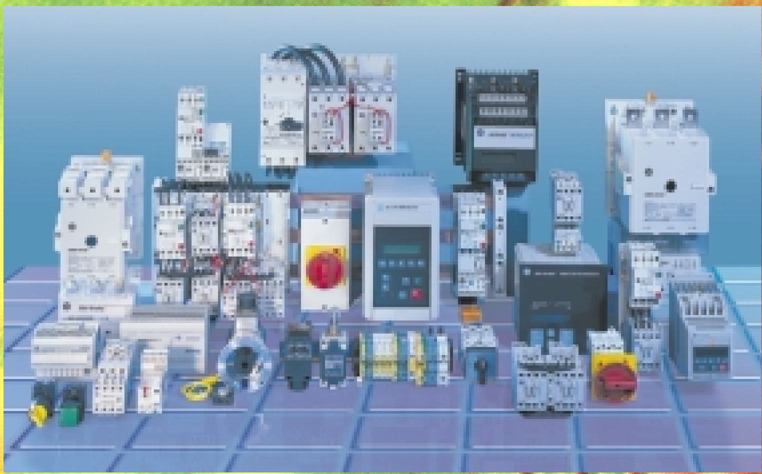
DuPont Engineering Polymers



Branching and control manual with DuPont Engineering Polymers

CONTENTS

Synergy at work	3
DuPont Engineering Polymers in the branching and control industry	4
Outstanding performance	5-8
Research and development	9
Applications	
• Protection	10-11
• Control	12-14
• Wiring devices	15-17
• Secondary protection	18
Technical resources for effective cost reduction	19
Thermoplastics versus thermosets: a cost comparison for Branching and Control devices	20
Summary	22

Synergy at work

It all started with simple insulators made of wood, marble, slate and ceramics.

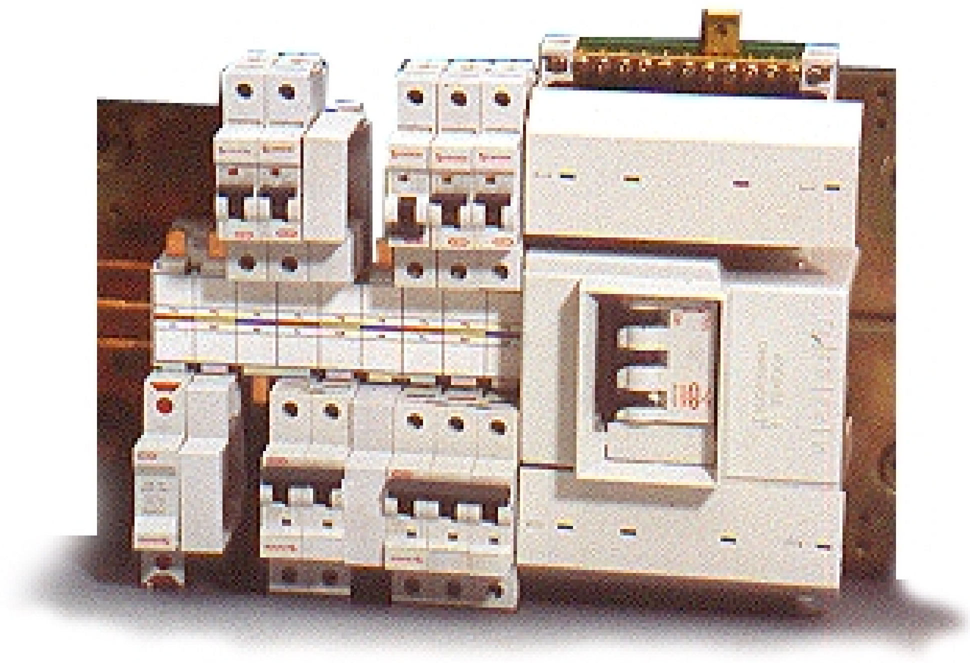
Then came thermoset polymers, which could be transformed from palette or other forms into intricate shapes while retaining the required thermal and electrical properties and which are still used, to a certain extent, today.

More recently, engineering thermoplastics, with their excellent electrical and thermal properties have been adopted by the Branching and Control industry.

The design and processing possibilities inherent in thermoplastics has led to added component and integration functionality - for example, in assemblies using snap-fit or welding technologies. This has, in turn, led to product miniaturisation and cost reduction.

An outstanding feature of thermoplastics is that they can be remelted and re-used.

Today's broad thermoplastic product offering enables electrical engineers to reduce energy, cost and weight, driving the evolution towards new-generation Branching and Control components.



DuPont Engineering Polymers in the Branching and Control industry

Electricity is a part of our lives. People use it for heat, light, the activation of household appliances, transportation and communication - to name just a few examples.

But electricity has certain inherent risks - and it is therefore essential that strict controls are applied to guarantee safety in its daily use.

Branching & Control (B&C) is comprised of devices that:
- guarantee the safe use of electricity (protection)
- help control electricity (control)
- establish connections (wiring devices)
- include all the above-mentioned functions (such as secondary protection and enclosures)

In this brochure, we will focus on the use of DuPont Engineering Polymers such as Crastin® PBT and Rynite® PET thermoplastic polyester resins, Delrin® acetal resins, Hytrel® thermoplastic polyester elastomers, Minlon® mineral reinforced nylon resins, Vespel® polyimide parts, Zenite® LCP liquid crystal polymers and Zytel® nylon resins.

These products are complemented with a range of well known products such as Mylar® polyester film, Kapton® polyimide film, Nomex® brand thermal technology and Teflon® fluoropolymer resin.

All these DuPont products have opened new opportunities for electrical engineers in the areas of cost reduction, miniaturisation and higher efficiencies.

DuPont's Engineering Polymer range was developed to serve the B&C industry's most demanding requirements and has helped engineers throughout the industry to optimize quality, performance, and productivity.

DuPont has also established fundamental data regarding the environmental and recycling properties of various materials to back up existing procedures and facilitate future industry, customer and end-user requirements.

With regard to specific regulations concerning flame retardant (FR) products, it should be noted that, globally, DuPont does not manufacture any materials containing Polybromiated Biphenyls (PBBs) or Polybromiated Diphenylethers (PBDEs). Likewise, DuPont Engineering Polymers has led the way in eliminating heavy metal colouring systems such as cadmium and chromium.

In addition, DuPont is driving activities to offer non-halogen, non-red phosphorous-containing flame retardant resins to the Branching & Control industry by using a variety of FR packages such as:
- standard halogen and phosphorous-free flame retardants
- unique and patented FR packages
- inherently flame retardant polymers or blends - for example those containing Liquid Crystal Polymers

Fig. 1. DuPont product portfolio for the B&C market

	Non FR				FR			
	unreinforced	reinforced	toughened	extrusion	unreinforced	reinforced	toughened	extrusion
Crastin® PBT	■	■	■	■	■	■	■	■
Delrin® acetal	■	■	■	■				
Hytrel® TEEE	■		■	■	■		■	■
Rynite® PET		■	■			■		
Zenite® LCP Liquid Crystal Polymer		■				■		
Zytel® nylon	■	■		■	■	■		
Zytel® HTN High Temperature Nylon		■	■			■		

FR = flame retardent

Outstanding performance

The basic function of Branching & Control equipment is to connect and interrupt electrical circuits safely over the life cycle of a device.

This can sometimes be complex, as in automatic circuit interruptions in the case of overload or leakage (e.g. MCBs, RCCBs or fuses) and controlled interruptions (e.g. plugs, switches, connectors, contactors or relays).

During the service life of a circuit, various electrical phenomena may occur which can adversely affect insulating properties. Consequently, electrical engineers need to select the best materials to manage these effects.

Some factors affecting the engineer's choice of insulating materials include:

- overheat resulting from current overload or poor contact resistivity
- the formation of an electrical arc resulting in sudden temperature increase, the generation of pressure wave, and an erosion or chemical decomposition in the insulating material
- surface contamination from the outside environment causing tracking between the active parts
- ignition of the insulator
- the insulation of contacts due to outgassing of organic materials in the immediate surrounding of the device

For optimal performance under conditions like these, insulating materials need to possess the following characteristics:

Flammability
- self extinguishing

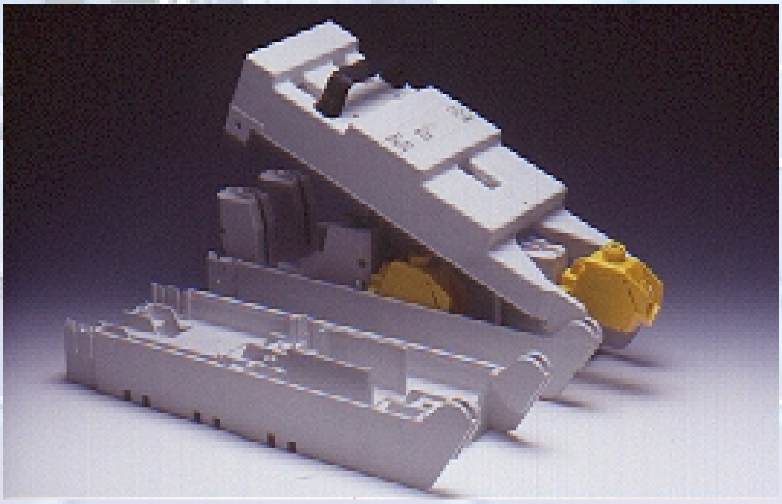
Electrical
- good dielectric strength
- sufficient volume and surface
- resistivity adequate arc and tracking resistance

Thermal
- heat resistance (both short and longer term)

Mechanical
- stiffness, toughness and impact resistance

Chemical
- chemical and weather resistance to aggressive environments

Dimensional
- warpage, coefficient of thermal expansion, moisture pick-up



The electrical industry has developed specific standards to minimize or eliminate risk when using insulating materials.

DuPont Thermoplastic Engineering Polymers enable electrical engineers to meet a wide variety of these standards.

It's often a case of combining smart design with the right product. This brochure aims to help design engineers to find the right mix of products, design techniques and innovative ideas for cost effective solutions to new applications.

Standard B&C industry test methods

Besides the high standards of mechanical, chemical and dimensional stability of DuPont Engineering Polymers, a group of specific electrical design requirements is herewith described in detail, including:

- flammability
- long term temperature ageing
- short term temperature performance
- insulation properties including CTI

Flammability

The burning and damping behaviour of an insulator is related not only to resin formulation but also to the shape of the application surface. For an overall comparison, and to aid selection by the engineer, two different test methods will be described in more detail. DuPont Engineering Polymers will be rated to facilitate customer selection.

The Unterwriter Laboratories UL 94 is widely recognized as an established selector for B&C products. UL 94 HB, V2, V1, V-0, 5V are used as criteria to differentiate plastic materials for flammability behaviour. The glow wire test is widely established in Europe to differentiate thermoplastic insulation material. IEC 60695-2-1 is the appropriate standard which is shown in Fig. 3.

Fig. 2. Selection of DuPont Engineering Polymers in accordance with UL 94

	Non FR				FR			
	unreinforced	reinforced	T/ST technology	extrusion	unreinforced	reinforced	T/ST technology	extrusion
Crastin® PBT	HB	HB	HB	HB	V0	V0	V0	V0
Delrin® acetal	HB	HB	HB	HB	—	—	—	—
Hytrel® TEEE	HB	—	HB	HB	V2/V0	—	V2/V0	—
Rynite® PET	—	HB	HB	—	—	V0	—	—
Zenite® LCP Liquid Crystal Polymer	—	V0	—	—	—	V0	—	—
Zytel® nylon	V2	HB	HB	V2	V0	V0	—	V0
Zytel® HTN High Temperature Nylon	—	HB	—	—	—	V0	—	—

Almost all DuPont engineering products carry an UL 94 yellow card
— = Not available

Fig. 3. Glow wire test 1 mm according to IEC 60695-2-1

	Non FR				FR			
	unreinforced	reinforced	T/ST technology	extrusion	unreinforced	reinforced	T/ST technology	extrusion
Crastin® PBT	650	650	650	650	960	960	960	960
Delrin® acetal	550	—	550	550	—	—	—	—
Hytrel® TEEE	650	—	650	—	960	—	960	—
Rynite® PET	—	650	650	—	—	960	—	—
Zenite® LCP Liquid Crystal Polymer	—	960	—	—	—	960	—	—
Zytel® nylon	850	850	750	750	960	960	—	960
Zytel® HTN High Temperature Nylon	—	850	—	—	—	960	—	—

GW 650
750 Ask your local DuPont representative for information about glow wire testing.
850 A broad range of products can be made available to fulfill these requirements.
960

CTI Comparative Tracking Index

The CTI is one of the key electrical tests carried out to differentiate and select thermoplastic materials according to cost performance.

It is performed to determine the safety of components carrying live parts. According to IEC 60112 and UL 746, it indicates the voltage at which a material continues to resist tracking. According to European standards for direct support of live parts, a CTI greater than 175V is required. A more rigorous test is the CTIM requirement which is described in the DuPont Electrical brochure Comparative Test methods, TRG 1424. Generally speaking, most semi-crystalline engineering polymers carry a CTI of > 175 V. However, it should be noted that all results are based on tests with materials in their natural colours and that certain additives (such as colour pigments and fillers) require a detailed investigation when used in the formulation of a given material (Fig. 4).

Delrin®

Fig. 4. CTI test according to UL 746

	Non FR				FR			
	unreinforced	reinforced	T/ST technology	extrusion	unreinforced	reinforced	T/ST technology	extrusion
Crastin® PBT	0	3	3	0	2	3	3	2
Delrin® acetal	0	—	—	0	—	—	—	—
Hytrel® TEEE	0	—	—	0	3	—	3	—
Rynite® PET	—	3	3	—	—	2	—	—
Zenite® LCP Liquid Crystal Polymer	—	2	—	—	—	2	—	—
Zytel® nylon	0	1	0	0	0	2	—	0
Zytel® HTN High Temperature Nylon	—	2	—	—	—	2	—	—

Class 0 (≥ 600V)
1 (400-600 V)
2 (275-400 V)
3 (175-250 V)

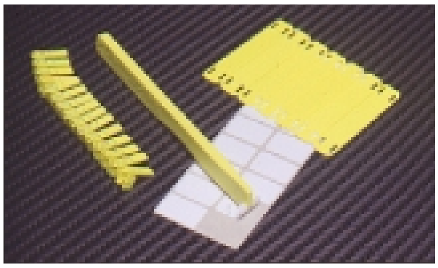
(available in the respective product range)

Fig. 5. RTI performance according to V0 UL 94 746B (electrical)

	Non FR				FR			
	unreinforced	reinforced	T/ST technology	extrusion	unreinforced	reinforced	T/ST technology	extrusion
Crastin® PBT	❹	❸	❸	❹	❹	❷	❸	❹
Delrin® acetal	❹	❸	❹	❹	—	—	—	—
Hytrel® TEEE	❹	—	—	❹	❹	—	❹	—
Rynite® PET	—	❷	❸	—	—	❶	—	—
Zenite® LCP Liquid Crystal Polymer	—	❶	—	—	—	❶	—	—
Zytel® nylon	❸	❸	❸	❸	❷	❷	❸	❷
Zytel® HTN High Temperature Nylon	—	❷	—	—	—	❶	—	—

❶ = RTI > 150°C ❷ = RTI ≤ 150°C ❸ = RTI ≤ 130°C ❹ = RTI ≤ 100°C

(available in the respective product range)



Zytel®

Thermal testing

Thermoplastic materials soften with increasing temperatures. To differentiate their functional performance, the three most relevant test methods for the B&C industry are detailed below.

UL 746 B-RTI: this relative temperature index indicates the material's ability to retain particular properties (electrical, mechanical) when exposed to elevated temperatures for long periods of time (up to 60,000 hours). This index is further defined in relation to impact performance (Fig. 5).

For ball pressure tests (BPT) (in accordance with IEC 60335-1): see DuPont brochure, Comparative Test method TRG 1424 which describes performance at elevated temperatures for the company's complete engineering polymers product portfolio.

Zytel® HTN

Delrin® and Zytel®

HDT, heat deflection temperature according to ISO 75: indicates product performance at elevated temperatures while supporting a load. Unlike amorphous materials, semi-crystalline products such as DuPont Engineering Polymers can be used at temperatures well above the HDT, dependant on factors such as load and time (Fig. 6).

Post treatment technologies for DuPont Engineering Polymers

Ease of integration, using available post-treatment processes, are a substantial factor in the cost reduction of a finished part.

Post-treatment could be differentiated into two areas labelled proactive and reactive.

Proactive post-treatment will help to add value to the semi-finished component, including:

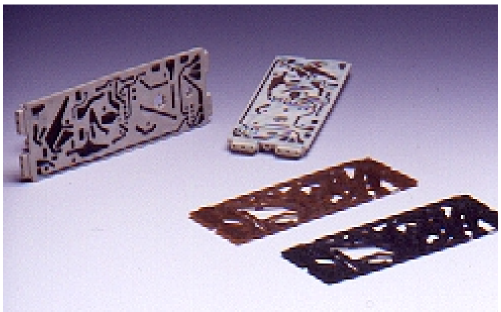
- assembly technologies such as
  - welding (hot plate, rotation welding, vibration welding, ultrasonic welding)
  - snap fit (use caution when using a snap fit one way assembly)
  - ability to be riveted (metal rivets)
  - press fit, etc.

- decoration technologies such as
  - hot foil stamping
  - painting
  - printing
  - laser marking or a combination of these
  - vacuum metallisation
  - plating
  - two component moulding

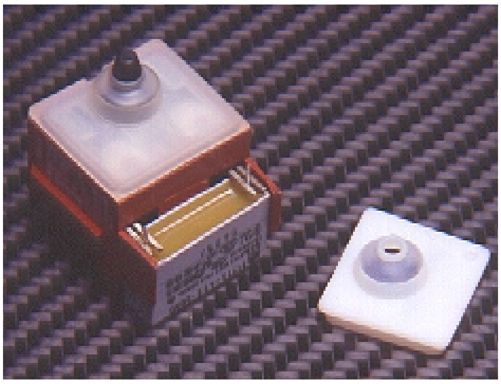
All these added-value post operations provide extra value to the application for requirements such as:

MID - Moulded Interconnect Devices
SMD - Surface Mount Devices
EMI - Electromagnetic Interference Shielding

Hard/soft combinations as a functional requirement should also be considered.



Rynite® PET



Hytrel®

Fig. 6. HDT performance of DuPont Engineering Polymers at 1.80 MPA

	Non FR				FR			
	unreinforced	reinforced	T/ST technology	extrusion	unreinforced	reinforced	T/ST technology	extrusion
Crastin® PBT	●	■	●	●	▲	■	■	▲
Delrin® acetal	▲	▲	▲	▲	—	—	—	—
Hytrel® TEEE	▲	—	▲	▲	▲	—	▲	—
Rynite® PET	—	■	■	—	—	■	—	—
Zenite® LCP Liquid Crystal Polymer	—	★	—	—	—	★	—	—
Zytel® nylon	■	■	▲	■	■	■	■	■
Zytel® HTN High Temperature Nylon	—	★	—	—	—	★	—	—

● = HDT ≤ 100°C ▲ = HDT 100 - 200°C ■ = HDT 200 - 250°C ★ = HDT > 250°C
(available in the respective product range)

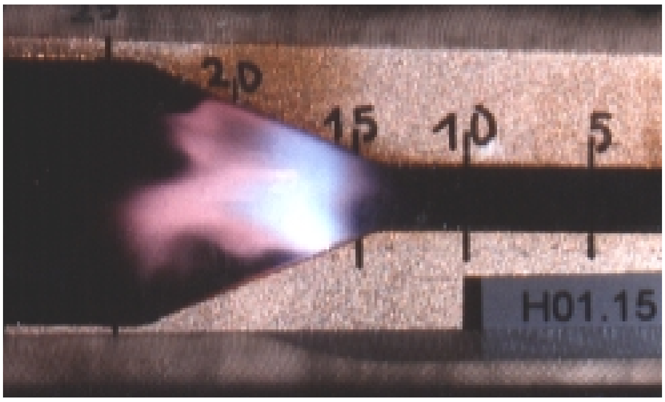
Research and Development

DuPont invests considerable resources into research and development for its engineering polymer product line. The enclosed results are confined to already-published data; further information is published on an ongoing basis.

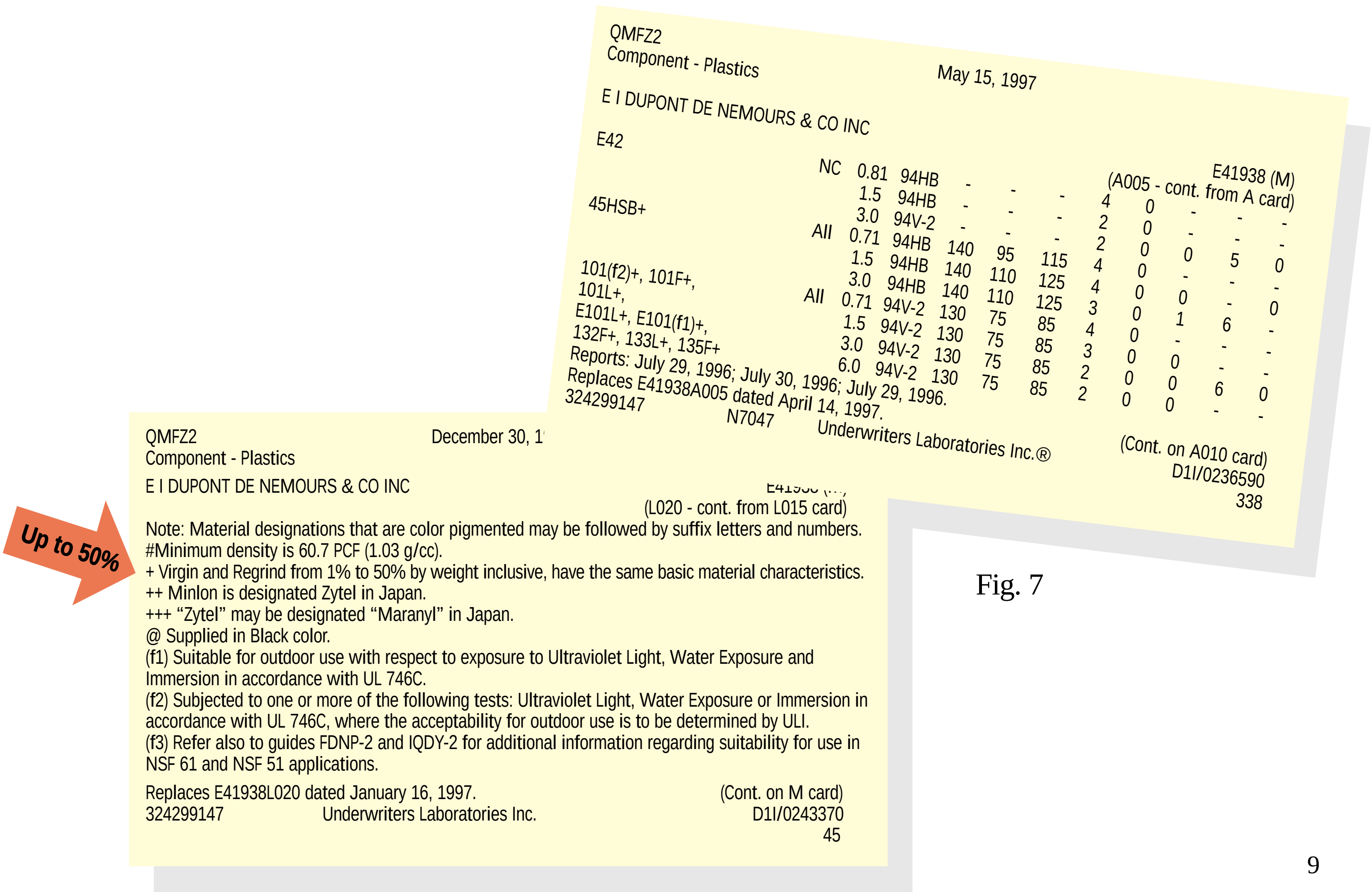
One of the most exciting R&D areas concerns DuPont's activities in the recycling of thermoplastic engineering polymers. Following part integration and miniaturisation, recycling has the next largest potential area of cost reduction for a wide range of product applications.

It is specified that up to 25% of the initial resin can be re-used in existing applications, as defined for all DuPont Engineering Polymers in compliance with UL 746B.

In addition, DuPont has various products available with a recycling rate of up to 50%. This substantial contribution to customer cost reduction was achieved through in-depth product and processing performance evaluation which is also available from your local DuPont representative.



Institute of low-voltage switching devices. With the courtesy of the Technical University, Vienna.



QMFZ2
Component - Plastics
May 15, 1997

E I DUPONT DE NEMOURS & CO INC

E42

E41938 (M)
(A005 - cont. from A card)

45HSB+	NC	0.81	94HB	-	-	-	4	0	-	-	-
		1.5	94HB	-	-	-	2	0	-	-	-
		3.0	94V-2	-	-	-	2	0	0	5	0
	All	0.71	94HB	140	95	115	4	0	-	-	-
101(f2)+, 101F+, 101L+, E101L+, E101(f1)+, 132F+, 133L+, 135F+		1.5	94HB	140	110	125	4	0	0	-	0
		3.0	94HB	140	110	125	3	0	1	6	-
	All	0.71	94V-2	130	75	85	4	0	-	-	-
		1.5	94V-2	130	75	85	3	0	0	-	-
		3.0	94V-2	130	75	85	2	0	0	6	0
		6.0	94V-2	130	75	85	2	0	0	-	-

Reports: July 29, 1996; July 30, 1996; July 29, 1996.
Replaces E41938A005 dated April 14, 1997.
324299147 N7047 Underwriters Laboratories Inc.®
(Cont. on A010 card)
D1I/0236590
338

QMFZ2
Component - Plastics
December 30, 1
E I DUPONT DE NEMOURS & CO INC
(L020 - cont. from L015 card)

Note: Material designations that are color pigmented may be followed by suffix letters and numbers.
#Minimum density is 60.7 PCF (1.03 g/cc).
+ Virgin and Regrind from 1% to 50% by weight inclusive, have the same basic material characteristics.
++ Minlon is designated Zytel in Japan.
+++ "Zytel" may be designated "Maranyl" in Japan.
@ Supplied in Black color.
(f1) Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL 746C.
(f2) Subjected to one or more of the following tests: Ultraviolet Light, Water Exposure or Immersion in accordance with UL 746C, where the acceptability for outdoor use is to be determined by ULI.
(f3) Refer also to guides FDNP-2 and IQDY-2 for additional information regarding suitability for use in NSF 61 and NSF 51 applications.

Replaces E41938L020 dated January 16, 1997. (Cont. on M card)
324299147 Underwriters Laboratories Inc. D1I/0243370
45

Fig. 7

Protection

DuPont Engineering Polymers are fast becoming the new industry standard materials for the B&C industry, replacing thermosets in many miniature circuit breaker applications (MCBs) of up to 63 Amp. nominal current.

The flammability, thermal and electrical properties of these polymers, in combination with mechanical features such as dimensional stability, have established a proven track record for reliability, high quality, recycling and cost reduction in today's market place.

The optimal economics of multi-functional chassis design and ease of processing have made engineering polymers an ideal choice for protective devices.

According to EN 60898 for household overload protection and similar applications, DuPont's Thermoplastic Engineering Polymer portfolio provides an excellent fit when key criteria like flame retardency, CTI, thermal behaviour, dimensional properties and cost are taken into consideration. Fig. 8 demonstrates the strength of the complete DuPont product offering.

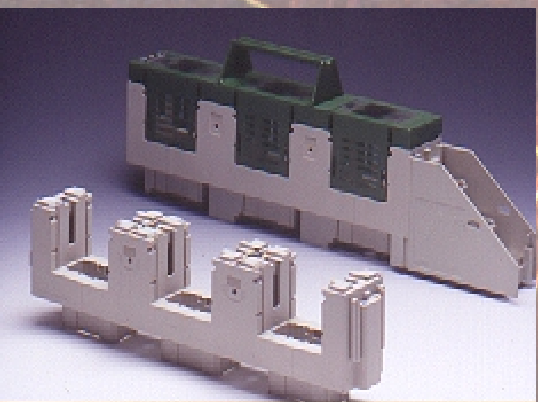
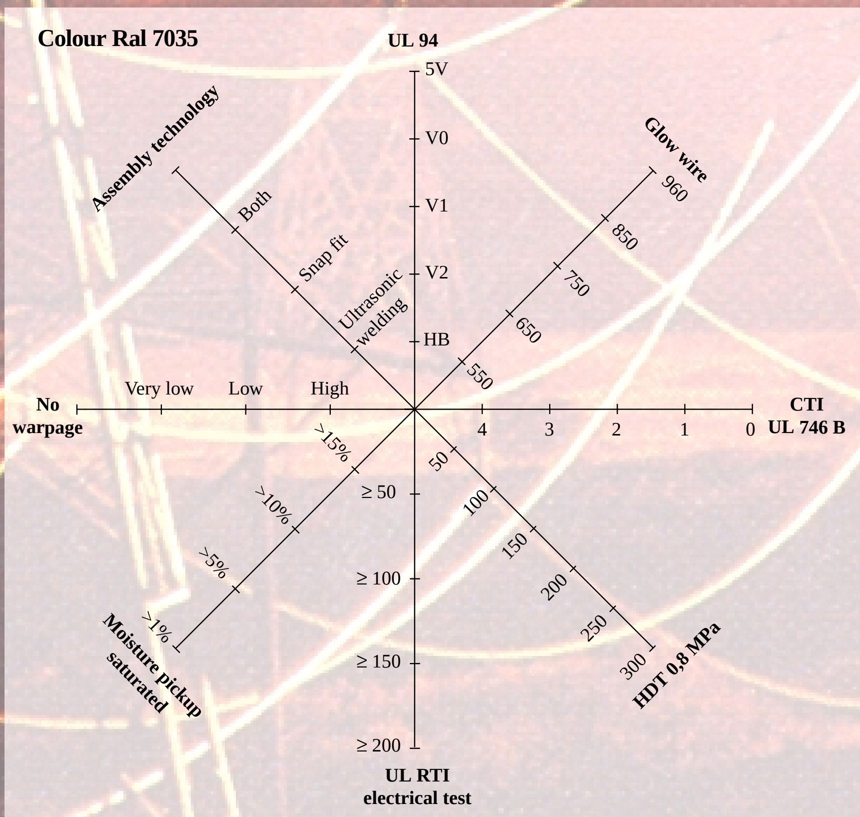
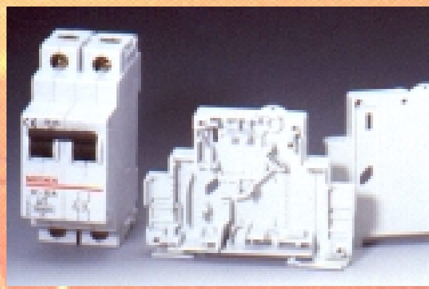
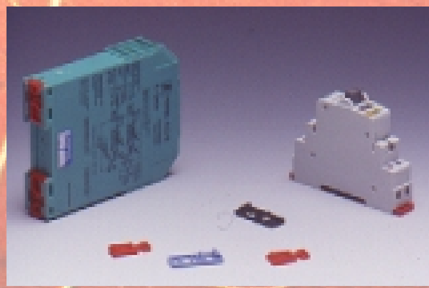


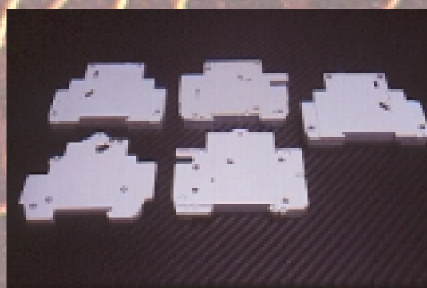
Fig. 8. DuPont offering for MCB housings



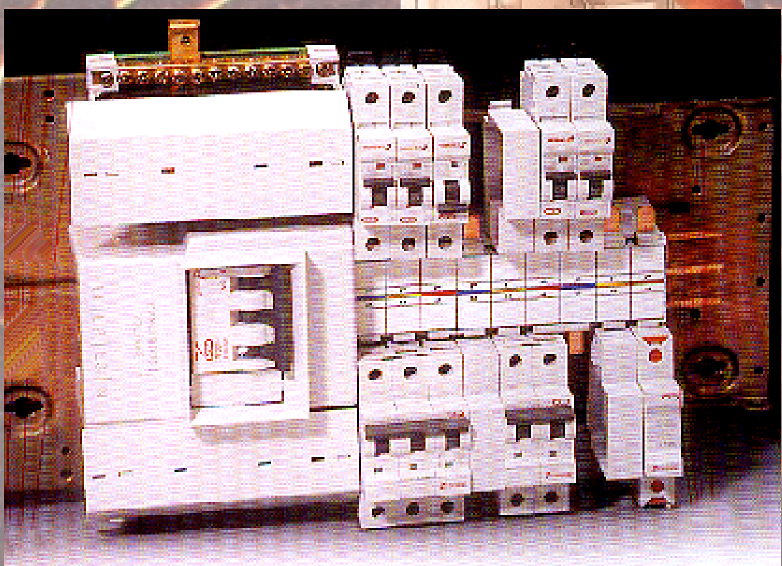
This summary indicates a selection of most stringent MCB requirements. The final choice of resin will always depend upon the specific requirements of a particular application.

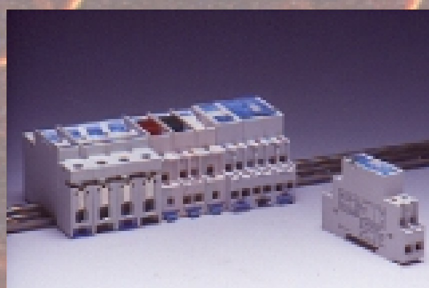






Examples of the DuPont offering for protection applications





Control

Like circuit breakers, switch gear applications require certain additional features for their design which take into account increased life cycle test methodology and reliable thermal and electrical performance. To support these requirements, special resins have been designed with features such as arc-quenching or low out-gassing performance, as well as reliability at elevated temperatures. Fig. 9 provides an indication of which products test meet a given requirement.

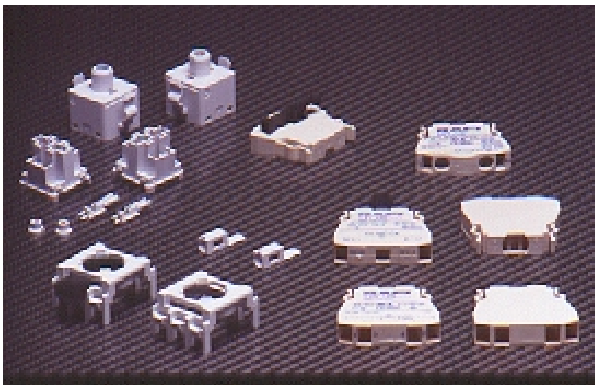
The following range of specific grades of DuPont high performance polymers: Crastin® PBT, Kapton®, Mylar®, Nomex®, Rynite® PET, Zytel®, Zytel® HTN, Zenite® LCP are compatible with the insulation components listed in UL File E75735 - the most extensive material selection guide available.

Wear resistance
As a critical part of the DuPont offering for control applications, the wear resistance of the polymer supporting the contact must be taken into consideration.

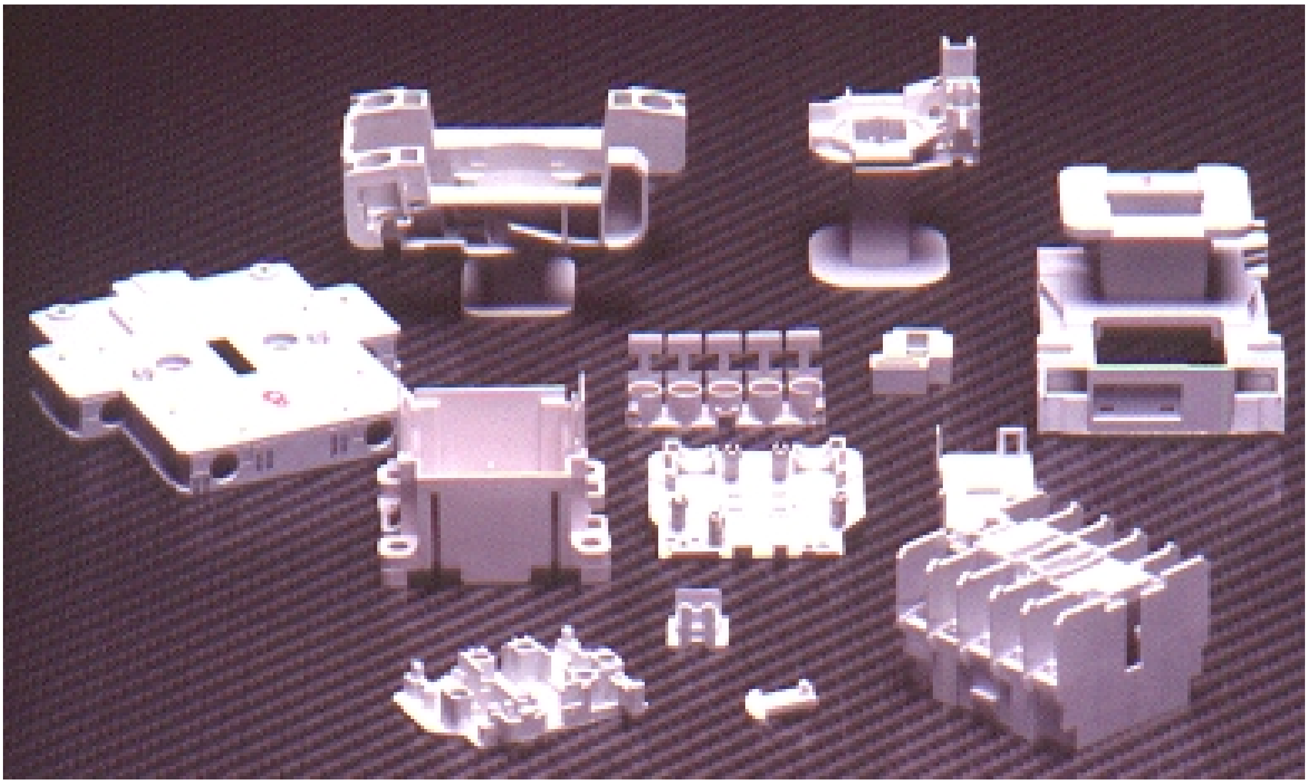
Materials requirements for switches, micro switches and push buttons are similar to those for contactors

Fig. 9. Requirement for control components

Requirement	Solution 1	Solution 2	Solution 3
Arc quenching	Zytel® 101L	Delrin® 500	Zytel® EFE7298
Low outgassing	Crastin® PBT SK645	Crastin® PBT CE7931	Zenite® LCP 6130
UL94 V0		Almost all FR grades	
UL94 V2	Zytel® 101L	Zytel® FR70G25V0	Zytel® FR70M40GW
CTI ≥ 250V		A variety of different products	
CTI ≥ 300V	Crastin® PBT LW9020FR	Crastin® PBT LW9330FR	Crastin® PBT LW9320FR
Halogen and red phosphorous free flame retardant	Zytel® FR7026V0F	Zenite® LCP 3130L	Zenite® LCP 6130



Examples of DuPont offering for control applications



Insulation and encapsulation

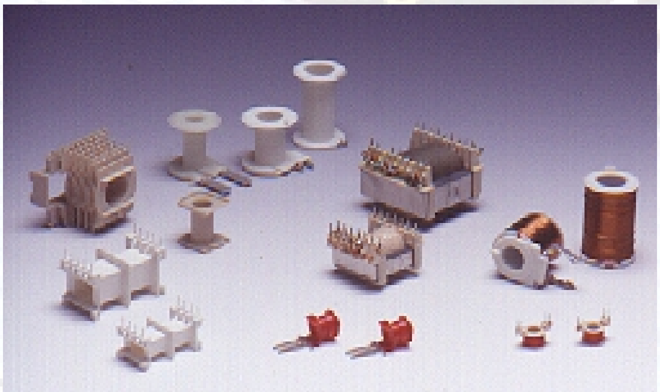
As a mark of its commitment to the control industry, DuPont offers a unique portfolio of insulation and encapsulated systems from Class B 130°C to R 220°C according to UL 1446. This covers systems such as transformers, contactors, motors and starters up to 600 Volts.

DuPont insulation materials offer a unique combination of thermal stability, electrical and mechanical properties and flammability ratings up to 5 V, according UL 94.

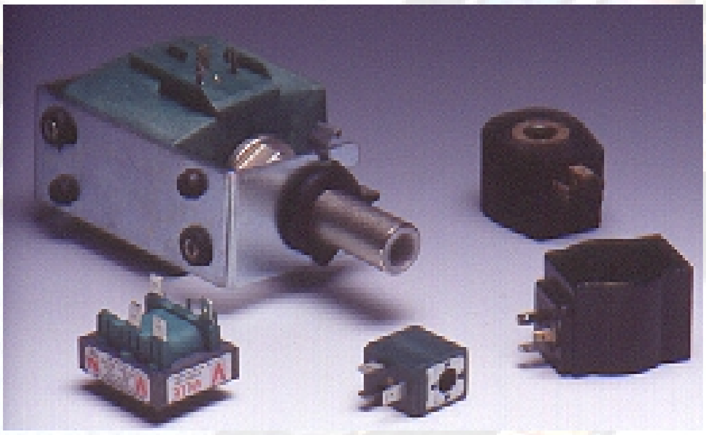
The DuPont encapsulation systems also offer reduced processing steps with substantial cost reduction potential for insulation systems.

Fig. 10. Comparison and classification of electrical insulation and encapsulation systems according to UL 1446

	Generic	% Glass	UL94 Flammability at 0,8 mm	UL 1446/IEC 60085 Encapsulation Recognition
ZYTEL® nylon				
101L	PA66	—	V2	–
70G33L	PA66	33	HB	–
FR70G25V0	PA66	25	V0	–
5429ER	PA66	33	HB	Class B
ZYTEL® nylon "Electrical / Sensor Resins"				
FE5382 BK276	PA612	33	–	–
FE5389 BK276	PA66	33	–	–
ZYTEL® HTN				
HTN 51G35HSL NC010	HTN	35	HB	–
HTN FR51G35L NC010	HTN	35	V0	–
CRASTIN® PBT Polyesters				
T803	PBT	20	HB	–
T805	PBT	30	HB	–
T841FR	PBT	10	V0	–
T843FR	PBT	20	V0	–
T845FR	PBT	30	V0	–
RYNITE® PET Polyesters				
415HP	PET	15	HB	–
FR515	PET	15	V0	–
530	PET	30	HB	–
FR530	PET	30	V0	–
RYNITE® PET "Electrical Specialty Resins"				
815ER	PET	15	HB	Classes B, F
830ER	PET	30	HB	Class H
FR815ER	PET	15	V0	–
FR830ER	PET	30	V0	Class B
ZENITE® LCP				
6130 WT010	LCP	30	V0	–
Potted Coil Housings				
CRASTIN® PBT				
LW9020	PBT/ASA	20	HB	–
LW9030	PBT/ASA	30	HB	–
LW9020FR	PBT/ASA	20	V0	–
LW9030FR	PBT/ASA	30	V0	–
RYNITE® PET				
935	PET	35 mica /glass	HB	–
530	PET	30	HB	–
FR530	PET	30	V0	–



Crastin® PBT



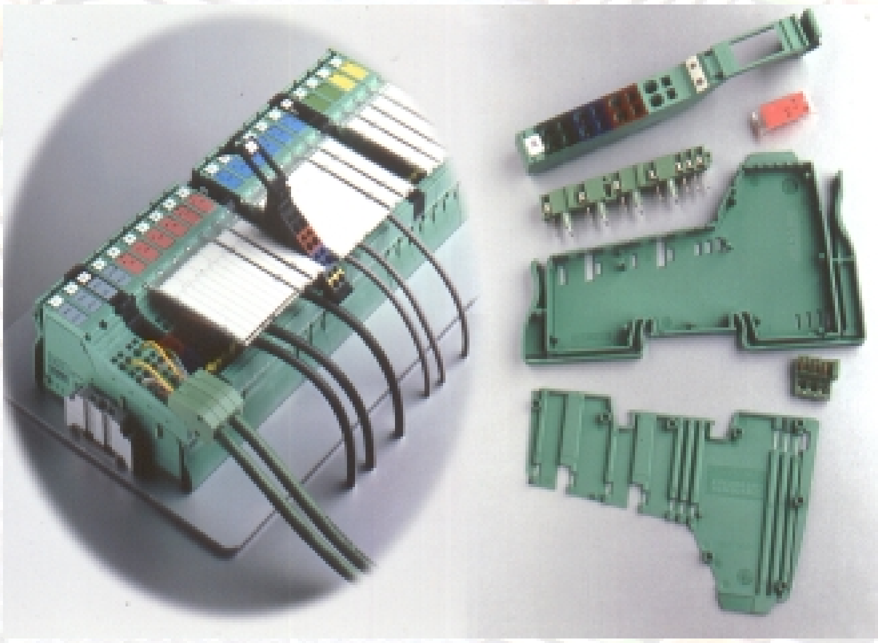
Rynite® PET

Wiring devices

EN 60309 (former 4343/VDE 0623) covers the critical segment of a range of major industrial applications such as plugs, socket outlets and couplers. Industrial plug/socket IEC 60884 and EN 60998 cover most of the residential plugs and sockets and devices for low voltage circuits.

Most DuPont Engineering Polymers fulfil the above-mentioned requirements for non-contact carrying parts.

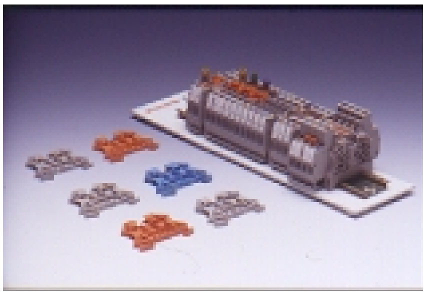
For the more stringent requirements of components in proximity with contact-carrying parts, a range of Crastin®, Rynite®, Zytel®, Zytel® HTN and Zenite® resins are available. Most can be identified by their code which carry an FR (flame retardant) symbol. Only Zenite® is inherently flame retardant.

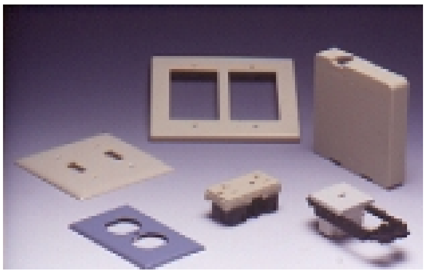


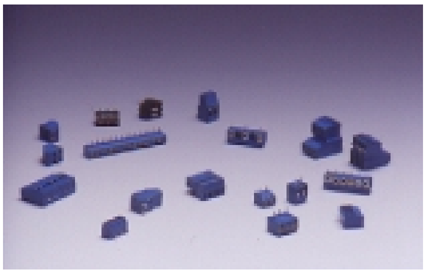
Crastin® PBT

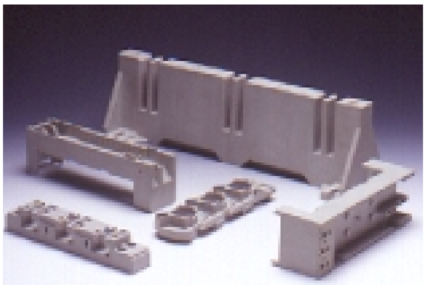
Zytel® ST

Fig. 11 gives recommendations for the usage of DuPont resins in these applications:









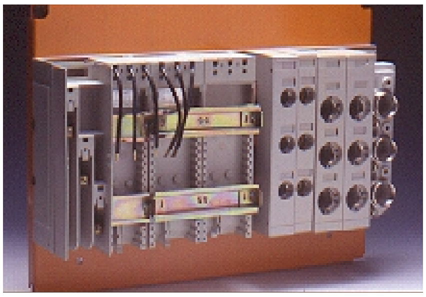


Fig. 11. Recommendations for the usage of DuPont resins

Application	Needs	Recommended resin
Residential wall plate	Gloss, colour static dissipation	Zytel® 101L Crastin® S600F10
Residential contact carrier	GW960, CTI low warpage	Zytel® FR70M30V0 Zytel® FR70M40GW
Industrial plug housing	Impact strength GW, colour	Zytel® 101L Zytel® 408 Zytel® ST801HS
Industry contact carrier	GW/V0, dimensional stability low wear	Zytel® FR70M30V0 Crastin® LW9020FR Crastin® LW9320FR
Industrial plug socket housing	Dimension stability RAL 7035/7032	Zytel® FR7026V0F Crastin® S650FR Crastin® S680FR Crastin® CE1064
Terminal block	UL 94 V2/CTI, RTI, colour	Zytel® 103HSL Zytel® 101L
Terminal block	UL 94 V0 CTI 600 Volt, colour halogen free	Zytel® FR7026V0F
Print connectors	UL 94 V0 CTI colour RTI > 80°C	Zytel® FR7026V0F Crastin® T841FR Crastin® T843FR Crastin® LW9020FR Crastin® LW9320FR
Industrial/ busshousing	Impact strength/colour dimensional stability V0	Zytel® FR7026V0F Crastin® S650FR Crastin® S680FR Crastin® CE1064
Industrial/ bussbars adapters	Stiffness impact strength, UL 94 V0	Crastin® SK645FR Rynite® FR530L Zytel® FR70G25V0

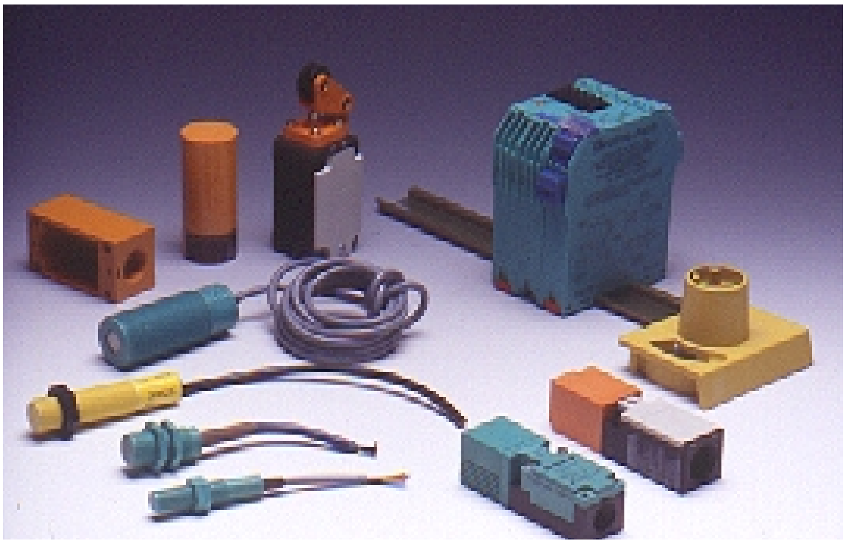


Fig. 12. Typical applications such as enclosures, structural parts, cable support components as cable ties, clamps, snap fits, chains, release devices

	Requirements						
	Glow wire ≥ 850 C	Glow wire ≥ 650 V	CTI ≥ 175V	RTI electrical ≥ 120C	Warpage	Stiffness	Toughness flexibility
Product selection							
Zytel® unreinforced	▲ ■	■ ■	■	▲	▲	●	■
Zytel® glass reinforced	● ■	■ ■	■	▲	●	■	●
Minlon® mineral reinforced	● ■	■ ■	■	●	▲	▲	●
Crastin® PBT unreinforced	● ■	■ ■	■	●	▲	●	■
Crastin® PBT glass reinforced	● ■	■ ■	■	■	●	■	●
Crastin® PBT blend glass reinforced	● ■	■ ■	■	■	▲	■	●
Rynite® PET glass reinforced	● ■	■ ■	■	■	●	■	●
Zytel® HTN glass reinforced	● ■	■ ■	■	■	●	■	●
Hytrel® TEEE unreinforced	●	■ ■	■	●	▲	●	■

Glow wire at 3 mm wall thickness according to TKG 1424

■ standard non FR grade
■ FR - flame retardant grade

● low potential candidate
▲ potential candidate
■ high potential candidate

Secondary protection

In compliance with EN 60670 (the former VDE 0606 European standard for the enclosures of household and similar fixed electrical installations) two requirements on glow wire cup are:

- for current carrying parts > 850°C
- none current carrying parts > 650°C

Select DuPont Engineering Polymers for structural parts from Fig. 13 (except large flat panel designs).

DuPont also provides resins for rod stock and shapes for use in the Branching and Control industry.

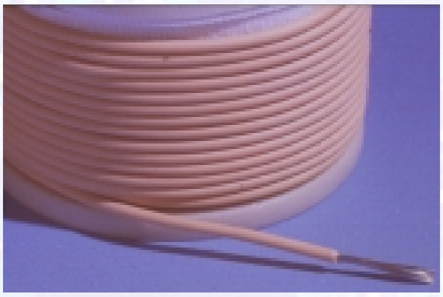
Additional requirements for Branching & Control extrusion applications and their end-uses are shown in Fig. 13.

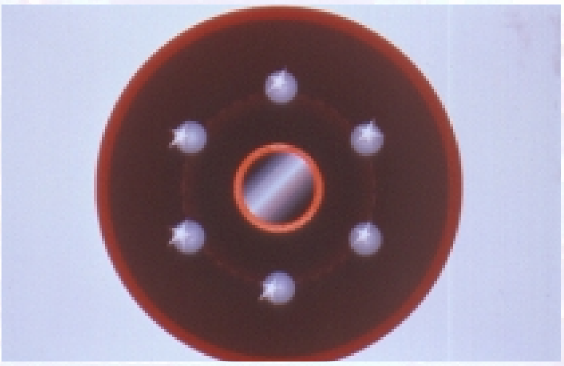
Some of these grades (marked *) offer halogen-free, flame retardency which minimize the toxicity and corrosion in case of fire.

Delrin® and Rynite® PET

Fig. 13. Typical grades for wire and cable extrusion

Applications	Glow wire ≤ 650°C	Glow wire ≥ 650°C
Cables	Crastin® S600 F10*	Zytel® 101/103HSL *
Cable tubes & corrugated tubes	Zytel® 101/103HSL * Zytel® 73G30 *	Zytel® FR7026V0F *
Direct wire coating	Hytrel® HTR8303 *	Hytrel® HTR8303FR



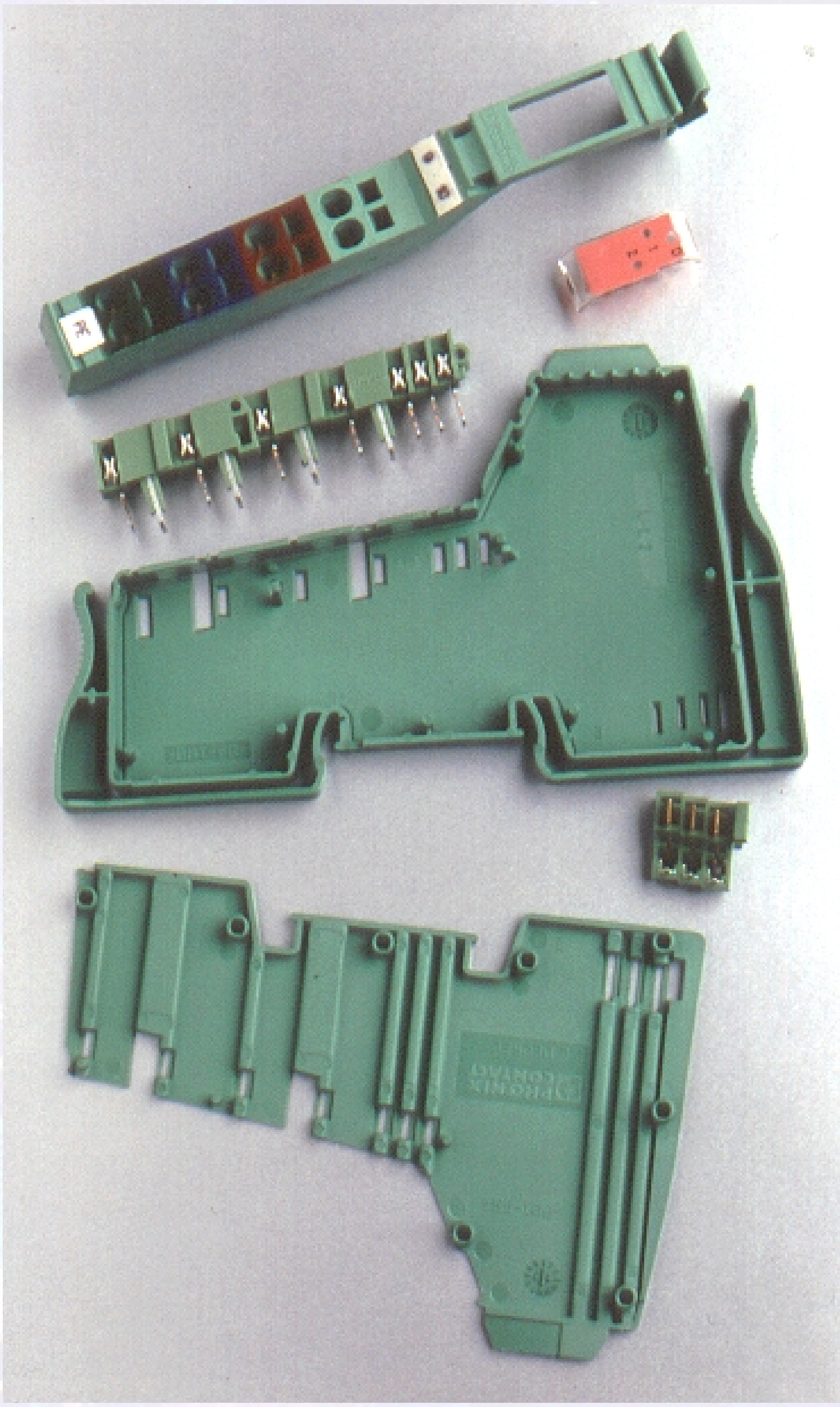


Technical resources for effective cost reduction

As already outlined, the need to constantly reduce costs has become a substantial driver in the Branching and Control industry.

This industry trend is posing challenges concerning resin selection, design and assembly.

The comparison on page 20 summarises the advantages of thermoplastics, compared to thermosets.



Crastin® PBT

Thermoplastics versus thermosets: a cost comparison for Branching and Control devices

In addition to satisfying the demanding technical requirements of the B&C industry, thermoplastic resins offer cost advantages over thermosets. Generally, these cost savings more than offset the higher material cost. Thermoplastics are also more environmentally acceptable.

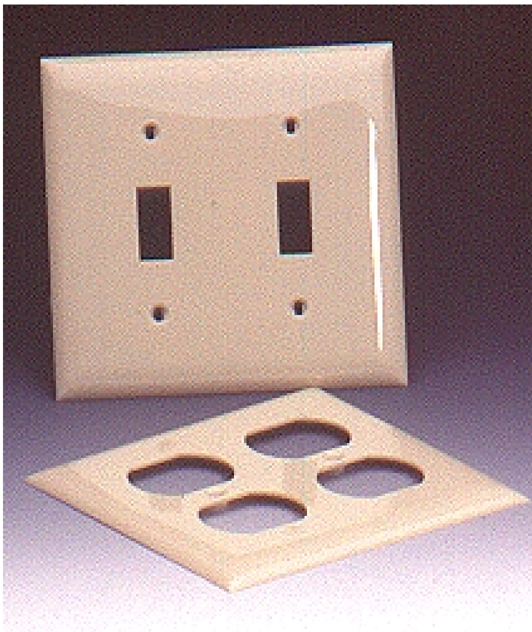
Thermoplastics give design engineers these important benefits:

1. Wall thickness reduction
2. Function integration
3. Ease of assembly
4. Processing advantages
5. No need for finishing operations
6. Higher productivity
7. Simplified packaging
8. Reduced waste concerns

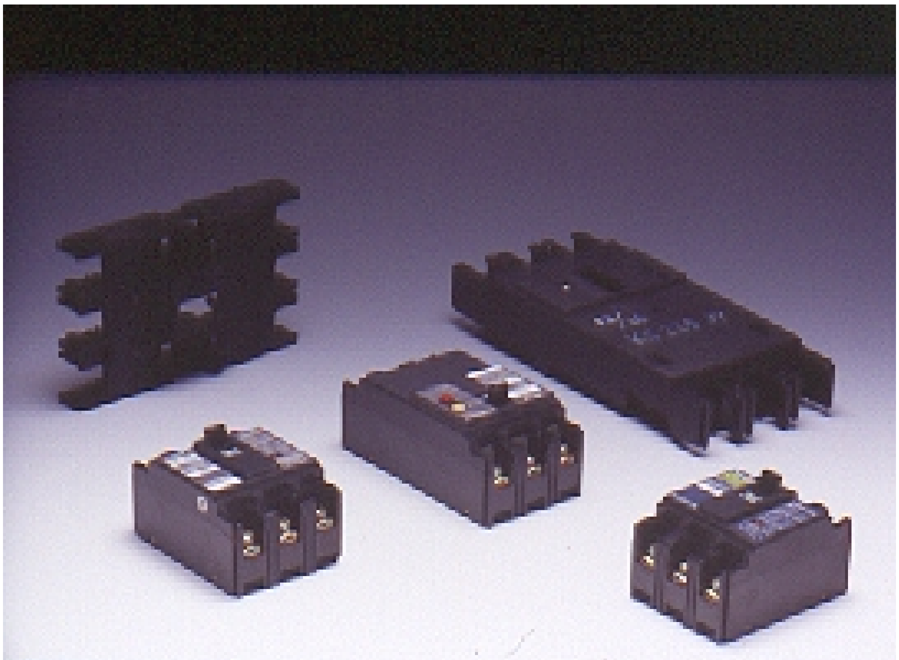
1. Wall thickness reduction
Depending on the application, reductions of up to 50% in wall thickness have been achieved using thermoplastics. These reductions result directly from the superior mechanical properties of thermoplastics, including added tensile strength and impact resistance. Such reductions positively affect moulding cycle times.

2. Function integration
It is well known that engineering thermoplastics lend themselves more than thermosets to part integration, replacing costly part assembly. For example, the elongation of polyamides can be used to make junction blocks easy to fasten onto fixation rails.

3. Ease of assembly
The higher elongation strength and other favourable characteristics of thermoplastics lead to a range of assembly techniques which are difficult or even impossible to realise with thermosets. These include the use of self-tapping screws, snap-fits, press-fits, moulded-in hinges, ultrasonic welding and riveting.



Zytel®



Rynite® PET

Another advantage of thermoplastic parts is that they are less susceptible to breakage during assembly operations since they are very tough. This factor can sometimes lead to faster assembly lines.

4. Processing advantages

A. - Cycle times
Cycle times are generally two to four times shorter for thermoplastics, compared with compression moulding, and faster in thick sections, compared with thermoset injection moulding. Since thermoplastic parts are usually thinner parts than thermosets, the cycle advantage is even bigger.

B. - Yields
Direct processing yields are higher with thermoplastics. This is mainly related to part breakage that occurs while processing thermosets.

C. - Resin re-use
Sprues and runners in thermoplastics can be reprocessed without affecting part properties. The use of runnerless moulding is also generally possible, which is normally not the case with thermosets.

D. - Tool costs
Tooling costs are generally slightly higher for moulding thermosets. The service life of the tools is also somewhat shorter than it is with thermoplastics, due to higher abrasion with thermosets.

E. - Shelf life of thermosets
Thermoset resins often have a limited shelf life, measured in weeks or months. Proper facilities for their storage may sometimes require a conditioned environment. This is not the case for thermoplastic resins.

F. - Machine settings
As some thermoset resins have a tendency to start their cross-linking process in storage, moulding conditions may have to be re-adjusted between two production runs, which can lead to higher costs.

Zytel® and Thermoset

5. Finishing operations
Deflashing after moulding is not required for parts in thermoplastics. Not only is deflashing an additional cost with thermosets, but it is often the cause of additional part breakage.

6. Higher productivity
Throughout manufacturing and shipping operations, productivity is much higher with thermoplastics than with thermosets. Thermoplastics can be moulded faster, and there is less breakage during processing, deflashing, parts assembly, packaging and installation.

7. Packaging
The superior impact resistance of thermoplastics makes them much less susceptible to breakage during shipping and handling in general. In many cases, this can lead to less expensive packaging.

8. Waste disposal
Today, the safe disposal of thermoset flashes and broken parts has become a real environmental concern. These problems can be avoided by using thermoplastics.

Your local DuPont representative will help you complete a thorough analysis, if needed.

Summary

All the parameters briefly reviewed in this brochure show that there are many advantages to using thermoplastics, despite their higher material cost. This becomes clear when calculating the total cost of the finished part, as opposed to the finished item.

A material selection check list for branching and distribution device components in thermosets and thermoplastics is shown on the following page.

DuPont is ready to assist you in going through your own part cost calculation, or to comment on any of the points in the check list that follows.

To simplify the selection of the best product for your application, DuPont has developed a Quality Function Deployment (QFD) spreadsheet that should be filled in before the first project meeting.

A copy of this form is reproduced on the next page.

Please fill in the blanks with your identified needs and quantify them. Also, don’t forget to mention your priorities in the column rating.

Then, send your request to your local DuPont contact, who will provide you with a selection of functional candidates.

Checklist for material selection of E/E components

Customer:	
Contact name:	
Telephone/fax:	
Date:	

Application:	
Material 1:	
Material 2:	
Material 3:	

Real customer needs	Criteria	Rating (10 high, 5 low)
1. Type of flame retardent	Halogen	
	Phosphorous	
	H & p free	
2. Flammability rating	HB	
	V2	
	V1	
	V0	
	Glow wire test	
	Oxygen index or I/F rating	
3. Electrical properties	Comparative tracking index (CTI) CTI > 175 V	
	CTI > 400 V	
	CTI > 600 V	
	Arc resistance(s)	
	Dielectrical strength (KV/mm) Where thickness = 2,3 mm	
	Where thickness = 3,2 mm	
	Volume resistivity (ohm x cm)	
4. Dimensional stability	Coefficient of linear thermal expansion	
	Water absorption	
	Warpage	
5. Mechanical properties	Tensile strength	
	Elongation at break	
	Tensile E - modulus	
	Charpy impact strength - unnotched	
	- notched	
6. Thermal properties	Temp. of deflection under load at 1,8	
	Relative temperature index (RTI) Electrical	
	Mechanical with impact	
	Mechanical without impact	
7. Decoration requirements	Surface treatment / printing	
	Surface treatment laser printing	
	Colouring according to RAL card	
	Surface gloss requirements	
8. Chemical resistivity	Acid (indicate PH level)	
	Leach (indicate PH level)	
	Solvent (indicate type)	
9. Processing	Tool runner / system standard cold	
	- hotrunner	
	Max. flow length in cavity	
	Mould deposit	
	Mould shrinkage	
	Tool & machine wear	
	Tool surface temperature	
10. Assembly techniques	Snap fit assembly	
	Screw fit assembly	
	Press kit assembly	
	Weld fit assembly	
	Soldering technique	
11. Economics	Resin price per litre	

For further information on Engineering Polymers contact:

Belgique / België
Du Pont de Nemours (Belgium)
Antoon Spinoystraat 6
B-2800 Mechelen
Tel. (15) 44 14 11
Telex 22 554
Telefax (15) 44 14 09

Bulgaria
Serviced by Interowa.
See under Österreich.

Česká Republika a Slovenská Republika
Du Pont CZ, s.r.o.
Pekarska 14/268
CZ-155 00 Praha 5 – Jinonice
Tel. (2) 57 41 41 11
Telefax (2) 57 41 41 50-51

Danmark
Du Pont Danmark A / S
Roskildevej 163
Post Boks 139
DK-2620 Albertslund
Tel. 43 62 36 00
Telefax 43 62 36 17

Deutschland
Du Pont de Nemours
(Deutschland) GmbH
DuPont Straße 1
D-61343 Bad Homburg
Tel. (06172) 87 0
Telex 410 676 DPD D
Telefax (06172) 87 27 01

Egypt
Medgenco International Trade Co.
13, El Bostan Street
ET-Cairo
Tel. (02) 392 78 66
Telex 93 742 MK UN
Telefax (02) 392 84 87

España
Du Pont Ibérica S.A.
Edificio L'Illa
Avda. Diagonal 561
E-08029 Barcelona
Tel. (3) 227 60 00
Telefax (3) 227 62 00

France
Du Pont de Nemours (France) S.A.
137, rue de l'Université
F-75334 Paris Cedex 07
Tel. 01 45 50 65 50
Telex 206 772 dupon
Telefax 01 47 53 09 67

Hellas
Ravago Plastics Hellas ABEE
8, Zakythou Str.
GR-15232 Halandri
Tel. (01) 681 93 60
Telefax (01) 681 06 36

Israël
Gadot
Chemical Terminals (1985) Ltd.
22, Shalom Aleichem Street
IL-633 43 Tel Aviv
Tel. (3) 528 62 62
Telex 33 744 GADOT IL
Telefax (3) 528 21 17

Italia
Du Pont de Nemours Italiana S.p.A.
Via Aosta 8
I-20063 Cernusco sul Naviglio (Mi)
Tel. (02) 25 30 21
Telefax (02) 92 107 845

Magyarország
Serviced by Interowa.
See under Österreich.

Maroc
Deborel Maroc S.A.
40, boulevard d'Anfa - 10°
MA-Casablanca
Tel. (2) 27 48 75
Telefax (2) 26 54 34

Norge
Distrupol Nordic
Niels Leuchsvei 99
N-1343 Eiksmarka
Tel. 67 16 69 10
Telefax 67 14 02 20

Österreich
Interowa
Fürer-Haimendorf GmbH
Bräuhausgasse 3-5
A-1050 Wien
Tel. (01) 512 35 71
Telex 112 993 IROWA A
Telefax (01) 512 35 71 12 /
512 35 71 31

Polska
Du Pont Poland Sp. z o.o.
ul. Prosta 69
PL-00-838 Warszawa
Tel. (022) 691 09 01
Telefax (022) 691 09 10

Portugal
ACENYL
Rua do Campo Alegre, 672 - 1°
P-4100 Porto
Tel. (2) 69 24 25 / 69 26 64
Telex 23 136 MACOL
Telefax (2) 600 02 07

Romania
Serviced by Interowa.
See under Österreich.

Russia
E.I. du Pont de Nemours & Co. Inc.
Representative Office
B. Palashevsky Pereulok 13 / 2
SU-103 104 Moskva
Tel. (095) 797 22 00
Telex 413 778 DUMOS SU
Telefax (095) 797 22 01

Schweiz / Suisse / Svizzera
Dolder AG
Immengasse 9
Postfach 14695
CH-4004 Basel
Tel. (061) 326 66 00
Telex 962 306 DOL CH
Telefax (061) 326 62 04

Slovenija
Serviced by Interowa.
See under Österreich.

Suomi / Finland
Du Pont Suomi Oy
Piispankalliontie 17
PO Box 199
FIN-02201 Espoo
Tel. (9) 72 56 61 00
Telefax (9) 72 56 61 66

Sverige
DuPont Sverige AB
Box 23
S-164 93 Kista (Stockholm)
Tel. (8) 750 40 20
Telefax (8) 750 97 97

Türkiye
Du Pont Products S.A.
Turkish Branch Office
Sakir Kesebir cad. Plaza 4
No 36 / 7, Balmumcu
TR-80700 Istanbul
Tel. (212) 275 33 82
Telex 26541 DPIS TR
Telefax (212) 211 66 38

Ukraine
Du Pont de Nemours
International S.A.
Representative Office
3, Glazunova Street
Kyiv 252042
Tel. (044) 294 96 33 / 269 13 02
Telefax (044) 269 11 81

United Kingdom
Du Pont (U.K.) Limited
Maylands Avenue
GB-Hemel Hempstead
Herts. HP2 7DP
Tel. (01442) 34 65 00
Telefax (01442) 24 94 63

Argentina
Du Pont Argentina S.A.
Avda. Mitre y Calle 5
(1884) Berazategui-Bs.As.
Tel. (541) 319-44 84 / 85 / 86
Telefax (541) 319-44 17

Brasil
Du Pont do Brasil S.A.
Al. Itapecuru, 506 Alphaville
06454-080 Barueri-São Paulo
Tel. (5511) 421-84 68 / 85 56

Asia Pacific
Du Pont Kabushiki Kaisha
Arco Tower, 14th Fl.
8-1, Shimomeguro 1-chome
Meguro-ku, Tokyo 153
Tel. (03) 54 24 61 00

South Africa
Plastamid (Pty) Ltd.
43 Coleman Street
P.O. Box 59
Elsies River 7480
Cape Town
Tel. (21) 592 12 00
Telefax (21) 592 14 09

USA
DuPont Engineering Polymers
Barley Mill Plaza, Building #22
P.O. Box 80022
Wilmington, Delaware 19880
Tel. (302) 892 05 41
Telefax (302) 892 07 37

Requests for further information from countries not listed above should be sent to:

Du Pont de Nemours International S.A.
2, chemin du Pavillon
CH-1218 Le Grand-Saconnex
Geneva
Tel. (022) 717 51 11
Telex 415 777 DUP CH
Telefax (022) 717 52 00

Internet location:
http://www.dupont.com/enggpolymers/europe

12.99
L-12118
Printed in Switzerland
® DuPont registered trademark

DuPont Engineering Polymers