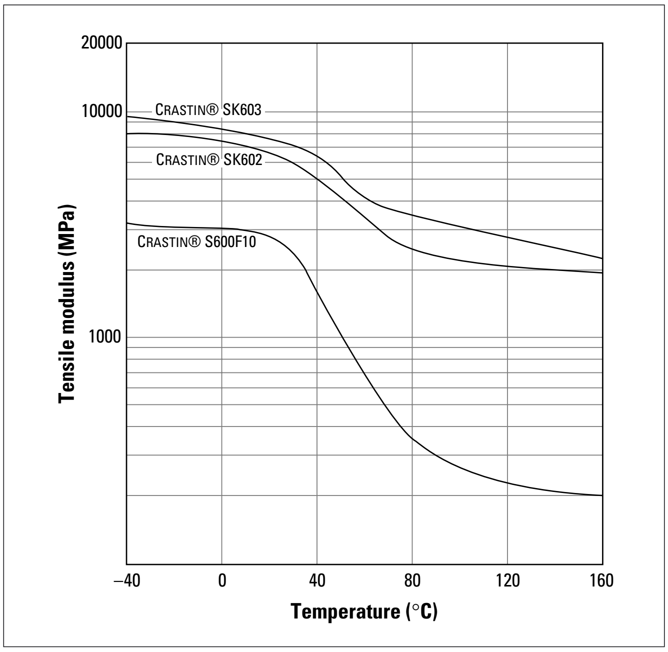


Fig 3.2.4 **Tensile modulus as function of the temperature for CRASTIN® S600F10, SK602 and SK603**

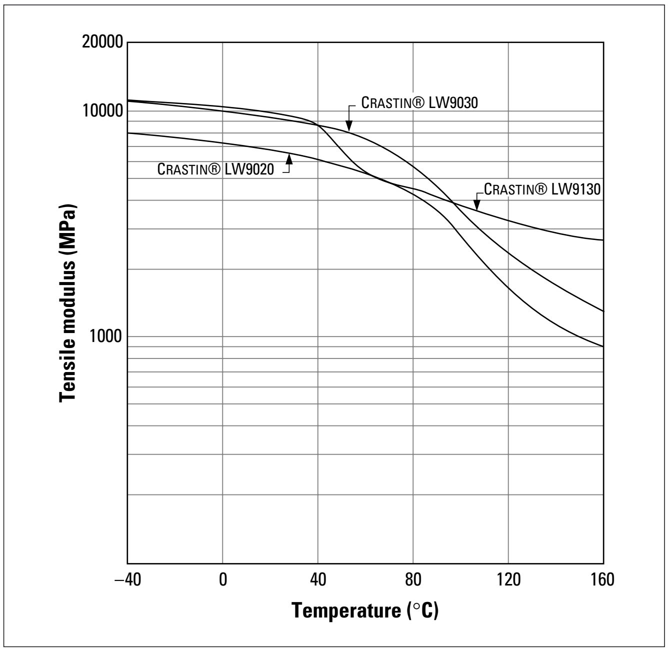


Fig 3.2.6 **Tensile modulus as function of the temperature for CRASTIN® LW9020, LW9030 and LW9130**

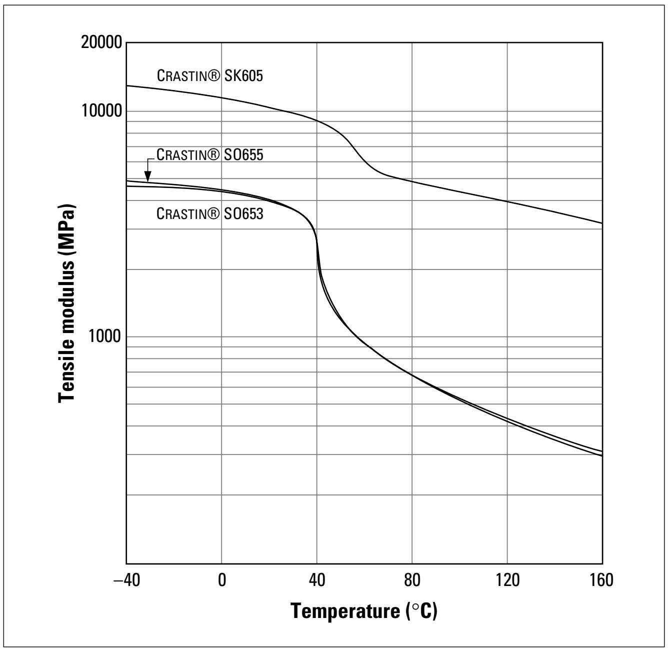


Fig 3.2.5 **Tensile modulus as function of the temperature for CRASTIN® SK605, SO653 and SO655**

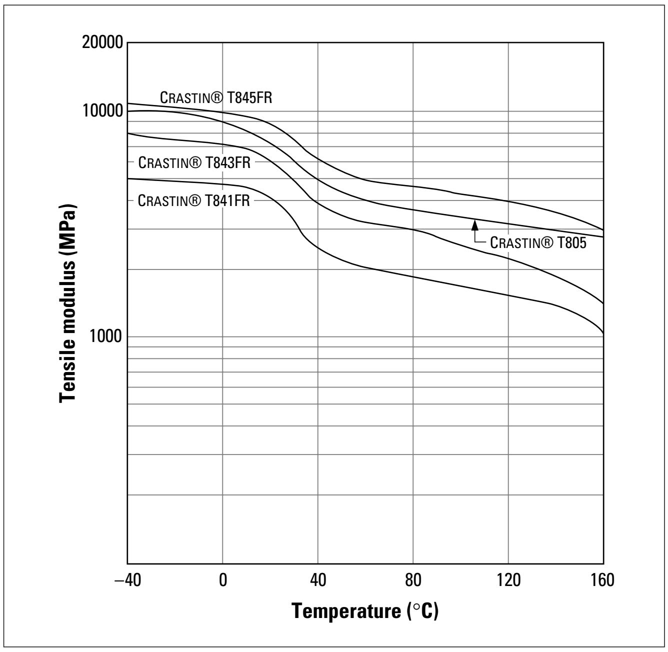


Fig 3.2.7 **Tensile modulus as function of the temperature for CRASTIN® T845FR, T843FR, T841FR and T805**

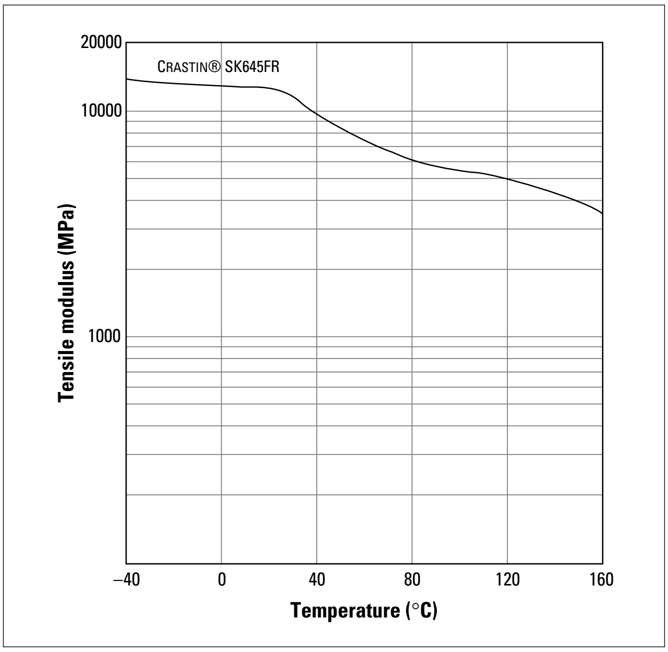


Fig 3.2.8 **Tensile modulus as function of the temperature for CRASTIN® SK645FR**

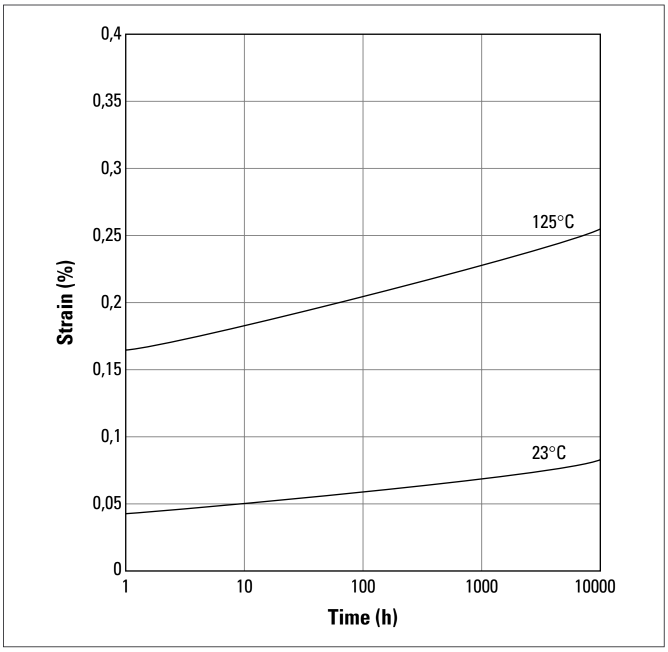


Fig 3.4.1 **Creep in flexure for RYNITE® 555 at 6,9 MPa stress**

3.3 – Secant modulus

With the aid of a stress-strain curve the secant modulus (or, apparent modulus) can be calculated as follows:

– Strain at given stress (σ) equals $\epsilon_{\%}$ (or: Stress at given strain (ϵ) equals σ)

– Secant modulus: $E_s = 100\ \sigma/\epsilon_{\%}$ (MPa)

3.4 – 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 moulding conditions. The creep characteristics of RYNITE® thermoplastic polyester resins moulded in hot moulds 90°C are given in Figures 3.4.1 – 3.4.12.
These data, determined according to ASTM D2990, indicate that RYNITE® thermoplastic polyester resins have good resistance to creep at high temperature and stress levels. For optimum creep resistance and dimensional stability, mould temperature must be greater than 90°C.

Creep (apparant) modulus at various stress levels and temperatures

The creep modulus can be obtained as follow:

– from curves 3.4.1 – 3.4.12 at given time (t), stress (σ) and temperature (T): read strain ($\epsilon_{\%}$).

– calculate creep modulus with:

$E_C = 100\ \sigma/\epsilon_{\%}$ (MPa).

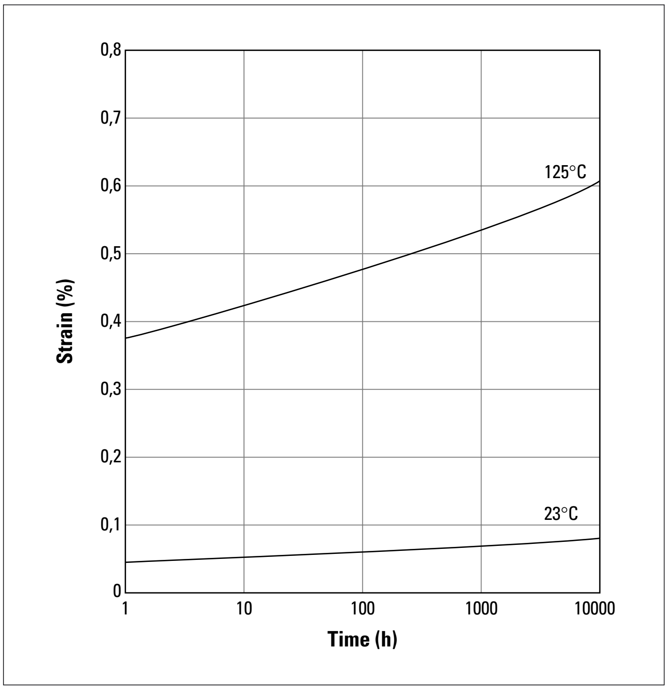


Fig 3.4.2 **Creep in flexure for RYNITE® 935 at 6,9 MPa stress**

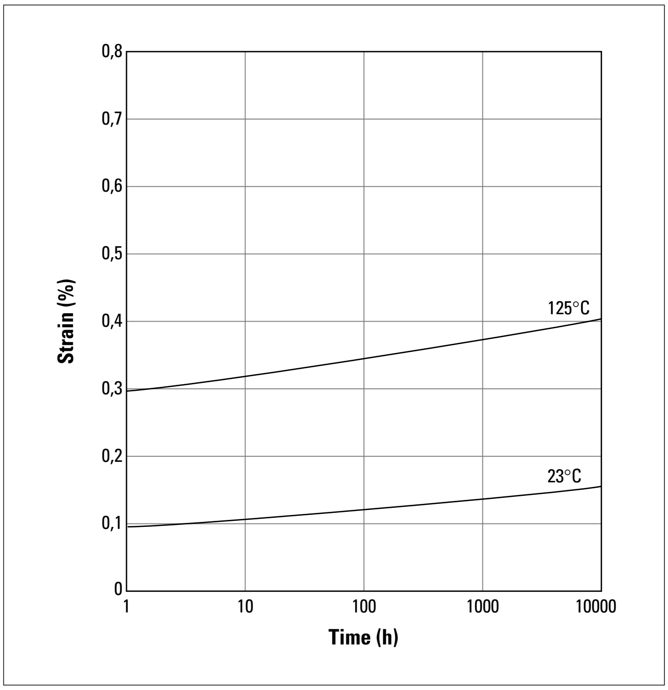


Fig 3.4.3 **Creep in flexure for Rynite® 555 at 13,8 MPa stress**

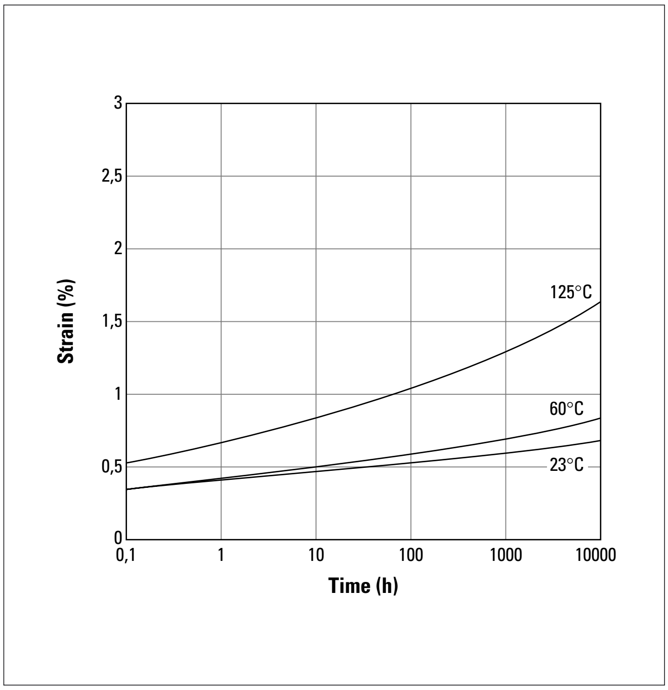


Fig 3.4.5 **Creep in flexure for Rynite® 530 at 27,6 MPa stress**

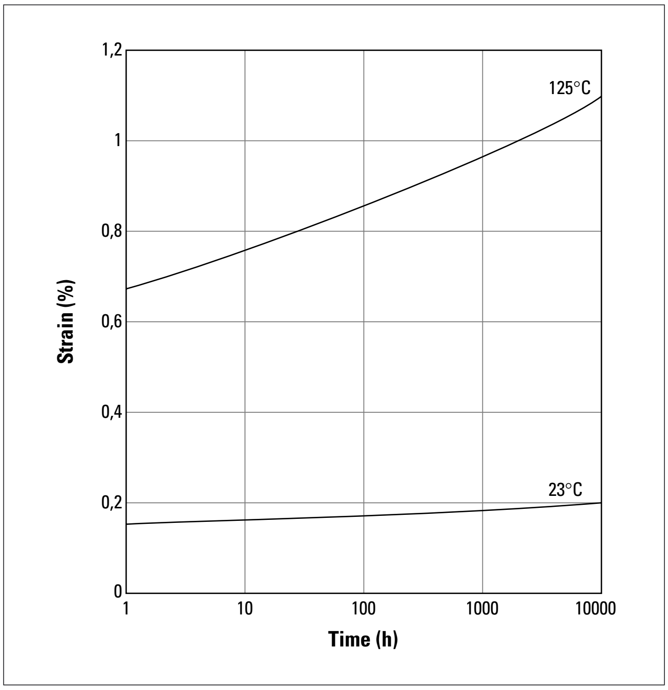


Fig 3.4.4 **Creep in flexure for Rynite® 935 at 13,8 MPa stress**

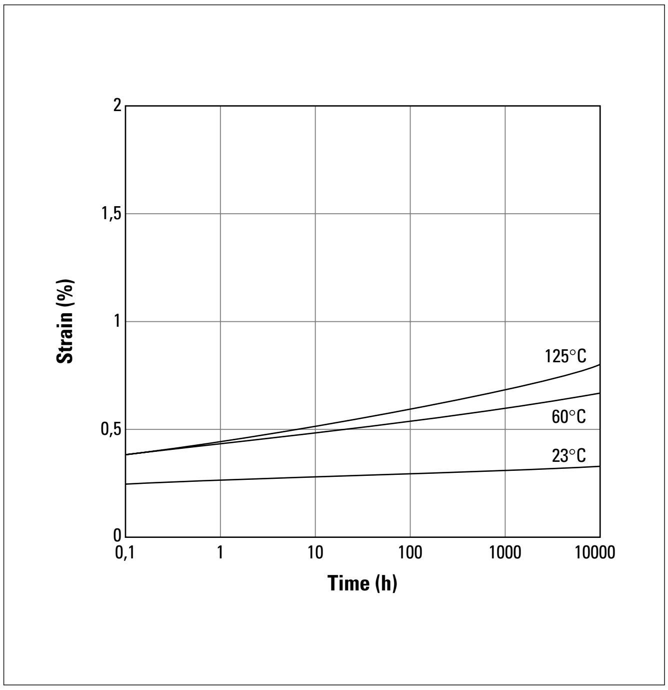


Fig 3.4.6 **Creep in flexure for Rynite® 545 at 27,6 MPa stress**

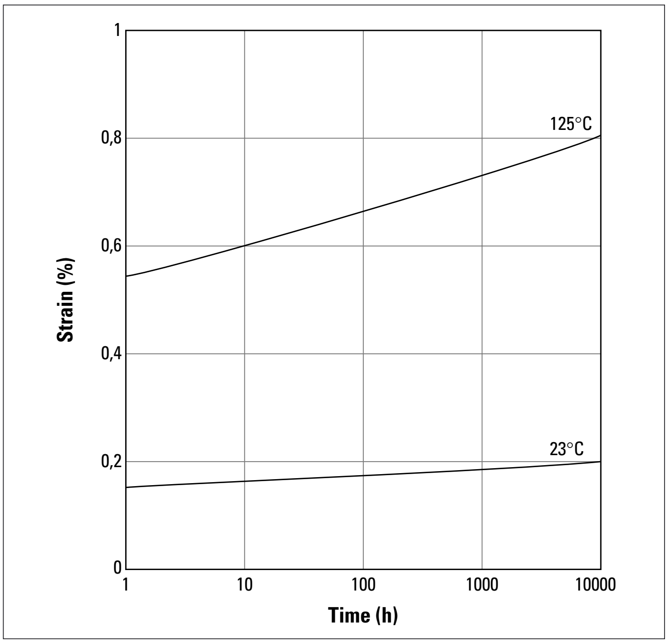


Fig 3.4.7 **Creep in flexure for RYNITE® 555 at 27,6 MPa stress**

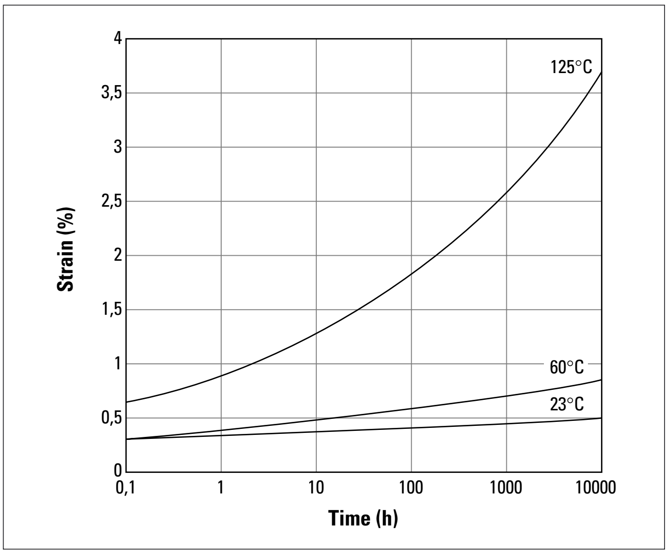


Fig 3.4.8 **Creep in flexure for RYNITE® 935 at 27,6 MPa stress**

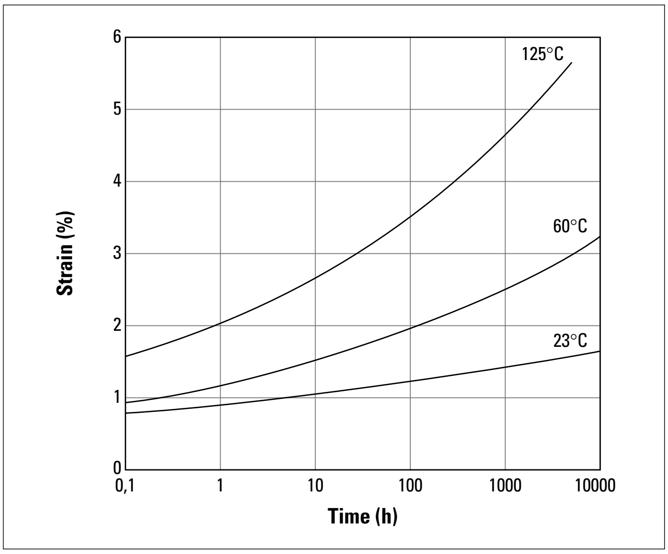


Fig 3.4.9 **Creep in flexure for RYNITE® 415HP at 27,6 MPa stress**

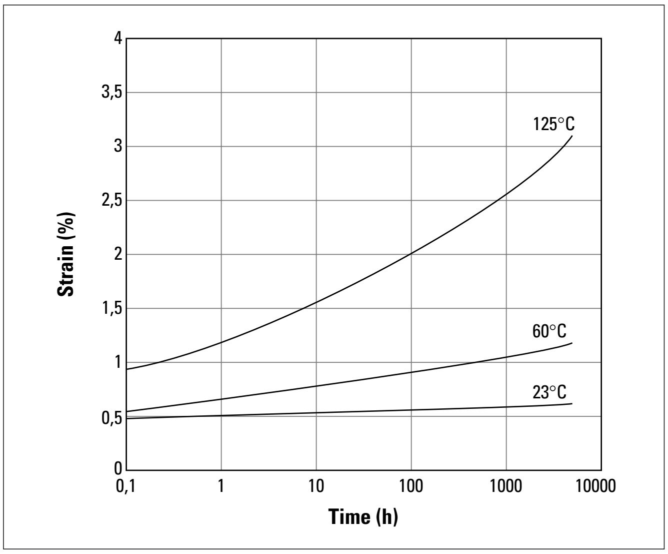


Fig 3.4.10 **Creep in flexure for RYNITE® FR515 at 27,6 MPa stress**

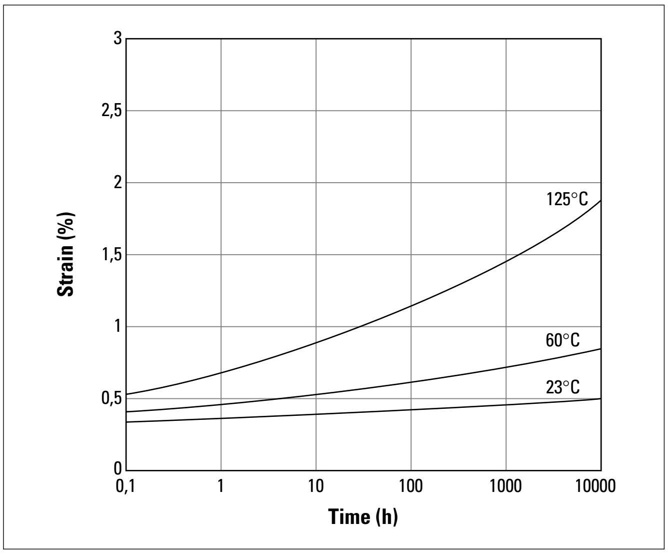


Fig 3.4.11 **Creep in flexure for RYNITE® FR530L at 27,6 MPa stress**

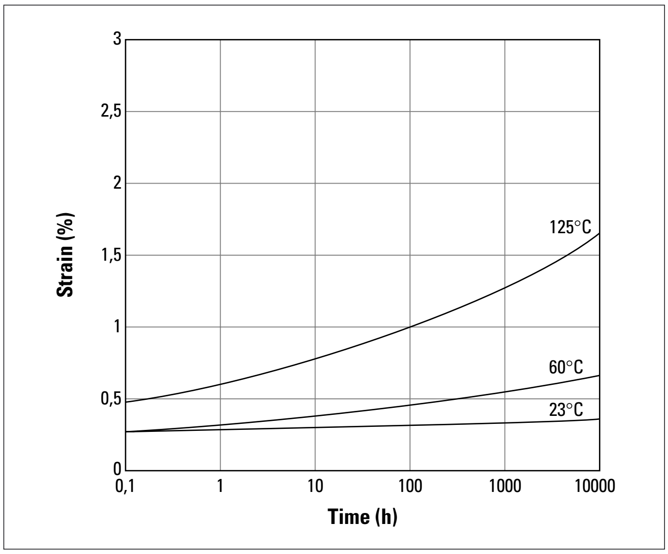


Fig 3.4.12 **Creep in flexure for RYNITE® FR943 at 27,6 MPa stress**

3.5 – Fatigue resistance

Fatigue failure can occur in materials at stress levels below their ultimate tensile strengths when they are cyclically stressed. Fatigue endurance is the cyclical stress level at which test specimens will not break before one million cycles are completed. 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.

The fatigue resistance properties of RYNITE® thermoplastic polyester resins are shown in Figure 3.5.1 to 3.5.3.

These flexural fatigue data were determined according to ASTM D671.

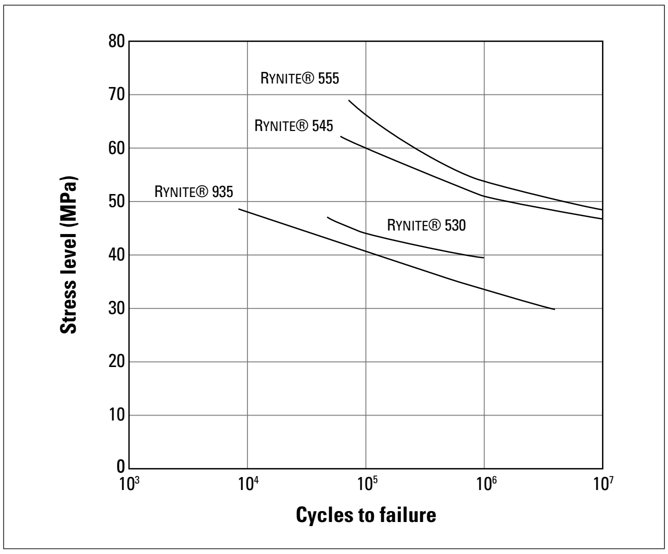


Fig 3.5.1 **Flexural fatigue of RYNITE® 530, 545, 555 and 935 at 23°C**

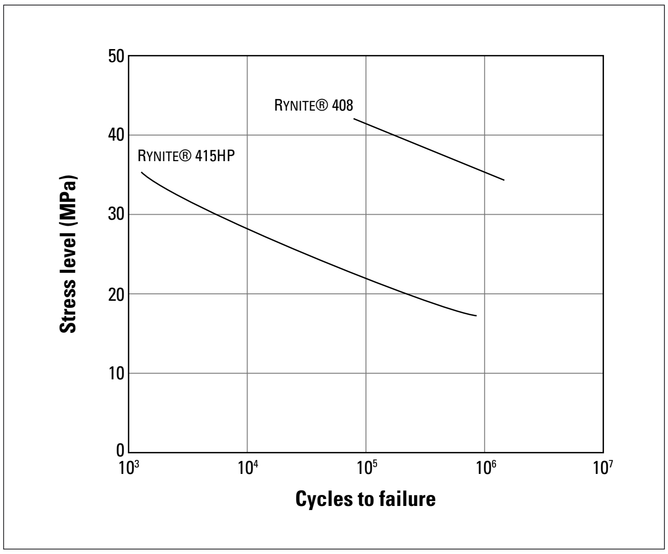


Fig 3.5.2 **Flexural fatigue of RYNITE® 408 and 415HP at 23°C**

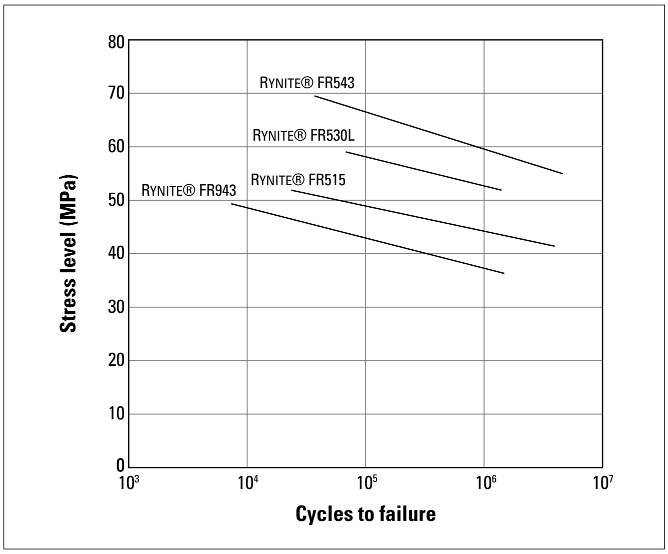


Fig 3.5.3 **Flexural fatigue of RYNITE® FR515, FR530L, FR543 and FR943 at 23°C**

The fatigue resistance of some CRASTIN® grades is shown in Figures 3.5.4 – 3.5.7.

These curves have been developed at a temperature of 23°C and for a frequency of 25 Hz according to DIN 53442.

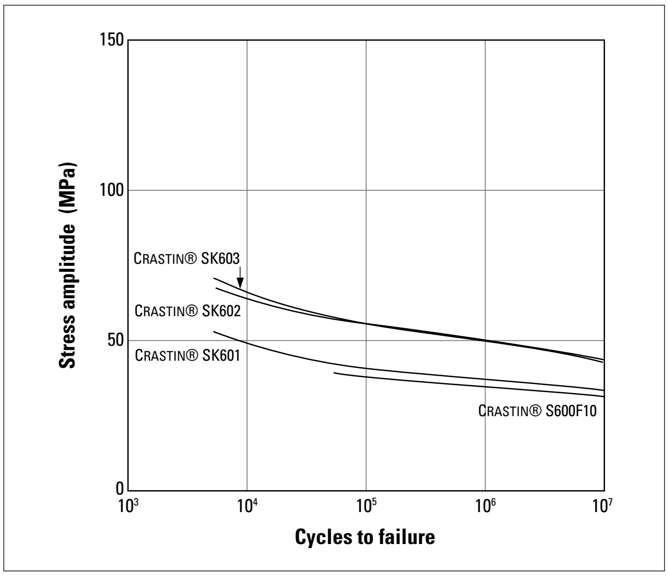


Fig 3.5.4 **Flexural fatigue of CRASTIN® S600F10, SK601, SK602 and SK603 at 23°C**

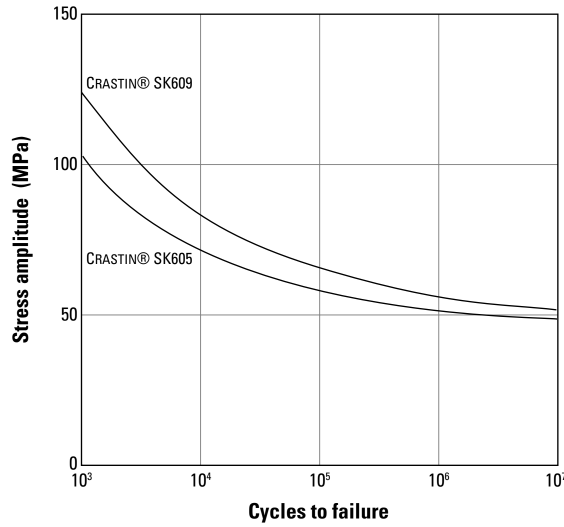


Fig 3.5.5 **Flexural fatigue of Crastin® SK605 and SK609 at 23°C**

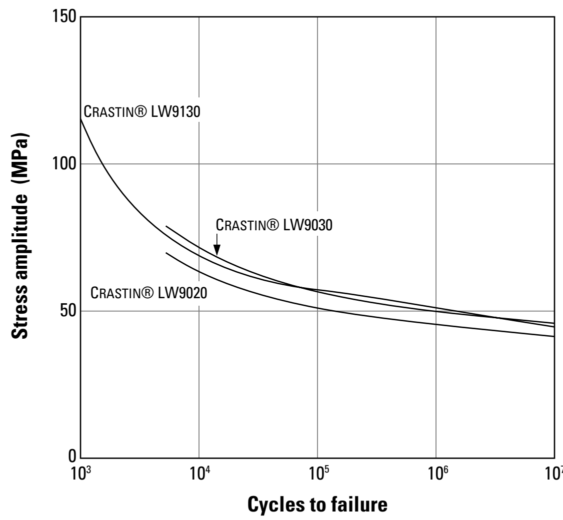


Fig 3.5.6 **Flexural fatigue of Crastin® LW9020, LW9030 and LW9130 at 23°C**

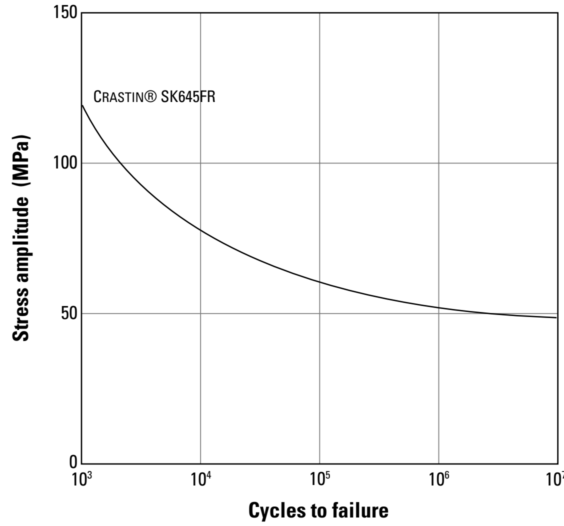


Fig 3.5.7 **Flexural fatigue of Crastin® SK645FR at 23°C**

3.6 – Influence of fibre reinforcement on properties

The influence of the amount of glass fibre on the mechanical properties of polyester resins is significant.

For Crastin® PBT resins, this effect is shown in Figures 3.6.1 – 3.6.6.

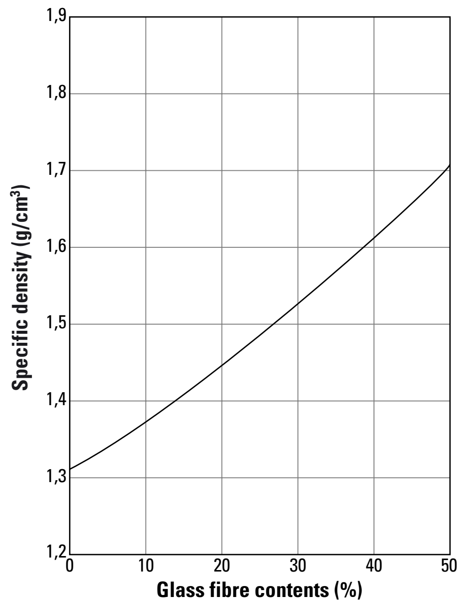


Fig 3.6.1 **Influence of glass fibre reinforcement on density for Crastin® SK grades**

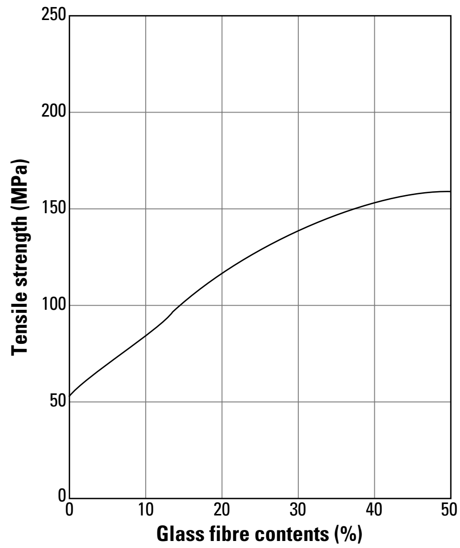


Fig 3.6.2 **Influence of glass fibre reinforcement on tensile strength for Crastin® SK grades**

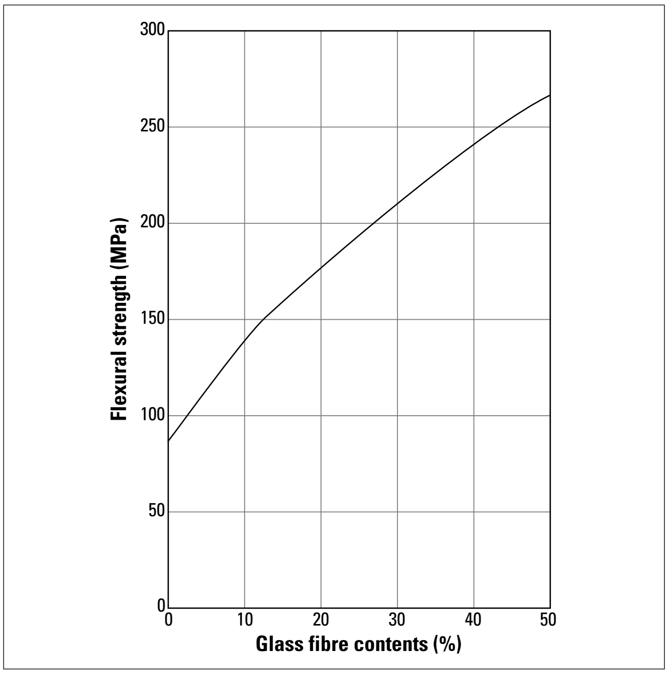


Fig 3.6.3 **Influence of glass fibre reinforcement on flexural strength for Crastin® SK grades**

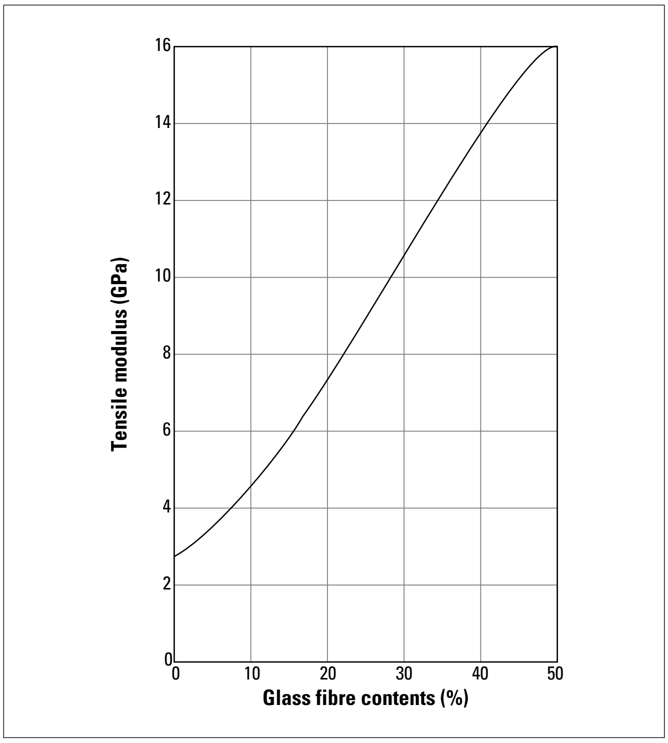


Fig 3.6.4 **Influence of glass fibre reinforcement on tensile modulus for Crastin® SK grades**

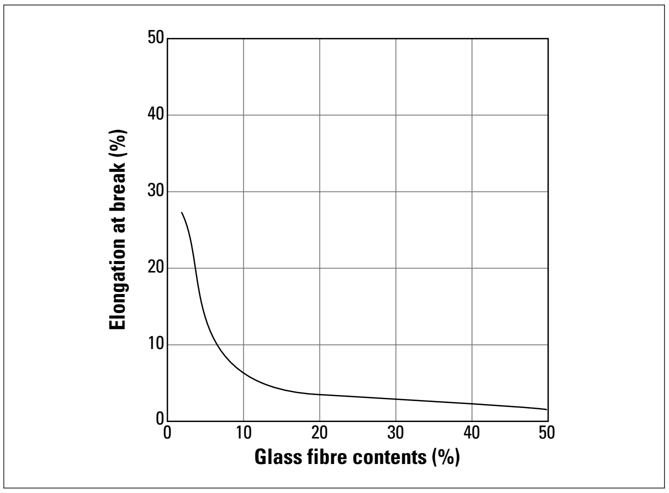


Fig 3.6.5 **Influence of glass fibre reinforcement on elongation at break for Crastin® SK grades**

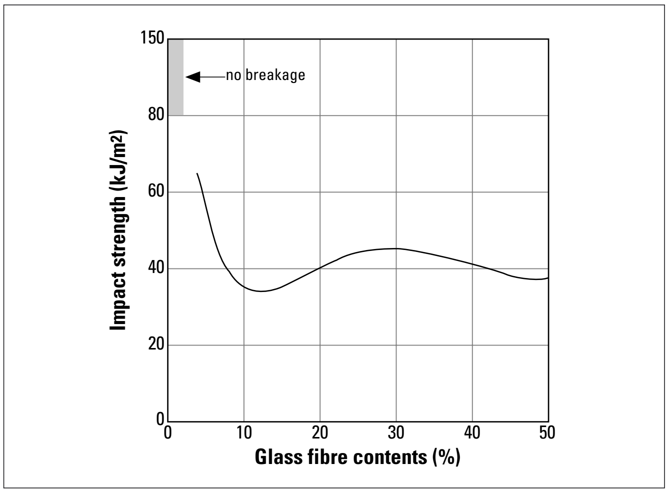


Fig 3.6.6 **Influence of glass fibre reinforcement on impact strength for Crastin® SK grades**

3.7 – Influence of fibre orientation on properties

The properties of glass reinforced plastics are affected by fibre orientation. Table 3.1 lists the effect on mechanical properties of glass fibre orientation for several RYNITE® grades.

These data were determined on tensile test specimens machined from plates as shown in Figure 3.7.1.

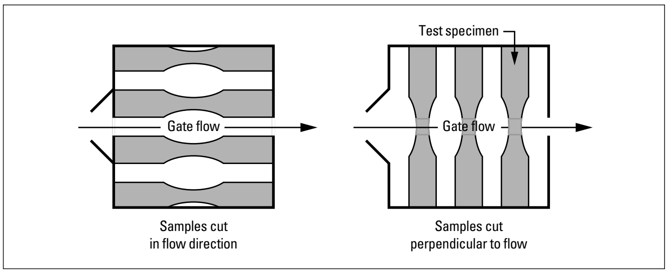


Fig 3.7.1 **Preparation of tensile specimens**

Table 3.1 Reduction of properties, perpendicular to flow vs. parallel to flow direction

RYNITE® grade	530	545	555	FR530
Tensile strength	35%	35%	35%	40%
Flexural modulus	45%	50%	50%	45%
Izod impact strength	55%	50%	60%	60%

Reduction of properties on samples machined versus moulded

The properties of glass reinforced plastic components are substantially different if the same part is machined or moulded. The difference is particularly significant for Izod impact strength. Table 3.2 lists the effect on mechanical properties of ASTM test bars machined in flow direction and moulded for several RYNITE® grades.

Table 3.2 Reduction of properties in flow direction, machined vs. moulded

RYNITE® grade	530	545	555	FR530
Tensile strength	25%	30%	35%	35%
Flexural modulus	3%	10%	15%	3%
Izod impact strength	45%	55%	55%	10%

3.8 – Summary of variables affecting toughness and strength

The variables that may cause a reduction in toughness and strength of CRASTIN® and RYNITE® polyester resins include:

- Moisture in the virgin or rework resin. For optimum properties, RYNITE® resins (virgin and rework) must be dried and maintained at moisture levels less than 0,02% during processing. The maximum recommended moisture content for the granulate of CRASTIN® resins should be less than 0,04% by weight.
- Long melt-residence time (>10 minutes).
- Too high or too low melt temperature (285 ± 5°C is recommended for RYNITE® resins; 250 ± 10°C is recommended for CRASTIN® resins).
- Combination of all three above. The toughness of CRASTIN® and RYNITE® resins depends upon moisture, hold-up time and melt temperature.
- Improper mould venting.
- Glass fibre length. In order to minimize glass fibre breakage:
  – Use minimum allowable screw speed.
  – Use little back pressure.
  – Keep the rework low (25% or less).
  – Use proper rear zone temperature.
- Contaminated rework or moulding equipment.
- The use of additives, e.g. certain types of mould release lubricants, pigments, etc.
- Part design – sharp corners, non-uniform wall thickness.

3.9 – Using regrind of CRASTIN®

Only regrind from optimally processed original material should be used.

In order to keep the loss of strength and toughness at a low level, not more than 30% by weight of regrind should be added to unreinforced products. In the case of glass-fibre reinforced CRASTIN® types, increased loss of strength must be expected due to the reduction of fibre length which occurs during regrinding. For this reason, not more than 25% by weight of regrind should be added to reinforced materials.

The reduction in the flexural and impact strength of CRASTIN® SK605 with various regrind percentages and repeated use is shown in Figure 3.9.1.

The actual amount of regrind which can be added must be determined for each part by testing. Only the operational and performance requirements of a moulded part can determine the amount of regrind that can be acceptable.

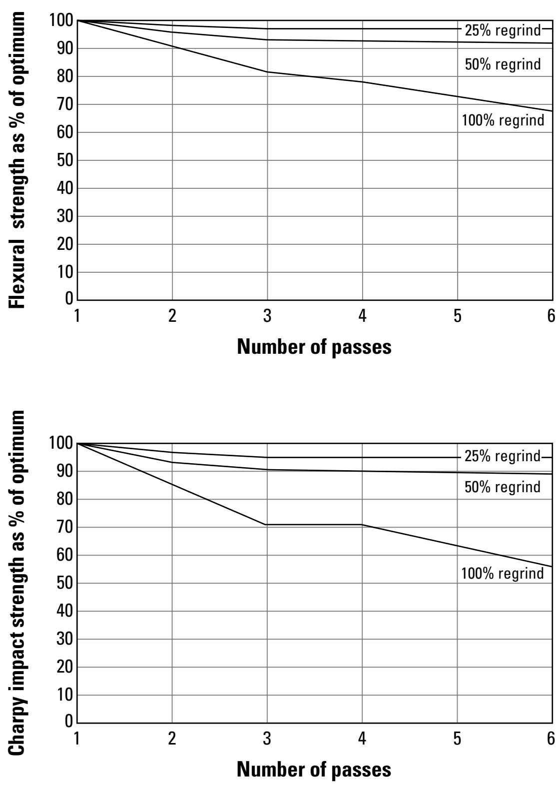


Fig 3.9.1 **Reduction of the flexural and impact strength of CRASTIN® SK605 for various regrind percentages and repeated use**

In the case of parts subjected to mechanical loads, regrind should be used only rarely. A higher amount of regrind is feasible, for example, when in addition to electrical insulating properties, the part needs only a high heat deflection temperature.

Recycled material should have approximately the same granule size as fresh granulate. Grinder screens with a mesh size of about 5 mm yield a grain size of approximately 3 mm in diameter.

A screen with a mesh of approximately 2,5 mm can be used for removing dust particles in the regrind. Before processing, the regrind should be dried to avoid the possibility of degradation due to the presence of moisture in the granulate.

4 – Effects of environment on properties

4.1 – Thermal behaviour

The influence of temperature on dimensional changes for RYNITE® grades can be found in the following table. The values of CRASTIN® can be found in chapter 2, (page 12–15).

RYNITE® grades:	**520**	**530**	**545**	**555**	**935**	**408**	**415HP**	**FR515**	**FR530L**	**FR543**	**FR943**
Coefficient of linear thermal expansion (10^{-4} K^{-1})											
Parallel –40°C to 23°C	0,31	0,22	0,18	0,13	0,26	0,24	0,40	0,33	0,22	0,16	0,21
23°C to 55°C	0,25	0,10	0,13	0,08	0,16	0,14	0,20	0,18	0,19	0,11	0,19
55°C to 160°C	0,11	0,04	0,05	0,01	0,14	0,08	0,32	0,12	0,10	0,07	0,06
Normal –40°C to 23°C	0,72	0,67	0,54	0,54	0,53	0,85	0,98	0,70	0,68	0,55	0,51
23°C to 55°C	0,93	0,81	0,71	0,75	0,52	0,85	1,17	0,88	0,92	0,79	0,65
55°C to 160°C	0,90	1,07	0,95	0,95	0,81	0,92	1,09	1,05	0,98	0,96	0,84

Test method: ASTM E831

4.2 – Effect of heat ageing

The effect of exposure to high temperatures on the properties of RYNITE® thermoplastic polyester resins is given in Figures 4.1 – 4.11. These data were measured by exposing test specimens in an oven at various temperatures. The change in properties over time and temperature was measured. Oil, grease, water, etc. may have a different effect on the properties of the resins at high temperatures. See section 4.4 on chemical resistance (pages 43 to 55). Tensile strength tests were carried out according to ASTM D-638; Impact tests according to ASTM D-256.

CAUTION: Exposure of RYNITE® thermoplastic polyester resins – particularly natural and light colours – to high temperatures in air may result in discolouration, depending upon conditions. RYNITE® thermoplastic polyester resins stabilized to minimize discolouration at elevated temperatures are available. Contact your local DuPont Engineering Polymers sales offices for specific information.

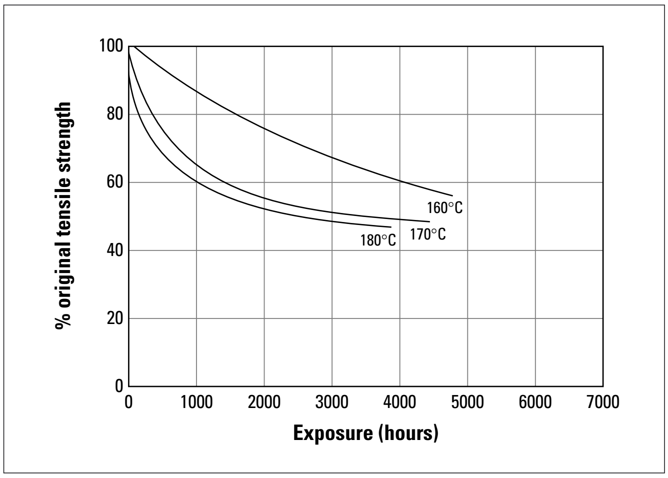


Fig 4.1 **Effect of heat ageing on tensile strength of RYNITE® 530**

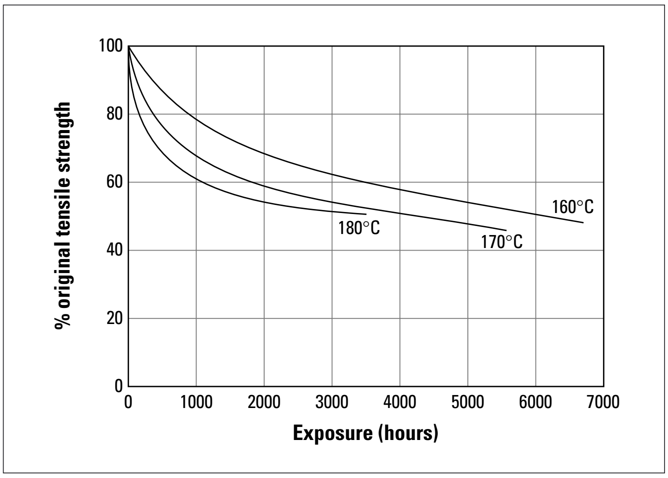


Fig 4.2 **Effect of heat ageing on tensile strength of Rynite® 545**

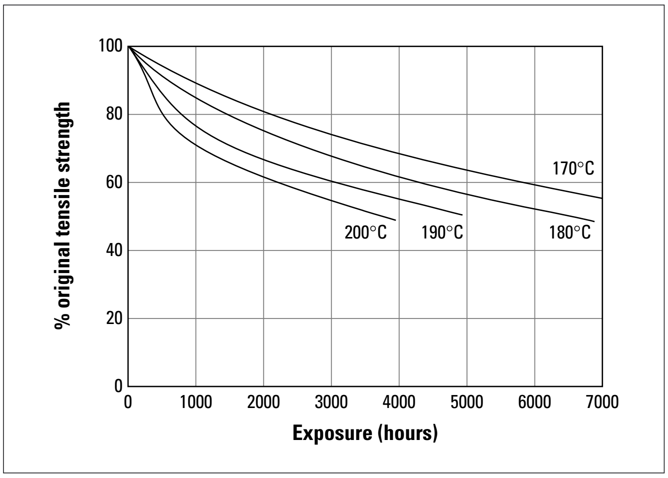


Fig 4.5 **Effect of heat ageing on tensile strength of Rynite® FR543**

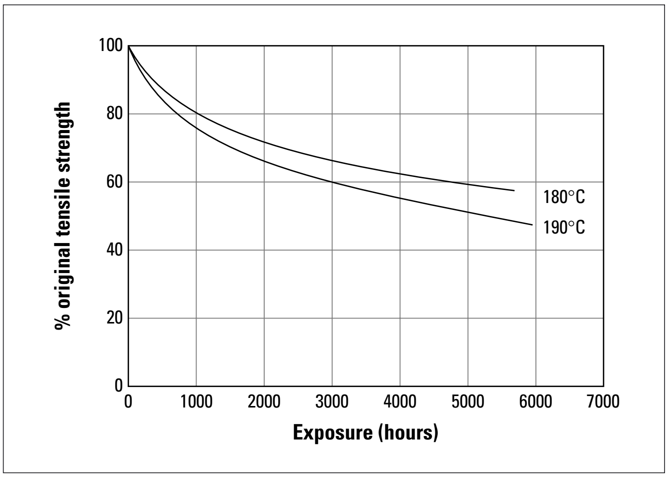


Fig 4.3 **Effect of heat ageing on tensile strength of Rynite® 555**

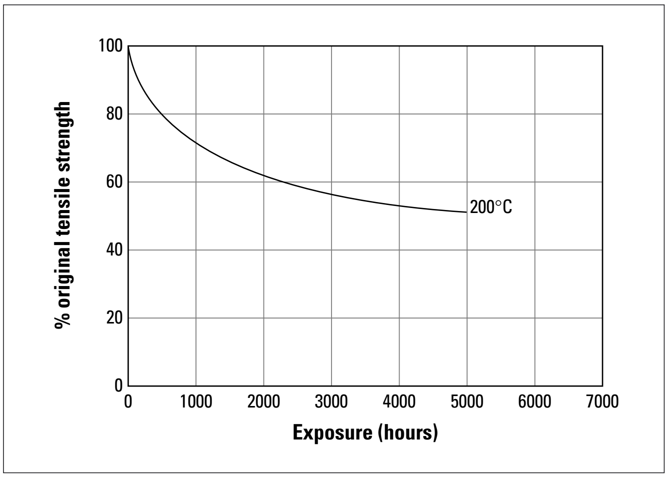


Fig 4.6 **Effect of heat ageing on tensile strength of Rynite® FR943**

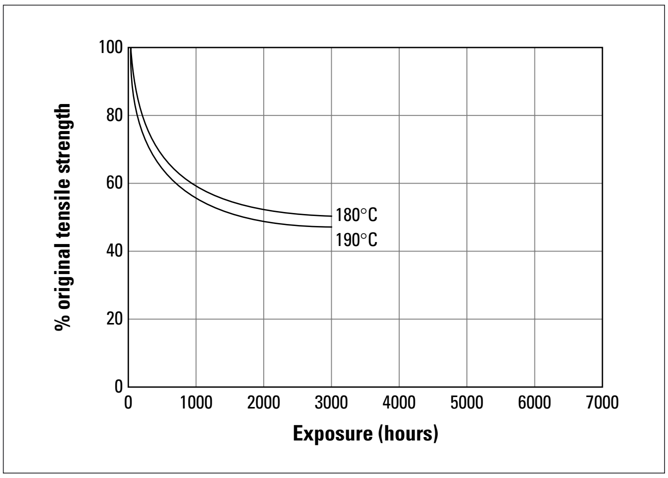


Fig 4.4 **Effect of heat ageing on tensile strength of Rynite® FR530**

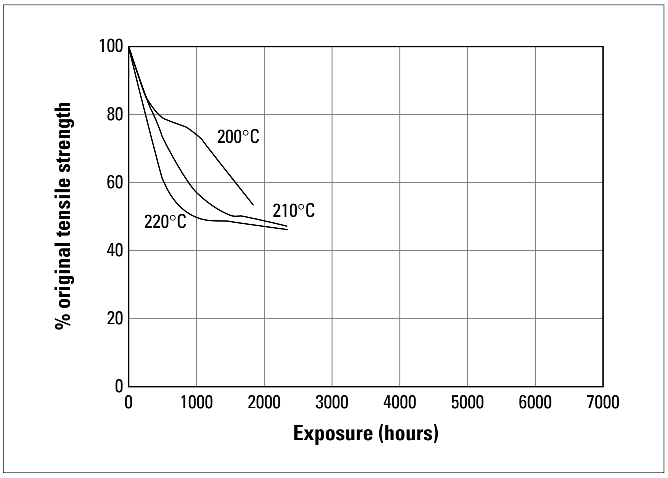


Fig 4.7 **Effect of heat ageing on tensile strength of Rynite® 408**

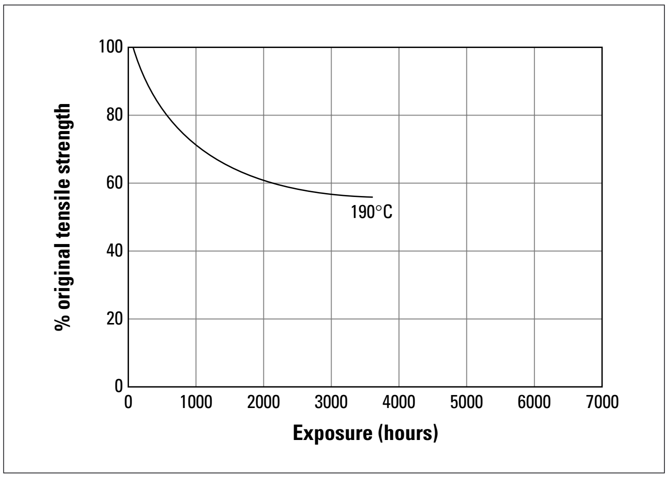


Fig 4.8 **Effect of heat ageing on tensile strength of Rynite® 935**

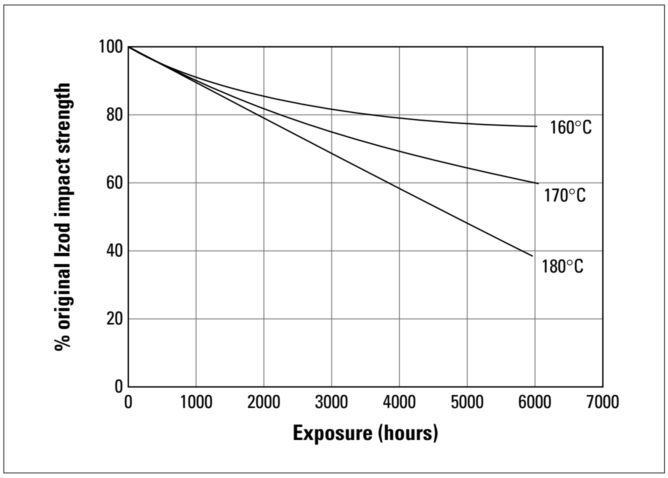


Fig 4.10 **Effect of heat ageing on impact resistance of Rynite® 545**

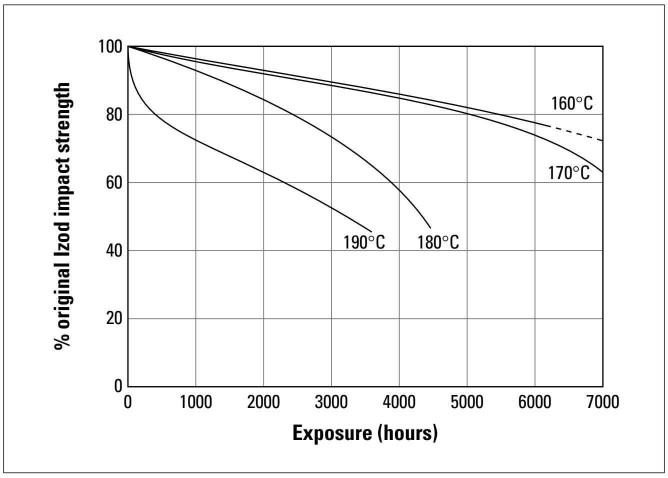


Fig 4.9 **Effect of heat ageing on impact resistance of Rynite® 530**

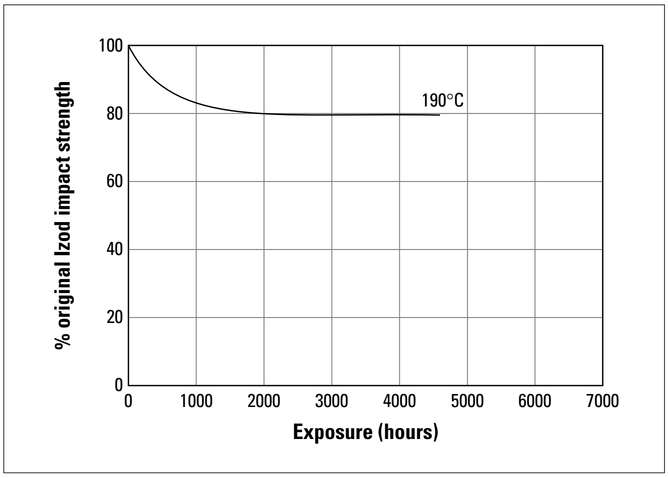


Fig 4.11 **Effect of heat ageing on impact resistance of Rynite® FR530**

The thermal endurance of CRASTIN® thermoplastic polyester resins is given in fig. 4.12. It shows the maximum allowed ageing time for a given temperature and a retention of 50% of the tensile strength for various grades.

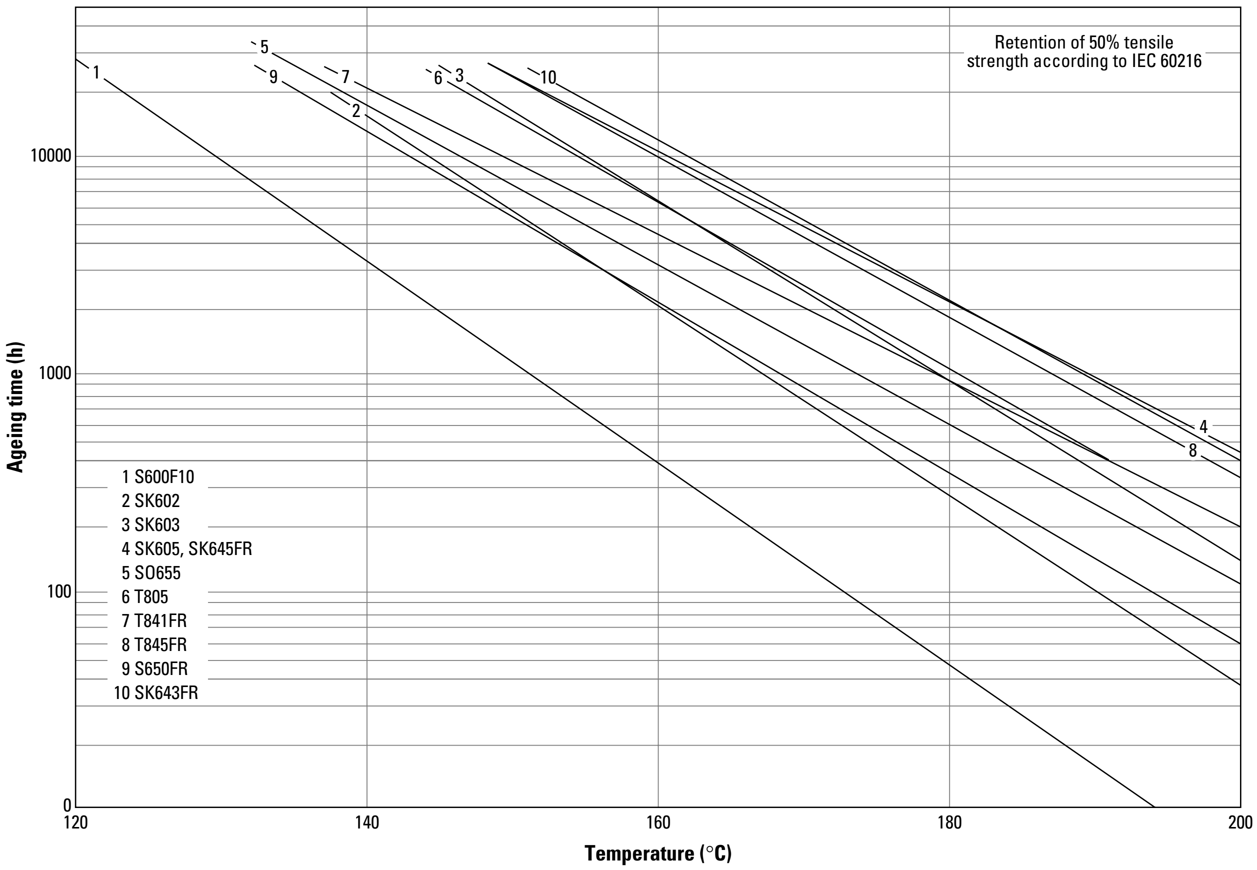


Fig 4.12 **Thermal endurance of CRASTIN® grades**

4.3 – Weathering

Introduction

Thermoplastic polyester resins rank high, among engineering polymers, for resistance to outdoor weathering. The effect of weathering on the properties of RYNITE® has been measured 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 that in general, RYNITE® exhibits good property retention. Overall performance is improved, especially impact strength, by the addition of carbon black (>0,3% by weight) to the resin.

X-W Weather-Ometer

In the X-W Weather-Ometer, 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 water at 32°C for 18 minutes. This is followed by a water evaporation cycle for 102 minutes at 63°C. The whole two-hour 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-Ometer tests. However, it is estimated that 400 to 1000 hours in the X-W Weather-Ometer is equivalent to one year of outdoor weathering in Florida.

General purpose resins

After 10 000 hours in the X-W Weather-Ometer:

1. RYNITE® 530 NC010 and Rynite 545 NC010 retain over 70% of their initial tensile strength and 55% of their original elongation properties.
2. Pigmented RYNITE® 530 resins retain higher tensile strength and elongation than the RYNITE® 530 natural resin. For example, the RYNITE® 530 black (BK503), white (WT501), grey (GY501), blue (BL503), and red (RD502) retain over 87% of their original tensile strength and 75% of their original elongation properties, Figure 4.13.
3. The RYNITE® 530 resins listed above retain over 83% of their original Izod impact properties.
4. The surface of the test samples exhibited an “etched”, rough appearance, i.e., the surface gloss had significantly reduced and glass fibres were exposed. There is a slight yellowing of the white (WT501) composition.

Toughened resins

After 5000 hours of exposure in the X-W Weather-Ometer:

1. The RYNITE® 408 resins retain over 85% of their original tensile strength and 80% of their original elongation properties.
2. The surface of the test bars were “etched” but not chalked.

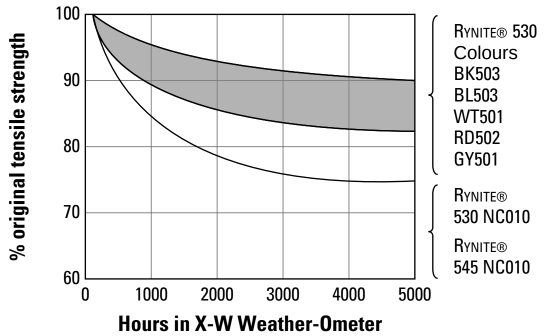


Fig 4.13 **% retention of original tensile strength after exposure in X-W Weather-Ometer**

Flame-retarded grades

After 1000 hours in the X-W Weather-Ometer, RYNITE® FR530 BK507 black retains a higher percentage of original tensile strength and elongation properties than the RYNITE® FR530 NC010 natural resin. Both resins retain over 93% of their original tensile and 77% of their original elongation properties.

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 three years. The data determined on these exposed samples indicate that the resins have retained over 72% of their initial tensile strength and over 50% of their initial elongation.
As expected, the compositions containing carbon black have a higher property retention, see Tables 4.1 and 4.2. After three years, all the test samples were slightly “etched”.

Low warp resins

After three years of exposure in Arizona, RYNITE® 935 BK505 retains over 97% of original tensile strength and 76% of original elongation, Table 4.2

Accelerated natural weathering in Arizona

General purpose resins

After 500 000 Langleys* of exposure in the EMMA (Equatorially Mounted Mirror Assisted) and EMMAQUA (EMMA with water) environments, RYNITE® 530 NC010 and BK503 and RYNITE® 545 NC010 and BK504 resins retain 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 4.3. All 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 3,3 years of natural weathering in Arizona.

* 1 Langley = 42 kJ/m^2.

Table 4.1 Outdoor weathering Florida, % retention of original physical properties

Exposure: Florida, 45° S	RYNITE® 530 NC010	RYNITE® 530 BK503	RYNITE® 545 NC010	RYNITE® 545 BK504
Tensile strength after				
0 years	100	100	100	100
0,5 years	98	100	89	88
1 years	92	100	84	90
2 years	82	93	75	91
3 years	76	98	72	91
Elongation after				
0 years	100	100	100	100
0,5 years	85	87	77	67
1 years	77	91	68	78
2 years	69	91	73	89
3 years	58	87	50	78

Table 4.2 Outdoor weathering Arizona, % retention of original physical properties

Exposure: Arizona: 45° S	RYNITE® 530 NC010	RYNITE® 530 BK503	RYNITE® 545 NC010	RYNITE® 545 BK504	RYNITE® 935 BK505
Tensile strength after					
0 years	100	100	100	100	100
0,5 years	100	98	98	100	100
1 years	98	100	88	97	100
2 years	90	98	87	94	100
3 years	87	98	82	90	97,5
Elongation after					
0 years	100	100	100	100	
0,5 years	85	91	82	83	100
1 years	88	96	77	94	94
2 years	79	96	73	89	94
3 years	78	83	68	78	76

Table 4.3 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 Langley = one year' exposure, 1 langley= 42 kJ/m^2

Xenotest 150 (ASTM D790)

The effect of weathering time on the flexural strength of some CRASTIN® grades, exposed to the above test, is shown in Figure 4.14.

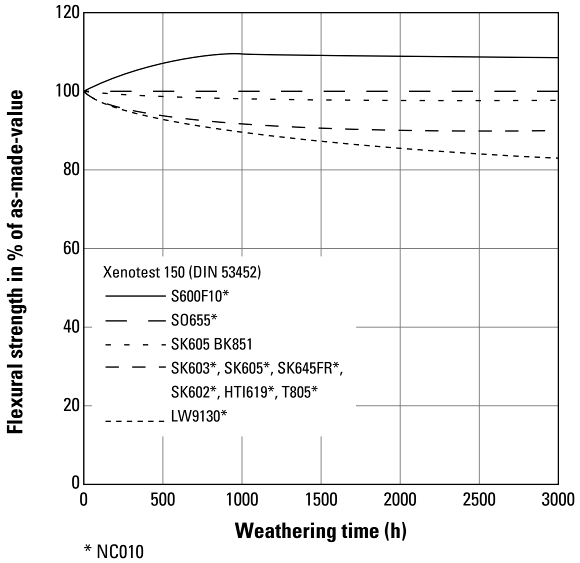


Fig 4.14 **Effect of weathering on flexural strength of some CRASTIN® grades**

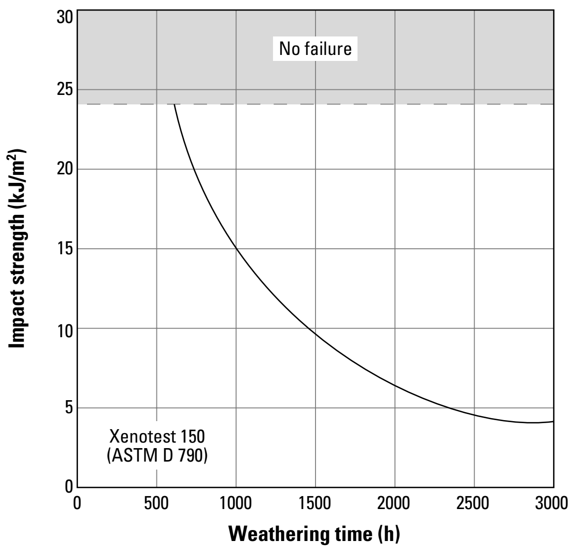


Fig 4.16 **Impact strength vs weathering time of CRASTIN® S600F10 NC010**

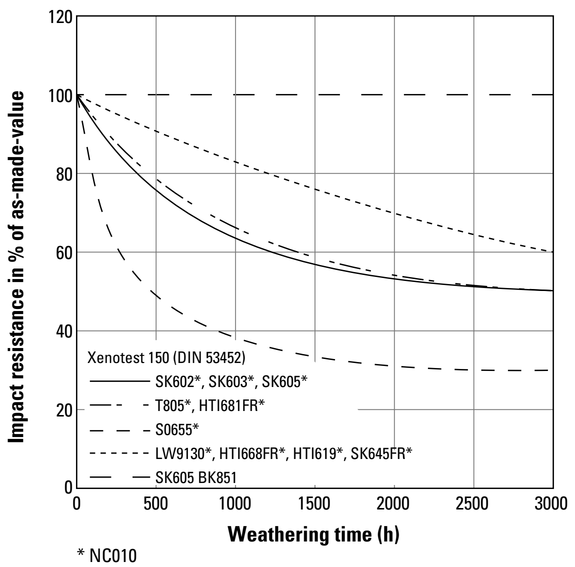


Fig 4.15 **Impact resistance (DIN53452) versus weathering time**

Table 4.4 Retention of properties after natural weathering in Central Germany for 3 CRASTIN® grades

		Change of properties versus unexposed products				
CRASTIN® grade	Weathering time (years)	Tensile strength (%) DIN 53455	Tensile modulus (%) DIN 53457	Flexural strength (%) DIN 53452	Charpy Impact strength, unnotched (%) ISO 179	Charpy Impact strength, notched (%) ISO 179
S600F10 NC010	0	100	100	100	NB	100
	1/2	92	102	99	NB	33
	1	96	107	101	NB	40
	2	91	108	99	NB	41
	3	91	89	101	92,9 kJ/m^2	45
	4	93	98	98	89,5 kJ/m^2	29
SK605 NC010	0	100	100	100	100	100
	1/2	87	93	96	90	100
	1	92	87	91	82	99
	2	75	95	79	64	89
	3	81	97	81	68	83
	4	76	83	79	52	81
SO655 NC010	0	100	100	100	*) 100 (100)	100
	1/2	92	86	9/8	47 (61)	60
	1	90	92	100	65 (69)	58
	2	83	98	93	61 (72)	60
	3	85	83	91	55 (60)	57
	4	85	90	87	43 (68)	52

*) In this case the values are based on the value at the beginning of the storage. The figures in parenthesis represent the impact strength change of non-exposed samples and depend on the storage time in the test laboratory versus the initial start of the test programme.

0. Begin: 6.1.1975	Hours of exposure to the sun	Duration (years)
1. Sample taken: 15.7.75	900 h	1/2
2. Sample taken: 5.1.76	1545 h	1
3. Sample taken: 3.1.77	3318 h	2
4. Sample taken: 17.1.78	4575 h	3
5. Sample taken: 6.2.79	5860 h	4

The property values of the exposed samples were compared to those samples which were stored in darkness in the laboratory at the same time.

The hours of exposure in the sun were measured with the Schuster's Ball.

These outdoor weathering tests were carried out in Lautertal in Central Germany.

4.4 – Chemical Resistance

RYNITE® thermoplastic polyester resins exhibit excellent resistance to a wide variety of chemicals. Tables 4.5 and 4.6 detail the effects of various automotive related chemicals, organic solvents, acids, bases, salt solutions and water on the properties of RYNITE® 530 and 545 resins after exposure at various times and temperatures. These data are based on unstressed test bars that were moulded via recommended moulding conditions. The resistance of RYNITE® thermoplastic polyester resins to certain chemicals (e.g., chlorinated hydrocarbons) at elevated temperatures depends on the surface crystallinty of the moulded part. Annealed parts or parts moulded in hot molds >95° C will exhibit good resistance, whereas parts moulded in cold moulds may surface craze. We strongly recommend enduse testing be carried out on actual parts (as opposed to test bars) to determine the suitability of RYNITE® thermoplastic 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 recommend that parts made from RYNITE® should not be used in an environment where there is continuous exposure to water at temperatures above 50° C.

Hydrolysis resistance of RYNITE® 530 at 100% RH Time to reach one half of initial property value:

Tensile Strength

Temperature	Time (Weeks)
85° C	4
70° C	22
55° C	100
40° C	>104

Unnotched Impact

Temperature	Time (Weeks)
85° C	1
70° C	6
55° C	38
40° C	60

Due to excessive degradation, we recommend that the maximum continuous exposure temperature of parts made from RYNITE® thermoplastic resins to oil be 121° C.

Table 4.5 Chemical resistance of RYNITE® 530 and 545

Chemical media	Temperature °C	Days of immersion	% retention of original tensile strength	% weight gain	% dimensional change
Automotive-Related Environments					
Diesel Fuel	23	21	90-95	1	0
Diesel Fuel + 15% Ethanol	121	2	60-70	2-2,5	–
		7	20-30	2	–
		14	15-20	2	–
Diesel Fuel/Unleaded Gasoline (50/50)	23	21	95-99	1	0
Unleaded Gasoline	23	21	100	0,1	–
	42	84	100	0,1	0,01
	60	84	90	0,5	0,1
Unleaded Gasoline/ Methanol (85/15)	23	21	90-95	1	0,04
	60	21	70	1,8	0,1
		84	45-50	2,3	0,2
Unleaded Gasoline Ethanol (85/15)	23	21	85-90	1	0,01

Table 4.5 Chemical resistance of Rynite® 530 and 545 (continued)

Chemical media	Temperature °C	Days of immersion	% retention of original tensile strength	% weight gain	% dimensional change
Automotive-Related Environments					
Unleaded Gasoline + 5% Methanol + 2,5% Mixed Alcohols	42	28 84	90 73	1,5 2,9	0,1 0,2
Unleaded Gasoline + 5% Methanol + 3,2% Ethanol	42	28 84	86 75	1,9 3,1	0,1 0,2
Unleaded Gasoline + 5% Methanol + 4,1% Propanol	42	28 84	92 82	1,2 2,4	0,1 –
Unleaded Gasoline + 5% Methanol + 4,2% Mixed Alcohols	42	28 84	88 79	1,5 2,7	0,1 0,2
Unleaded Gasoline + 5% Methanol + 5% Butanol	42	28	100	1,2	0,1
Leaded Gasoline	23	7	90-95	1	0,03
Ford Motor Oil	121	28 112	95-99 15	– –	– –
Shell Motor Oil	121	14 28 84	90-95 55-65 15	– – –	– – –
Synthetic Motor Oil	150	21 42	70 45	– –	– –
Omnilube 300	93	290	99	–	–
Turbo 33	93	290	99	–	–
Rotron Diester Oil	93	290	99	–	–
Dextron Transmission Fluid	121 150	28 21	95-99 20-25	– –	– –
GM Power Sterring Fluid	23 121	21 14 90	97-100 85-90 50	0 0,1 0,22	0 – 0,08
Delco Supreme #1 Brake Fluid	23 66 121	21 28 14	95 90-90 30	0,15 – –	0,01 – –
Quaker State Lithium Based Grease	23	21	95-100	1	0,01
Kendal 3 Star 80W160 Gear Lubricant	23	21	90-96	1	–
Permatex Hydraulic Jack Oil	23	21	94-100	0,15	0,01
Anti-Freeze (50%)	23	21	90-95	1	0,1
Ethylene Glycol (100%)	23	21	95-99	1	0,01
«Optikleen» Windshield Washer Solvent (100%)	23	21	90-95	1	0,02
«Optikleen»/Water (50/50)	23	21 90	90-95 85	1 1	0,01 0,01

Table 4.5 Chemical resistance of RYNITE® 530 and 545 (continued)

Chemical media	Temperature °C	Days of immersion	% retention of original tensile strength	% weight gain	% dimensional change
Organic Solvents					
Acetone	23	21	70-80	5	0,1
Benzyl Alcohol	23	21	95	0,04	0
Ethanol	23	21	98-100	0	0,01
Ethyl Acetate	23	21	80-90	5	0,04
Ethyl Ether	23	21	85-95	0,15	0,01
Iso-Octane	23	21 364	99 99	0 0,04	0,01 0,01
Isopropanol	23	21	95-99	0,1	0
Methanol	23	21	95-96	1	0,01
Methylene Chloride	23	21	45-50	8-10	0,3
Methyl Ethyl Ketone -MEK	23	21	80-92	0,7	0,07
Nitromethane	23	21	70	4	0,12
Toluene	23	21	95-98	0,5	0,01
Acid					
Acetic Acid (100 %)	23	21	85-95	1	0,04
Hydrochloric Acid (10 %)	23	21	92-96	1	0,01
Sulfuric Acid (10 %)	23	21	91-96	1	0,02
Sulfuric Acid (Battery)	23	3	90-95	1	0,01
Bases					
Ammonium Hydroxide (10 %)	23	21	85-93	0,3	0,02
Sodium Hydroxide (10 %)	23	21	0-47	5	0,02
Other Solvents					
Bleach «Clorox» (100 %)	23	21	90-95	0,1	0,07
Calcium Chloride (10 %)	23	21	85-95	0,25	0
Hydrogen Peroxide (30 %)	23	21	90	0,25	0,02
Sodium Chloride	23	21	90-95	0,31	0
1,1,1-Trichloroethane	23	21	90	0,3	0
WD-40	23	21	90	0,05	0,01
Zinc Chloride (10 %)	23	21	91-96	1	0,01
Zinc Chloride (50 %)	23	8	90-95	1	0,01

Table 4.6 RYNITE® 545 immersed for 1 year at 23°C

	% retention of original tensile strength	Weight gain (%)	Dimensional change (%)
Ethanol	97	0,13	0,02
Iso-octane	100	0,04	0,01
Methanol	87	0,6	0,07
95 octane petrol	99	0,08	0,03
Toluene	90	0,99	0,05
Toluene/Methanol (85:15 (v/v))	61	3,14	0,24
Unleaded petrol/Ethanol (85:15 (v/v))	93	0,28	0,03
Unleaded petrol/Methanol (85:15 (v/v))	83	0,96	0,09
Water	92	0,47	0,07
White petrol/Methanol (85:15 (v/v))	84	1,06	0,09

Resistance of CRASTIN® to chemicals, ionizing radiation, micro- and macro-organisms

Compared with many other plastics CRASTIN® shows superior chemical resistance.

At room temperature CRASTIN® is unaffected by the following chemicals:

Aliphatic, aromatic and perhalogenated hydrocarbons; oils; greases; alcohols; ethers; long-chained esters; water; aqueous neutral and acid salt solutions; dilute acids.
However, it is not resistant to alkalis, concentrated acids, oxidizing mineral acids (including dilute), phenols and cresols.

At temperature >50 – 60°C some chemicals, such as alcohols and aromatic hydrocarbons, have a more agressive effect on the PBT-molecule than at room temperature.

Up to 60°C water has little effect on CRASTIN®. At higher temperatures, hydrolytic decomposition occurs in water and all aqueous solutions. This causes a reduction in strength and toughness.

1. Notes

The information contained in the tables on the following pages is derived from laboratory tests and experience in practice. In laboratory tests, unless otherwise shown, 2 mm thick standard specimens were immersed in the medium for twelve months. The test results should be regarded as a guideline, since identical results may not be obtained in practice. Experience shows that the wall thickness of mouldings or the ratio of volume to wetted surface can influence results quite considerably. Therefore, parts likely to be subject to exposure to potentially aggressive media should be tested under practical conditions.

2. Explanation of information in the tables

2.1 Concentrations

%: by weight g/g
% (vol): by volume cm^3/cm^3
tech. pure: technically pure
sat.: saturated aqueous solution (at 20°C)
dil.: dilute aqueous solution
com.: commercial

2.2 Temperature

r.t.: room temperature 15 to 35°C (DIN 50014).

2.3 Behaviour

+: resistant
Medium causes no change or only slight change in strength, toughness, molecular weight, dimension and weight.

☆: conditionally resistance
Long term contact with the medium may cause considerable change in the properties of the moulding. This should be taken into account at the design stage. Occasional contact is, in most cases, acceptable. Practical tests are advisable.

–: not resistant
The moulded component is irreversibly damaged by short term contact with the medium.
Brief contact (e. g. use of the medium as a cleaning agent) may be acceptable. Premliminary testing is advisable.

2.4. Remarks

This column contains observations that were noticeable and/or different test conditions or results.

Table 4.7 Chemical resistance of CRASTIN® grades

Medium	Conc %	Temperature °C	Behaviour	Remarks
Acetic acid	5	r.t.	+	
	5	60	☆	
	10	r.t.	+	
	10	60	☆	
	95	r.t.	☆	
	95	60	–	
Acetone	tech. pure	r.t.	☆	S600F10 at r.t. +
	tech. pure	60	–	
Air, liquid		–190	+/☆	reduced toughness
Aniline	tech. pure	r.t.	☆	
Ammonia, aqueous	10	r.t.	+	
	10	60	–	
Ammonia, liquified	tech. pure	r.t.	☆	
	tech. pure	60	–	
ASTM oil No. 2	tech. pure	r.t.	+	
(see lubricating oils)	tech. pure	80	+	slightly yellowish discolouration at 80°C
ASTM oil No. 3	tech. pure	r.t.	+	slightly yellowish
(see lubricating oils)	tech. pure	80	+	discolouration at 80°C
Benzene	tech. pure	r.t.	☆	S600F10 at r.t. +
	tech. pure	60	–	
Brake cylinder grease	com.	120	+	test period 100 h
Brake fluids	com.	r.t.	+	DOT3, DOT4,
	com.	60	+	ISO 4925
	com.	80	☆	
Butane	tech. pure	r.t.	+	
	tech. pure	60	+	
Butanol	tech. pure	r.t.	+	
	tech. pure	60	☆	
Butene	com.	r.t.	+	
Butyl acetate	tech. pure	r.t.	+	
	tech. pure	60	☆	
Calcium chloride, aqueous	sat.	r.t.	+	
	sat.	60	+	
Calcium hypochloride	sat.	r.t.	+	
	sat.	60	☆	
Carbon dioxide		r.t.	+	
		60	+	
Carbon monoxide		r.t.	+	
		60	+	
Chlorobenzene	tech. pure	r.t.	–	
Chlorofluorocarbons	com.	r.t.	+	e. g. ARKLONE®, FRIGEN®, KALTON®

Table 4.7 Chemical resistance of Crastin® grades (continued)

Medium	Conc %	Temperature °C	Behaviour	Remarks
Chloroform	tech. pure	r.t.	–	
Chromic acid (anhydride)	10	r.t.	+	
	10	60	+	
Citric acid, aqueous	10	r.t.	+	
	10	60	☆	
Citrus fruits and juices	com.	r.t.	+	
Cream (sweet, sour, whipped)	com.	r.t.	+	no change in taste
Crude oil	com.	r.t.	+	
	com.	60	+	
Cutting oils	com.	r.t.	+	
	com.	60	+	
Cutting oils	10	r.t.	+	
	10	60	+	
Disinfectants Active ingredient				Disinfectants and methods
– Alcohols	r.t.	+	+	according to «Bundesgesund-
– Chlorine, active	dil.	r.t.	+	heitsblatt» 25, No. 2, Febr.1982
– Formaldehyde and/or other aldehydes	dil.	r.t.	+	
– Phenol or phenol derivatives	dil	r.t.	+/☆	sligthly yellowish discolouration of toughened types
– Quarternary ammonium or phosphonium compounds (amphoteric tensides)	dil.	r.t.	+	
Disinfection methods				
– Scalding (soda 0,5 % aqueous)		ca.100	+/☆	
– Steam flow method		>100	+/☆	see steam sterilisation
– Hot air-steam-hot air (HDH)		120 – 105 – 120	+/☆	
– Hot air sterilisation		180	+/☆	
– Irradiation		23 – 35	+	up to 200kGy total dose (alpha, beta, gamma-radiation)
(see sterilisation)				
Developer (photo)	dil.	r.t.	+	recommended concentration
Diesel oil	com.	r.t.	+	
(see motor fuels)	com.	60	+	
Diethyl ether	tech. pure	r.t.	+	
	tech. pure	60	☆	
Dimethyl ether	tech. pure	r.t.	+	
Dish washer solution (aqueous)				test period 500 hours
20 g/l NaCl + 3 g/l cleaning agent (pH >10)	dil.	70	+	
20 g/l NaCl + 1 g/l clear rinsing agent (pH 2 – 3)	dil.	70	+	

Table 4.7 **Chemical resistance of Crastin® grades** (continued)

Medium	Conc %	Temperature °C	Behaviour	Remarks
Ethanol	40 (vol)	r.t.	+	
	40 (vol)	60	+	
	96 (vol)	r.t.	+	
	96 (vol)	60	☆	
Ethyl acetate	tech. pure	r.t.	☆	
	tech. pure	60	–	
Ethylene glycol	tech. pure	r.t.	+	
	tech. pure	60	☆	
Fats (lubricating greases edible fats)	com.	r.t.	+	
(see lubricating greases)	com.	60	+	
Fertilizers	com.	r.t.	+	
Fertilizers, aqueous	sat.	r.t.	+	
Fixing solutions (photo)	dil.	r.t.	+	recommended concentration
Fluorocarbons	com.	r.t.	+	
(see chlorofluorocarbons)	com.	60	+	
Formic acid	10	r.t.	–	
	10	60	☆	
	95	r.t.	☆	
	95	60	–	
Fuel oil EL (DIN 51603)	com.	r.t.	+	
	com.	60	+	
Glycerol	tech. pure	r.t.	+	
	tech. pure	60	+	
	tech. pure	80	☆	
Glycol	tech. pure	r.t.	+	
	tech. pure	60	☆	
	tech. pure	80	–	
Heptane	tech. pure	r.t.	+	
	tech. pure	60	+	
Hexane	tech. pure	r.t.	+	
	tech. pure	60	+	
Hydraulic fluids	com.	r.t.	+	toughened types at r.t. +
flame retardant	com.	60	+	toughened types at 60°C ☆
(phosphate ester based)	com.	80	☆	toughened types at 80°C –
Hydraulic oils	com.	r.t.	+	
mineral oil based	com.	80	+	
H and HL (DIN 51524)				
HLP (DIN 51525)				
Hydrochloric acid, aqueous	10	r.t.	+	
	10	60	–	
	37	r.t.	–	

Table 4.7 Chemical resistance of CRASTIN® grades (continued)

Medium	Conc %	Temperature °C	Behaviour	Remarks
Hydrofluoric acid, aqueous	10	r.t.	–	S600F10 at r.t. +
	10	60	–	
	40	r.t.	–	
Hydrogen peroxide, aqueous	5	r.t.	+	
	5	60	☆	
	35	r.t.	+	
	35	60	–	
Iodine in alcohol (iodine tincture)	com.	r.t.	+	strong discolouration
Isooctane	tech. pure	r.t.	+	
	tech. pure	60	+	
Isopropylalcohol (isopropanol)	tech. pure	r.t.	+	
	tech. pure	60	☆	
Linseed oil	com.	r.t.	+	
	com.	60	+	
Lubricating greases	com.	r.t.	+	
Anti-friction greases (DIN 51825)	com.	100	+	toughened types at 100° C ☆
Lubricating greases, synthetic	com.	r.t.	+	
semi-synthetic (basis diester, polyester, polyphenylene ester, silicone oil, synthetic lubricating oil	com.	100	+	toughened types at 100° C ☆
Lubricating oils				
Gearoils, mild-alloyed,	com.	r.t.	+	
high-alloyed (HYP)	com.	100	+	toughened types at 100° C ☆
Coupling gear oils ATF	com.	r.t.	+	toughened types at 100° C ☆
	com.	100	+	

Table 4.7 Chemical resistance of CRASTIN® grades (continued)

Medium	Conc %	Temperature °C	Behaviour	Remarks
Lubricating oils with and without active substances	com.	r.t.	+	slightly yellowish discolouration at 80 °C
Motorfuels HD Bearing oils Pneumatic oils Refrigerator oils Waterturbine oils Lubricating oils for textile machines (Air) filter oils Annealing oils Rust preventing oils Metal working oils Heat transmission oils Rolling oils Textile auxiliary oils (DIN 51501; 3; 6; 7; 8; 11; 13; 15; 17; 24; Cose No. BA; BB; BC; C; CG; DA; Gm; KA; KC; N; TD; TW; VN; VB; VC; X; XA; ZS; ZA; ZB; ZC; ZD; F; FS; H; J; L; R; S; U; W; XB; XS; as per DIN 51502)	com.	80	+	
Lubricating oils without additives	com.	r.t.	+	slightly yellowish discolouration at 80 °C
basis mineral oils (ASTM standard oils)	com.	80	+	
Lubricating oils, synthetic	com.	r.t.	+	
(basis ester oil, fluorohydrocarbons, polyalkylene, glycol, silicone oil) (E; FK; PG; SI as per DIN 51502)	com.	80	+	

Medium	Conc %	Temperature °C	Behaviour	Remarks
Mercury	tech. pure	r.t.	+	
Methanol	tech. pure	r.t.	+	
		60	☆	toughened types at 60 °C –
		80	–	
Methylene chloride	tech. pure	r.t.	–	
Methyl ethyl ketone	tech. pure	r.t.	–	toughened types at r.t. –
	tech. pure	60	–	
Micro-organisms in soil burial test		30	+	Naturally occuring mixed micro-organisms in test soil; bacteria and spoors
Mineral oils, motoroils	com.	r.t.	+	
(see lubricants)	com.	80	+	slightly yellowish discolouration at 80 °C

Table 4.7 Chemical resistance of Crastin® grades (continued)

Medium	Conc %	Temperature °C	Behaviour	Remarks
Motor fuels				
– Petrol, regular	com.	r.t.	+	
(DIN 53521)	com.	60	+	
– Petrol, four-star	com.	r.t.	+	
(DIN 53521)	com.	60	+	
– FAM motor test fuel	tech. pure	r.t.	+	
(DIN 51604)	tech. pure	60	+	toughened types at 60° C ☆
– M 15 (petrol)	tech. pure	r.t.	+	
four-star/methanol 85/15	tech. pure	60	+	toughened types at 60° C ☆
– Diesel oil	com.	r.t.	+	
(DIN 51601)	com.	60	+	
– Kerosene	com.	r.t.	+	
	com.	60	+	
Moulds (natural e.g. "mildew") (DIN 40046, p.10) Test J, DIN 41640, part 29		30	+	evaluation: 0
Naphtha (light petrol)	com.	r.t.		
Natural gas	com.	r.t.		
Nitric acid, aqueous	10	r.t.	+	toughened types at r.t. ☆/–
	10	60	☆/–	
	40	r.t.	–	
Octane	tech. pure	r.t.	+	
	tech. pure	60	+	
Olive oil	com.	r.t.	+	
	com.	60	+	
Perchlorethylene	tech. pure	r.t.	+	toughened types at r.t. ☆
	tech. pure	60	–	
Perfumes (alcoholic solutions)	com.	r.t.	+	
Pesticides	com.	r.t.	+	recommended concentration
Petroleum	com.	r.t.	+	
	com.	60	+	
Phenol, aqueous	5	r.t.	☆	toughened types at r.t. –
	10	r.t.	–	
Phosphoric acid, aqueous	5	r.t.	+	
	5	60	+	
	20	r.t	+	
	20	60	☆	
	85	r.t.	+	
	85	60	☆/–	

Table 4.7 **Chemical resistance of CRASTIN® grades** (continued)

Medium	Conc %	Temperature °C	Behaviour	Remarks
Potassium chloride, aqueous	10	r.t.	+	
	10	60	+	
Potassium hydroxide, aqueous	1	r.t.	–	S600F10 at r.t. +
	1	60	–	S600F10 at 60°C ☆
	10	r.t.	–	
Potassium hydrogen chromate	10	r.t.	+	
	10	60	+	
Radiation (alpha, beta, gamma)		r.t.	+/–	
Road salts, thawing salts, aqueous (sodium chloride, potassium chloride)	10	r.t.	+	
Sea water		r.t.	+	
		60	+	
Silicone oils, greases	com.	r.t.	+	
	com.	100	+	
Soaps, aqueous (sodium, potassium)	5	r.t.	+	
	5	60	+	
	5	80	–	
Sodium hydroxide, aqueous	1	r.t.	–	S600F10 at 1 % r.t. +
	1	60	–	
	10	r.t.	–	
	10	60	–	
Sodium hypochloride, aqueous	10	r.t.	+	
	10	60	☆	
Sodium salts, aqueous (carbonate, chloride, nitrate, sulphate, sulphite)	10	r.t.	+	
	10	60	+/☆	
Steam		above 100	–/+	
– sterilisation	13	134	+/☆	
Sulphuric acid, aqueous	5	r.t.	+	
	5	60	+	
	5	80	–	
	10	r.t.	+	
	10	60	+	
	28	r.t.	+	
	28	60	☆	
	98	r.t.	–	

Table 4.7 Chemical resistance of CRASTIN® grades (continued)

Medium	Conc %	Temperature °C	Behaviour	Remarks
Termites (Kalotermes flavicollis, Captotermes formosanus Shiraki Heterotermes indicola)		26 (95 % r. h)	+	compulsory feeding test: isolated traces of gnawing ad libitum feeding test: no traces of gnawing
Thermal waters (thermal springs)		50	+	
Toilet cleaning agents	dil.	r.t.	+	recommended
				concentration
Toluene	tech. pure tech. pure	r.t. 60	+ –	toughened types at r.t. ☆
Trichlorethylene	tech. pure tech. pure	r.t. 60	☆ –	toughened types at r.t. –
Turpentine	com.	r.t. 60	+ +	
Turpentine substitutes	com.	r.t. 60	+ +	
Urine		r.t.	+	
VASELINE®	com. com.	r.t. 60	+ +	
Vegetable oils	com. com.	r.t. 60	+ +	
Washing solutions (all purpose washing powder washing-up liquid, softening liquid, clear rinsing fluid)	dil. dil. dil.	23 60 70	+ + –/+	at 70° C up to 100 h test period +
Water (river, sea, mineral, drinking water)		r.t. 60 70	+ + –/+	
Waxes (vegetable, animal, mineral, synthetic waxes)	com. com.	r.t. 80	+ +	
Xylene	tech. pure tech. pure	r.t. 60	☆ –	

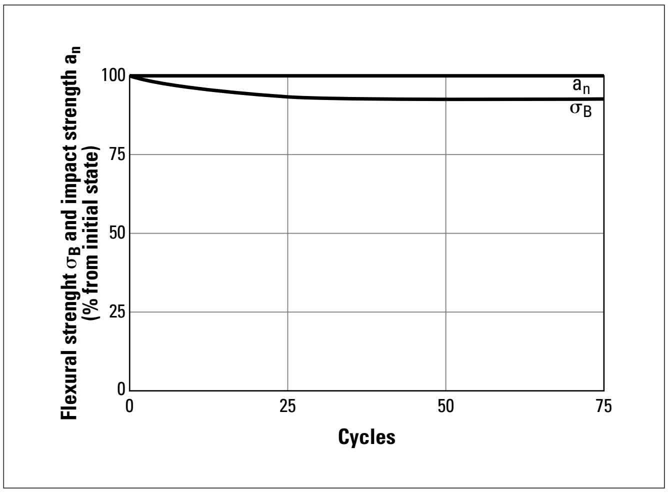


Fig. 4.17 **Change in flexural strength σ_B (DIN 53452) and impact strength a_n (DIN 53453) of CRASTIN® S600F10. Sterilization with steam, 134°C superheated steam, cycle 15 min. Impact strength a_n after 75 cycles; no failure**

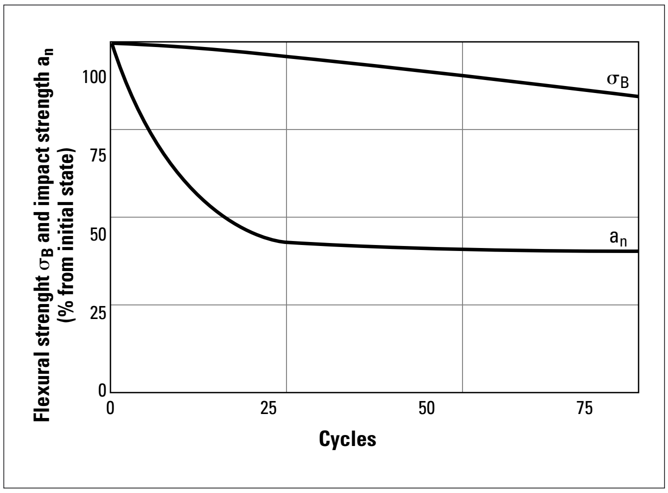


Fig. 4.20 **Change in flexural strength σ_B (DIN 53452) and impact strength a_n (DIN 53453) of CRASTIN® SK605. Disinfection with water, 100°C boiling water + 0,5% sodium carbonate, cycle 15 min**

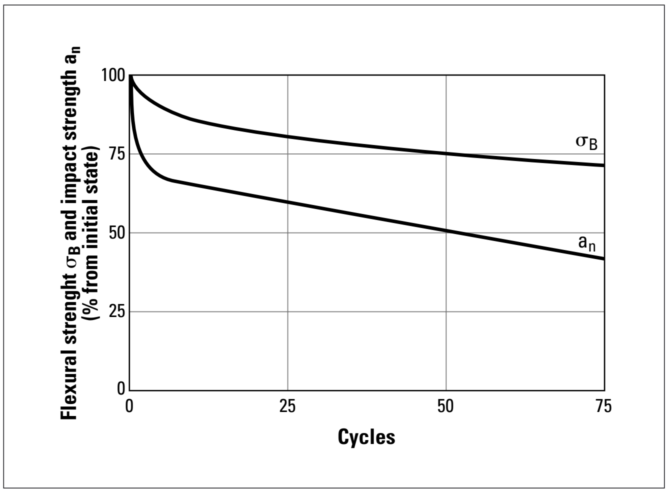


Fig. 4.18 **Change in flexural strength σ_B (DIN 53452) and impact strength a_n (DIN 53453) of CRASTIN® SK605. Sterilization with steam, 134°C superheated steam, cycle 15 min**

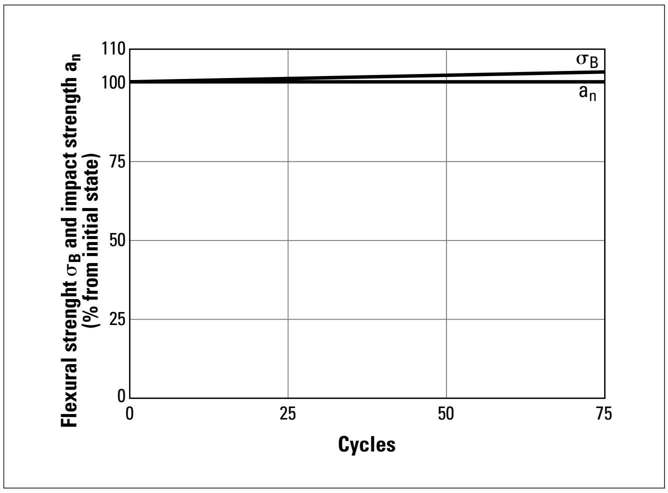


Fig. 4.21 **Change in flexural strength σ_B (DIN 53452) and impact strength a_n (DIN 53453) of CRASTIN® S600F10. Sterilization in hot air, 180°C, cycle 30 min. Impact strength a_n after 75 cycles no failure**

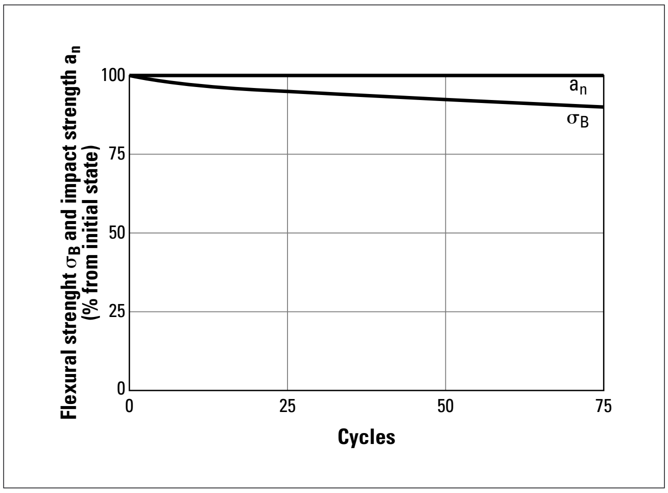


Fig. 4.19 **Change in flexural strength σ_B (DIN 53452) and impact strength a_n (DIN 53453) of CRASTIN® S600F10. Disinfection with water, 100°C boiling water + 0,5 % sodium carbonate, cycle 15 min. Impact strength a_n after 75 cycles; no failure**

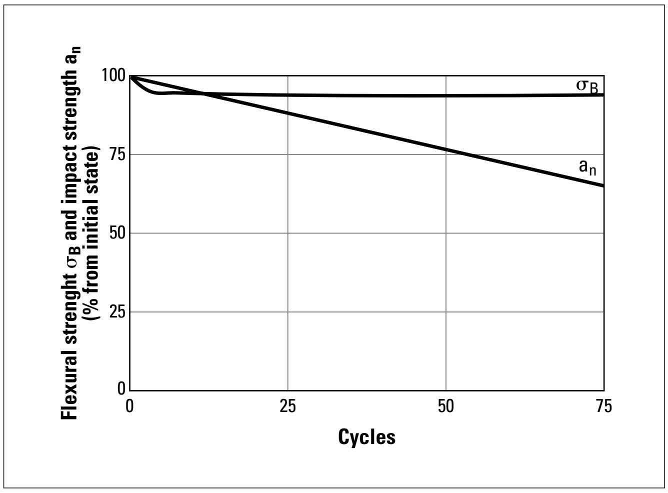


Fig. 4.22 **Change in flexural strength σ_B (DIN 53452) and impact strength a_n (DIN 53453) of CRASTIN® SK605. Sterilization in hot air, 180°C, cycle 30 min**

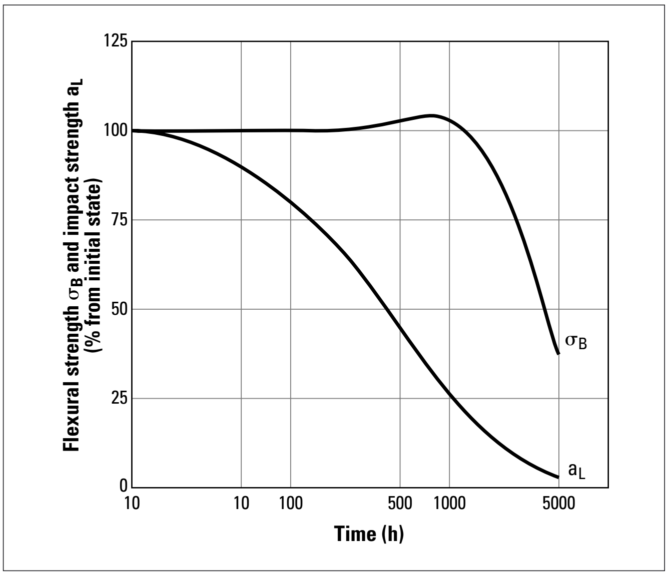


Fig. 4.23 **Change in flexural strength σ_B (DIN 53452) and hole notched impact strength a_L (DIN 53753) of CRASTIN® S600F10 after γ-radiation treatment (quantum energy 0,8 MeV) in air, temperature 23 – 35°C, dose rate 2 kGy/h**

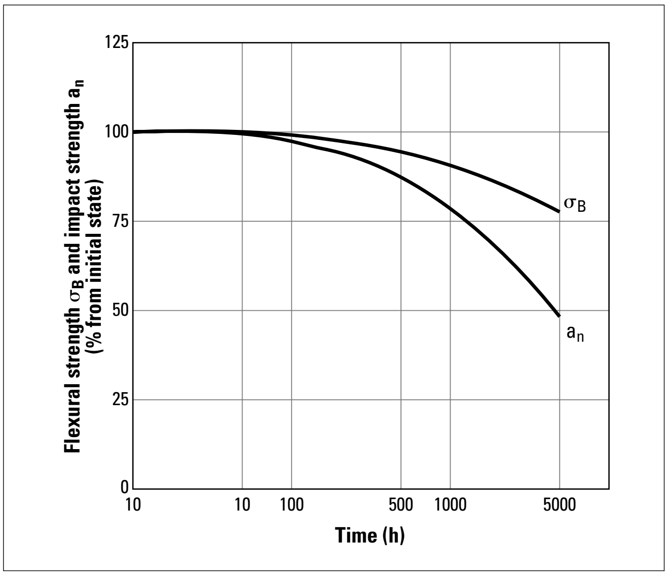


Fig. 4.24 **Change in flexural strength σ_B (DIN 53452) and impact strength a_n (DIN 53453) of CRASTIN® SK605 after γ-radiation treatment (quantum energy 0,8 MeV) in air, temperature 23 – 35°C, dose rate 2 kGy/h**

5. – Properties – Dimensional considerations

5.1 – Introduction

CRASTIN® and RYNITE® glass reinforced thermoplastic polyester resins are unique among polyester systems. These products contain uniformly dispersed glass fibres and/or other fillers, specially formulated for rapid crystallisation during the injection moulding process.
This makes possible the production of high performance parts by conventional injection moulding techniques. General handling and processing techniques are discussed in the CRASTIN® and RYNITE® moulding manual (TRP 30) available from your DuPont representative.

5.2 – Drying of CRASTIN® and RYNITE®

Moisture in the granulates results in an hydrolic reduction of the molecular weight during processing which causes a reduction in strength and toughness of moulded parts.

CRASTIN® and RYNITE® need pre-drying to obtain the best properties for moulded parts. Please refer to the polyester moulding guide for further details on handling and drying recommendations.

5.3 – Flow properties

CRASTIN® and RYNITE® polyester resins have very good flow properties. Parts with long flow paths and narrow wall thickness are easily moulded. The good flow properties also contribute to achieving high surface finish quality, even with glass fibre reinforced products. Mould details are precisely reproduced.

Figure 5.1 shows the flow length of RYNITE® resins using various moulding conditions.

Figure 5.2 shows the flow properties of standard CRASTIN® types. The indicated flow lengths, at wall thickness of 1, 2 and 3 mm, were determined with the aid of a test spiral.

The flow properties of products not shown here can be found in the relevant product data sheets.

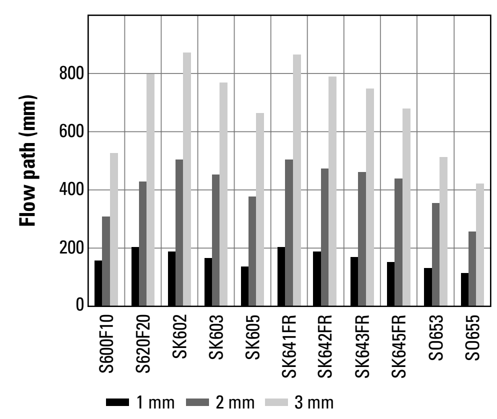


Fig. 5.2 **Flow length with wall thickness of 1, 2 and 3 mm, 100 MPa injection pressure, 250° C melt temperature and 80° C mould temperature for several grades of CRASTIN®**

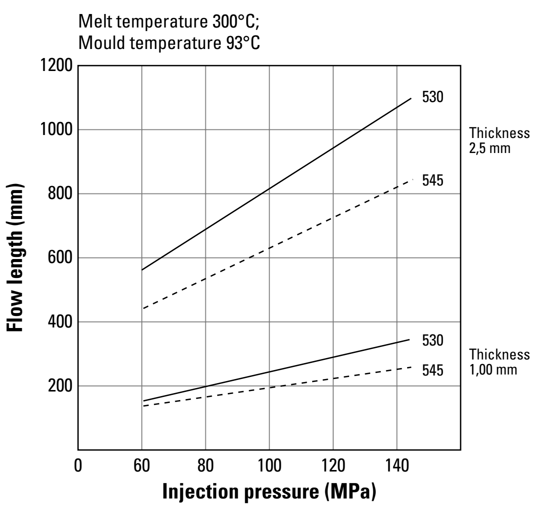


Fig. 5.1 **Flow length of RYNITE® resins**

5.4 – Moulding

As with most thermoplastic resins, the moulding of CRASTIN® and RYNITE® resins is ordinarily a safe operation. Following good processing practices, consideration should be given to the following potential hazards:

- Thermal effects.
- Off-gases and particulates.
- Slipping hazards.

For further details, please refer to the moulding manual or the material safety data sheets.

Table 5.1	Rynite® grades				Crastin® grades		
	530 545	FR530L	530CS 936CS	415HP 408	S600F10, SK605 SO655, T805 LW9030, S650FR SK645FR, T850FR LW9030FR	ST820	T845FR
Recommended melt temperature (°C)	285	280	280	280	250	250	240
Recommended mould temperature (°C)	≥110	110	140	110	80	60	80

NOTE: Moulding conditions to mould ISO or Campus test specimen may be different from those mentioned above. Please refer to ISO or Campus recommendations in this case.

Crastin® and Rynite® can be moulded in all standard screw injection moulding machines. The normal moulding conditions are shown in Table 5.1.

For more detailed information on moulding conditions, ask for the DuPont polyester moulding manual.

5.5 – Rheological and physical properties

For the simulation of injection moulding conditions computer programs have been developed which require properties such as melt-viscosity as function of shear rate and temperature.

These properties can be found in Campus (3.0 or above); for additional physical properties of several Crastin® and Rynite® grades, see Table 5.2.

For physical properties of grades not listed in Campus, nor given in this section, please contact your DuPont representative.

Table 5.2 Thermal properties (melt) of Crastin® PBT and Rynite® PET grades

Material	Melt density kg/m³	Specific heat J/kg · °C	Coefficient of thermal conductivity W/m · °C
Crastin® S600F10	1110	2130	0,270
Crastin® SK605	1300	1810	0,350
Crastin® SO655	1300	1800	0,350
Crastin® S650FR	1250	2200	0,270
Crastin® SK645FR	1435	1600	0,360
Rynite® 415HP NC010	1130	1940	0,155
Rynite® 530 NC010	1360	1550	0,181
Rynite® 545 NC010	1500	1610	0,228
Rynite® 555 NC010	1600	1540	0,296
Rynite® 935 NC010	1370	1790	0,236
Rynite® FR530L NC010	1480	1590	0,189

5.6 – Mould shrinkage

For amorphous thermoplastics, shrinkage is caused primarily by contraction of the moulded part as it cools to room temperature.

In semi-crystalline thermoplastics, which include unreinforced Crastin® and Rynite® grades, shrinkage is also influenced considerably by the crystallization of the polymer. The degree of crystallization depends largely on the transient and local temperature changes in the moulding. High mould temperatures and heavy wall thickness (high heat content of the melt) promote crystallization and therefore increase shrinkage.

5.7 – Warpage

Warpage is generally caused by non-uniform shrinkage of the resin. The non-uniform shrinkage may also be due to:

- *Anisotropic Shrinkage.* This factor (difference of shrinkage in the flow and transverse directions, see Table 5.3) probably contributes more to warpage problems in glass-reinforced resins than any other. Anisotropic shrinkage most often arises because of orientation of the glass fibres in the direction of flow which, in turn, restricts normal resin shrinkage. Therefore, any condition that can create an isotropic distribution of the glass fibres will reduce the warpage, i.e. abrupt change in flow direction, multiple gating, etc.
- *Non-uniform wall thickness of the part.* Whenever possible, parts should be designed with a uniform wall thickness. Thick parts should always be cored out in order to minimize shrinkage.
- *Mould Design.* Typically, round parts should be centre-gated, and long flow parts should be end-gated.
- *Processing Conditions.* The mould and cavity temperatures must be carefully controlled to prevent uneven cooling of any part prior to ejection.

Table 5.3 Measured shrinkage values on plaques of RYNITE® moulded under standard conditions

	End gated plaque 76,2 × 127 × 3,2 mm		End gated plaque 76,2 × 127 × 1,6 mm	
RYNITE® grades	shrinkage in flow direction (parallel) (%)	shrinkage in transverse direction (normal) (%)	shrinkage in flow direction (parallel) (%)	shrinkage in transverse direction (normal) (%)
520	0,35	0,90	0,23	0,82
530	0,25	080	0,18	0,78
545	0,20	0,75	0,15	0,67
555	0,20	0,70	0,13	0,66
FR515	0,50	0,95	0,34	0,69
FR530L	0,25	0,75	0,16	0,68
FR543	0,20	0,65	0,12	0,47
FR943	0,35	0,70	0,22	0,57
408	0,20	0,75	0,21	0,63
415HP	0,40	0,95	0,24	0,67

5.8 – Shrinkage of RYNITE®

The mould shrinkage of RYNITE® glass-reinforced resins depends on the orientation of the glass fibres, part thickness and processing conditions. RYNITE® glass-reinforced resins shrink less in the flow direction than in the transverse direction. Shrinkages listed in Table 5.3 are intended as a guide for estimating 'as moulded' dimensions. Shrinkage values according to ISO 2577 can be found in chapter 2.

Special grades of RYNITE® are available with a smaller differential shrinkage than RYNITE® 530 and 545. These grades are intended for applications where minimum warpage is needed.

For complex precision parts, prototype moulds (cavities) should be utilised to obtain more accurate dimensional data.

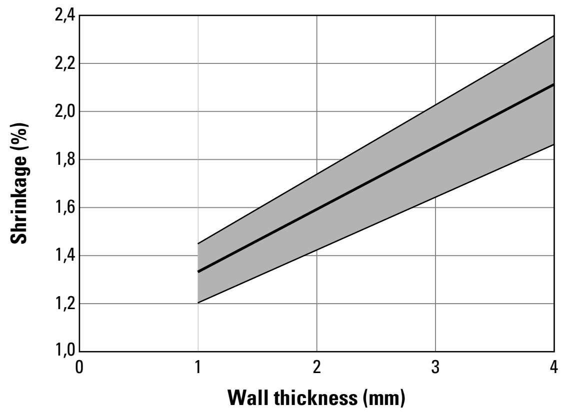


Fig 5.3 **Shrinkage of unreinforced (e.g. S600F10) and filled (e.g. SO655) CRASTIN® types as a function of wall thickness. Measured on plates 100 × 100 mm with a fan gate. Not valid for ST820**

5.9 – Shrinkage of CRASTIN®

Please refer to chapter 2 for shrinkage values according to DIN standards.

For more information please refer to the polyester moulding manual.

The influence of wall thickness on shrinkage of unreinforced CRASTIN® is shown in Figure 5.3. This shows the shrinkage of plates measuring 100 × 100 mm, with a wall thickness of 1–4 mm, using normal processing conditions.

The shrinkage behaviour of filled CRASTIN® types or of unreinforced, flame-retardant CRASTIN® types is similar to that of CRASTIN® S600F10.

For glass-fibre reinforced CRASTIN®, shrinkage is considerably influenced by the direction in which the glass-fibres are oriented. As a result, there is a difference in shrinkage parallel to and at right angles to the direction of flow and this makes accurate prediction of the shrinkage difficult. Depending on the fibre orientation, which is determined by the way in which the mould fills, shrinkage can also occur between the longitudinal and transverse shrinkage shown in Figure 5.4. In extreme cases, the difference in shrinkage may be greater than shown.

This depends on the degree to which the glass-fibres orient themselves as determined by the design of the part and the position of the gate.

Shrinkage values which differ from those shown in the diagrams can result not only from differences in processing conditions, but also from the effects of gate size or from the restrictions to shrinkage caused by such mould features as cores, slides, inserts, etc. If the gate diameter is very small compared to the wall thickness, much higher shrinkage can occur in unreinforced CRASTIN® than is shown in the diagrams, due to the reduced effectivness of holding pressure.

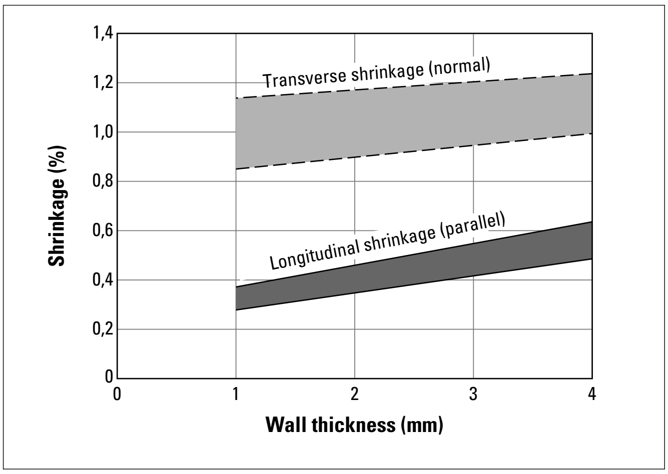


Fig 5.4 **Shrinkage of glass-fibre reinforced CRASTIN® types with a glass content of 30% by weight (e.g. SK605, SK645FR) as a function of wall thickness. Measured on plates 100 × 100 mm with a fan gate**

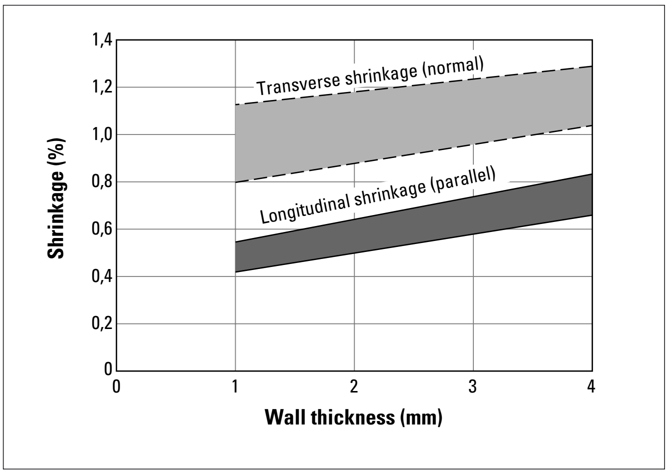


Fig 5.5 **Shrinkage of glass-fibre reinforced CRASTIN® types with a glass content of 15% by weight (e.g. SK602, SK642FR) as a function of wall thickness. Measured on plates 100 × 100 mm with a fan gate**

Post-shrinkage of CRASTIN®

Post-shrinkage can be defined as the dimensional change (in %) of a moulded part measured at 23° C after conditioning for a specific period at a specific temperature.

Within the group of semi-crystalline thermoplastics, CRASTIN® types exhibit low post-shrinkage values.

As can be seen in Figures 5.6 and 5.7, post-shrinkage is an inverse function of processing or mould shrinkage. Increasing the mould temperature reduces post-shrinkage for a given, constant conditioning temperature. In the case of glass-fibre reinforced types, these effects are minimal.

This means that precision parts with very narrow tolerances should be produced using higher mould temperatures, particularly if the parts have thin walls. The degree of crystallinity will then be sufficiently high that little or no post-shrinkage occurs if the parts are used at continuous high temperatures.

As well as processing shrinkage (Figure 5.5), glass-fibre reinforced products also exhibit different degrees of post-shrinkage parallel to and perpendicular to the glass-fibre orientation (Figure 5.7).

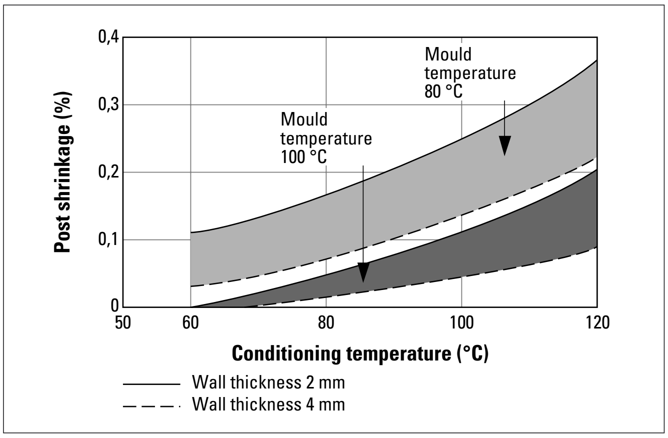


Fig 5.6 **Post-shrinkage of unreinforced (e.g. S600F10) and filled (e.g. SO655) CRASTIN® types with wall thickness of 2 and 4 mm and mould temperatures of 80 and 100° C, respectively, as a function of conditioning temperature**

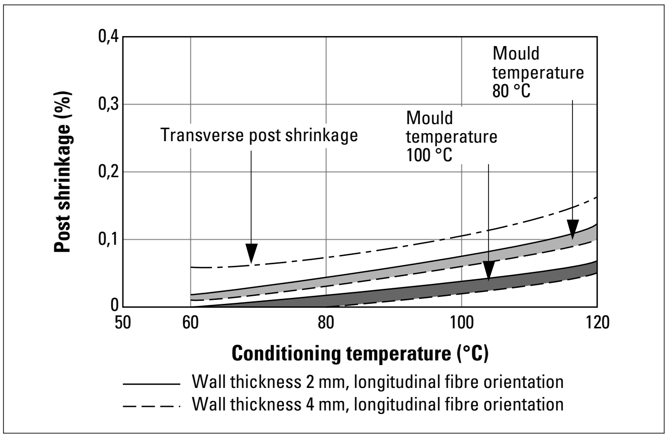
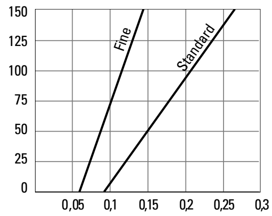


Fig 5.7 **Post-shrinkage of 30% glass-fibre reinforced CRASTIN® types (e.g. SK605, SK645FR) with wall thickness of 2 and 4 mm and mould temperatures of 80 and 100° C, respectively, as a function of conditioning temperature**

5.10 – A guide to tolerances

Drawing code	**Dimensions mm**	**Suggested tolerances**
A = Diameter (see notes 1 and 2)		
B = Depth (see note 3)		
C = Height (see note 3)	150 to 300 mm for each additional mm add ± 0,05 mm (fine)	
		Commercial ± mm
D = Bottom wall (see note 3)		0,10
E = Side wall (see note 4)		0,10
F = Hole size diameter (see note 1)	0 to 3 mm	0,05
	3 to 6 mm	0,08
	6 to 13 mm	0,08
	> 13 mm	0,10
G = Hole size depth (see note 5)	0 to 6 mm	0,08
	6 to 13 mm	0,10
	13 to 25 mm	0,13
Draft allowance per side (see note 6)		0,5 to 1°

NOTE: The commercial values shown above represent common production tolerances at the most economical level. The fine values represent closer tolerances that can be held but at a greater cost.

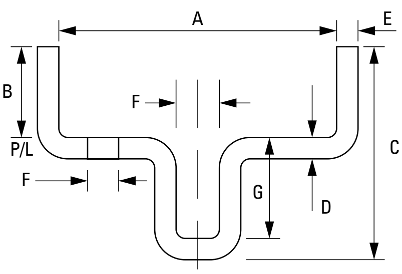
Reference notes:

1. These tolerances assume a mould temperature of ≥ 93° C, annealing at 150° C and will cause ≥ 0,1% overall dimensional change.
2. Tolerances based on 3,2 mm wall section.
3. Parting line must be taken into consideration.
4. Part design should maintain a wall thickness as constant as possible. Complete uniformity in this dimension is impossible to achieve.
5. Care must be taken that the ratio of the depth of a cored hole to its diameter does not reach a point that will result in excessive pin damage (*l* ≤ 3 d).
6. These values should be increased whenever compatible with desired design and good moulding technique.

Tolerance (a = dimension)

Standard: $\Delta a_s = 0{,}075 + 0{,}0015\ a$

Fine: $\Delta a_F = 0{,}67\ \Delta a_s$



6 – Government and agency approvals

6.1 – USA, UK, France specifications and regulatory agencies

Combustibility

The combustibility of CRASTIN® and RYNITE® has been determined by the FMVSS-302, FAR-25-853-B vertical burn test, and according to various glow wire test methods. The data obtained are recorded in Tables 6.1 and 6.2. The RYNITE® thermoplastic polyester resins tested by the FMVSS-302 test comply with the automotive requirements of less than 1072 mm/min. burning rate.

United States
Systems of insulating material UL-1446

RYNITE® 530, 935, FR515, FR530L have received final approval for class 180 (H), 155 (F) and 130 (B) insulation systems. RYNITE® FR530L has received approval also for class N (200° C) insulation systems.
CRASTIN® CE7030 and CE7931 have also been approved for class 155 (F) and 130 (B).

United Kingdom
British Telecom – Telecommunication

RYNITE® FR530L passes specification M-147 class 1 for flammability requirements of materials used in internal apparatus and equipment.

This test method is based on the Limited Oxygen Index (LOI) requiring a value of 27% or above.

France
Centre National d'Etudes des Télécommunications (CNET)

RYNITE® FR530L is classified E1.

Centre Scientifique et Technique du Bâtiment (SCTB)

Rynite FR530L is classified M2 at a thickness of 3,5 mm.

French Laboratories

RYNITE® FR530L is classified F2 for the emission of fumes on combustion.

Table 6.1 FMVSS* 302 ratings of various RYNITE® and CRASTIN® resins

Grade	Thickness (mm)	FMVSS-302 rating	Burning rate (mm/min.)
RYNITE® 530	1	B 24	24
RYNITE® 545	1	SE/NBR	Self-ext./no burn
RYNITE® 935	1	B 24	24
CRASTIN® S600F10 NC	1	SE	Self-ext.
CRASTIN® SK605 NC	1	B28	28
CRASTIN® SK605 BK	1	B62	62
CRASTIN® T805 NC	1	B38	38
CRASTIN® ST820 NC	1	B38	38
CRASTIN® LW9030 NC	1	B42	42

*Federal Motor Vehicle Safety Standard

Table 6.2 Combustibility of various RYNITE® resins

Test method	Grade	Glow wire temperature (° C)	Test passed at thickness: (mm)
Vertical burn			
FAR-25-853-B	FR530	–	3,2
Glow wire			
IEC 60695-2-1 or	FR530L NC010	960	1,2
NFC 20-455 or	FR530L NC010	750	2
Australian Standard	545 NC010	750	1
AS-2420		850	3

U.S. Military Specification MIL-M-24519

RYNITE® FR530 and CRASTIN® SK645FR are listed in the Qualified Products List (QPL 24519-7).

U.S. Military Specification MIL-P-46161A (MR)

This specification has been superseded by ASTM D-3220-81 which can be used to describe RYNITE® thermoplastic polyester resins. Contact your DuPont Engineering Polymers sales office for details.

Regulatory compliance

For use in many applications, a material has either to be approved or must meet the requirements of various governmental or private agencies. This is mainly to protect the user, the general public or the environment.

Besides meeting such regulations, all products and/or their constituents have to be listed in the different chemical inventories. Specific regulations exist for certain application areas like electrical applications or applications in contact with food.

DuPont makes sure that all materials supplied to its customers are in compliance with applicable regulations for the material itself.

As a subscriber to the RESPONSIBLE CARE® initiative, DuPont also has accepted to share information and help the product users to handle, process, use, recycle and dispose of its materials safely and in an environmentally sound manner.

For selected specific application areas, DuPont has developed information which will enable the product user to obtain approvals from authorities or to certify compliance with regulations.

Compliance statements with European and non-European food contact regulations

European Food Contact Regulations
U.S. Food and Drug Administration (FDA)

Standard grades of RYNITE® are not in compliance with food contact regulations. If such need arises, please consult with your DuPont representative on the availability of special grades, or what other alternative materials are given. Several grades of CRASTIN® are in compliance with European and US food contact regulations.

Please ask your DuPont representative for more detailed information.

Compliance statements with European and non-European drinking water regulations

UK:
The WRC (Water Research Council).

USA:
The NSF (National Sanitation Foundation).

Other countries:
Please consult with your DuPont representative on availability of special grades, or what alternative materials are given.

Support information for approval of applications for food processing equipment in the USA by NSF (National Sanitation Foundation) or USDA (United States Department of Agriculture).

Statements on the content of certain regulated chemicals as required e.g. by ‘European Waste Directives’ or the ‘Clean Air Act’ in the USA.

Regulations are constantly adapted as new information and new test methods become available and also as issues of concern develop in the public arena.

DuPont will adapt its products to the changing market needs or develop new products to satisfy new requirements. The same is true for information needed to support customers for regulatory compliance of their applications.

It is impossible in the frame of this bulletin to provide up-to-date information on all grades of CRASTIN® and RYNITE® meeting the various specifications. Our recommendation is therefore to consult with your DuPont representative on the best material selection for a given application at an early stage of any development.

6.2 – Underwriters' Laboratories ratings

Table 6.3 lists the U.S. UL ratings for RYNITE® thermoplastic. For CRASTIN® UL-data, please refer to tables in chapter 2.

Table 6.3 Ratings from Underwriter Laboratories issued on UL yellows cards

Material Designation	Colour	Minimum Thickness mm	UL94 Flame Class	Temperature Index, °C Electrical	Temperature Index, °C Mechanical With Impact	Temperature Index, °C Mechanical W/O Impact	Hot Wire Ignition	High Current Arc Ignition	High Voltage Track Rate	IEC Track (CTI)
RYNITE® 408	All	0,75	94HB	140	140	140	1	2	0	2
		1,5	94HB	140	140	140	1	2	0	2
		3,0	94HB	140	140	140	0	2	0	2
RYNITE® 415HP	All	0,75	94HB	140	120	140	3	1	2	2
		1,5	94HB	140	120	140	2	1	2	2
		3,0	94HB	140	120	140	0	1	2	2
RYNITE® 520 (f1)	NC, GY, BK,	0,75	94HB	140	140	140	3	1	2	3
		1,5	94HB	140	140	140	1	2	2	3
		3,0	94HB	140	140	140	0	1	2	3
RYNITE® 530 (f1)	All	0,81	94HB	140	140	140	2	1	2	2
		1,5	94HB	140	140	140	1	1	2	2
		3,0	94HB	140	140	140	0	1	2	2
		6,0	94HB	140	140	140	0	1	2	2
RYNITE® 545 (f1)	All	0,75	94HB	140	140	140	2	1	1	2
		1,5	94HB	140	140	140	1	1	1	2
		3,0	94HB	140	140	140	0	1	1	2
RYNITE® 555	All	0,75	94HB	140	140	140	2	1	1	3
		1,5	94HB	140	140	140	1	1	1	3
		3,0	94HB	140	140	140	0	1	1	3
RYNITE® 935 (f1)	NC, BK	0,75	94HB	140	140	140	2	1	1	2
		1,5	94HB	140	140	140	1	1	1	2
		3,0	94HB	140	140	140	0	1	1	2
FR515	All	0,86	94V-0	140	140	140	0	0	1	3
	NC, BK	1,5	94-5VA	140	140	140	0	0	1	3
	All	3,0	94V-0	140	140	140	0	1	1	3

(f1) Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL746C.

Table 6.3 Ratings from Underwriter Laboratories issued on UL yellows cards (continued)

Material Designation	Colour	Minimum Thickness mm	UL94 Flame Class	Temperature Index, °C			Hot Wire Ignition	High Current Arc Ignition	High Voltage Track Rate	IEC Track (CTI)
				Electrical	Mechanical With Impact	Mechanical W/O Impact				
FR530L (f1)	NC, BK	0,35	94V-0	–	–	–	3	1	1	2
	All	0,81	94V-0	155	155	155	2	1	1	2
	NC, BK	1,5	94-5VA	155	155	155	0	1	1	2
	All	2,0	94-5VA	155	155	155	0	1	1	2
		3,0	94V-0	155	155	155	0	1	1	2
FR543	NC, BK	0,81	94V-0	155	155	155	0	1	1	2
		1,5	94V-0	155	155	155	0	1	1	2
			94-5VA						1	2
		3,0	94V-0	155	155	155	0	1	1	2
			94-5VA						1	2
FR943	NC, GY, BK	0,35	94V-0	155	155	155	–	–	1	2
		0,81	94V-0	155	155	155	2	4	1	2
		1,5	94V-0	155	155	155	2	4	1	2
		3,0	94V-0	155	155	155	0	4	1	2
			94-5VA						1	2
Crastin® S600F10	All	0,75	–	130	115	120	–	–	0	2
		1,5	94HB	130	115	120	3	1	0	2
		3,0	94HB	130	115	120	3	0	0	2
		6,0	94HB	130	115	120	1	0	0	2
Crastin® S620F20	All	0,75	–	130	115	120	–	–	2	2
		1,5	94HB	130	115	120	3	1	2	2
		3,0	94HB	130	115	120	3	1	2	2
		6,0	94HB	130	115	120	2	1	2	2
Crastin® SK605	All	0,75	94HB	130	130	130	–	–	1	1
		1,5	94HB	130	130	130	3	1	1	1
		3,0	94HB	130	130	130	2	0	1	1
		6,0	94HB	130	130	130	0	0	1	1
Crastin® SO655	All	0,8	94HB	120	120	120	4	0	1	2
		1,5	94HB	120	120	120	3	0	1	2
		3,0	94HB	120	120	120	2	0	1	2
		6,0	94HB	120	120	120	2	1	1	2
Crastin® LW9030	All	0,75	–	130	125	130	–	–	2	1
		1,5	94HB	130	125	130	2	3	2	1
		3,0	94HB	130	130	130	0	3	2	1
		6,0	94HB	130	130	130	0	3	2	1
Crastin® T805	All	0,75	94HB	130	130	130	–	–	2	1
		1,5	94HB	140	130	140	2	2	2	1
		3,0	94HB	140	130	140	1	2	2	1
		6,0	94HB	140	130	140	0	2	2	1

Table 6.3 **Ratings from Underwriter Laboratories issued on UL yellows cards** (continued)

Material Designation	Colour	Minimum Thickness mm	UL94 Flame Class	Temperature Index, °C			Hot Wire Ignition	High Current Arc Ignition	High Voltage Track Rate	IEC Track (CTI)
				Electrical	Mechanical With Impact	Mechanical W/O Impact				
CRASTIN® S650FR	All	0,75	94V-0	130	130	130	4	0	3	2
		1,5	94V-0	130	130	130	3	0	3	2
		3,0	94V-0	130	130	130	2	0	3	2
		6,0	94V-0	130	130	130	1	0	3	2
CRASTIN® SK645FR	All	0,75	94V-0	140	125	140	–	–	2	2
		1,5	94V-0	140	125	140	2	0	2	2
		3,0	94V-0	140	130	140	1	0	2	2
		6,0	94V-0	140	130	140	1	0	2	2
CRASTIN® T845FR	All	1,5	94V-0	140	130	140	2	2	3	2
		3,0	94V-0	140	140	140	1	1	3	2
		6,0	94V-0	140	140	140	0	2	3	2
CRASTIN® T850FR	All	1,5	94V-0	75	75	75	–	–	–	–
		3,0	94V-0	75	75	75	–	–	–	–
CRASTIN® LW9030FR	All	0,75	–	140	125	130	–	–	4	2
		1,5	94V-0	140	125	130	2	3	4	2
	BK	2,0	94-5VA	140	125	130	2	3	4	2
	All	3,0	94V-0	140	130	140	1	3	4	2
		6,0	94V-0	140	130	140	0	3	4	2

Official UL PLC Conversion Chart

Hot-wire ignition (HWI)

Mean Ignition Time (s)				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	< 10	0
10	≤	TR	< 25	1
25	≤	TR	< 80	2
80	≤	TR	< 150	3
150	≤	TR		4

Comparative track index (CTI)

Tracking Index (volts)				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

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