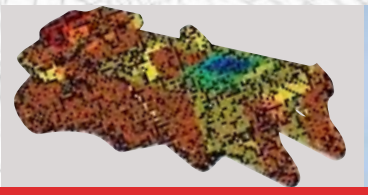
From concept to commercialisation with DuPont Engineering Polymers




DUPONT

The miracles of science™

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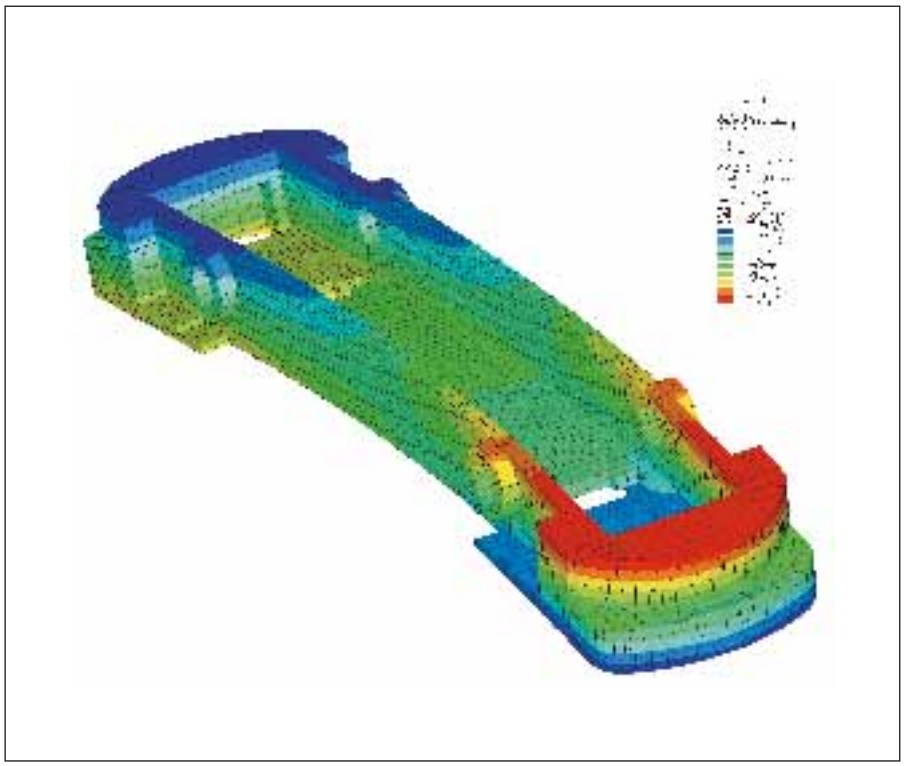
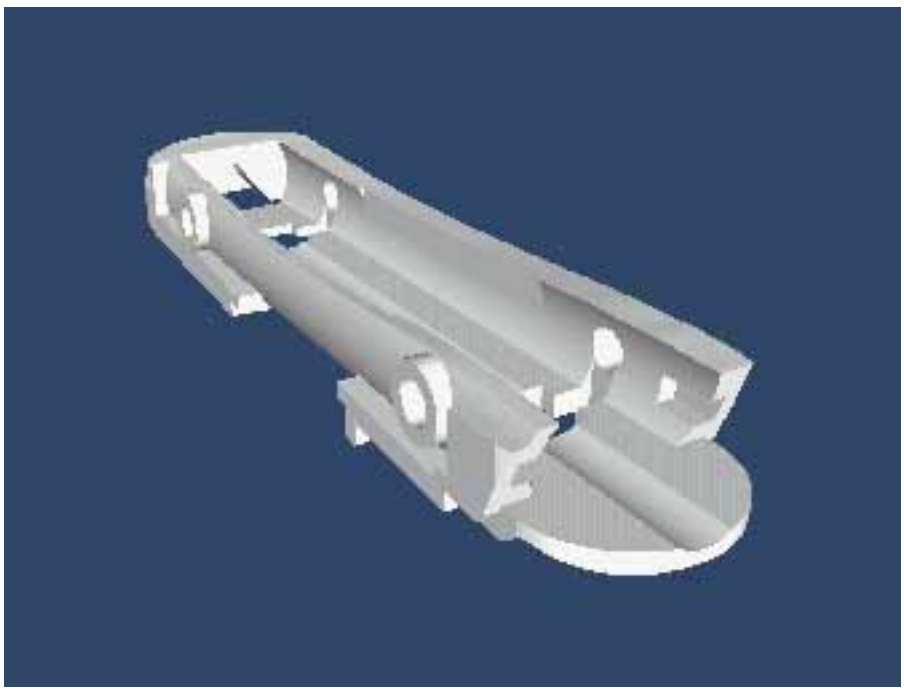




Start with DuPont… a partnership that works

Today you need more from your suppliers than just materials. You need a resource that is willing and able to join in at the earliest stages of the product development process. One that can carry a project from concept through design, component analysis, material selection, prototyping, testing, quality control, and even commercialisation. You need a fully fledged partner.

DuPont can be that partner. We believe that true partnership is a dynamic process of teamwork and sharing. And we recognise that only through your continued success will our relationship thrive, to bring out the best in both of us.

If you let our people work with your people from the initial design concept, and on through every stage from prototyping to full production, we can share our unrivalled experience, and help you choose the optimum engineering polymer for your needs. The result? A very competitive new product with time-proven success built in.

DuPont engineering polymers offer you the properties and benefits so important to giving your products that extra competitive edge: lightweight materials for lightweight parts and components; resistance to corrosion and abrasion; self-lubrication; reduced moulding costs; integral colour; reduced finishing time; easier assembly, and greater customer satisfaction. All these advantages add up to new opportunities in design, manufacture and finished part cost.

We wrote the book on engineering polymers. Nylon, which we invented back in the 1930s, led to the development of ZYTEL®, the first real engineering thermoplastic.

Our family of high performance polymers grew rapidly as we added DELRIN® acetal, glass-reinforced ZYTEL®, MINLON® mineral reinforced nylon resin, ZYTEL® ST super tough nylon and RYNITE® PET thermoplastic polyester. More recently, we added a complete range of PBT polyesters known as CRASTIN® PBT. Today we offer the broadest range of semi-crystalline engineering polymers available from a single supplier, and they all offer new possibilities for the replacement of traditional materials such as metal and wood, as well as better alternatives to many other plastics.

The most recent introductions include ZENITE® LCP liquid crystal polymers and ZYTEL® HTN high performance polyamide resins. In both cases, a standard range of grades has been commercialised and many new developmental grades are being tested for customer approval.

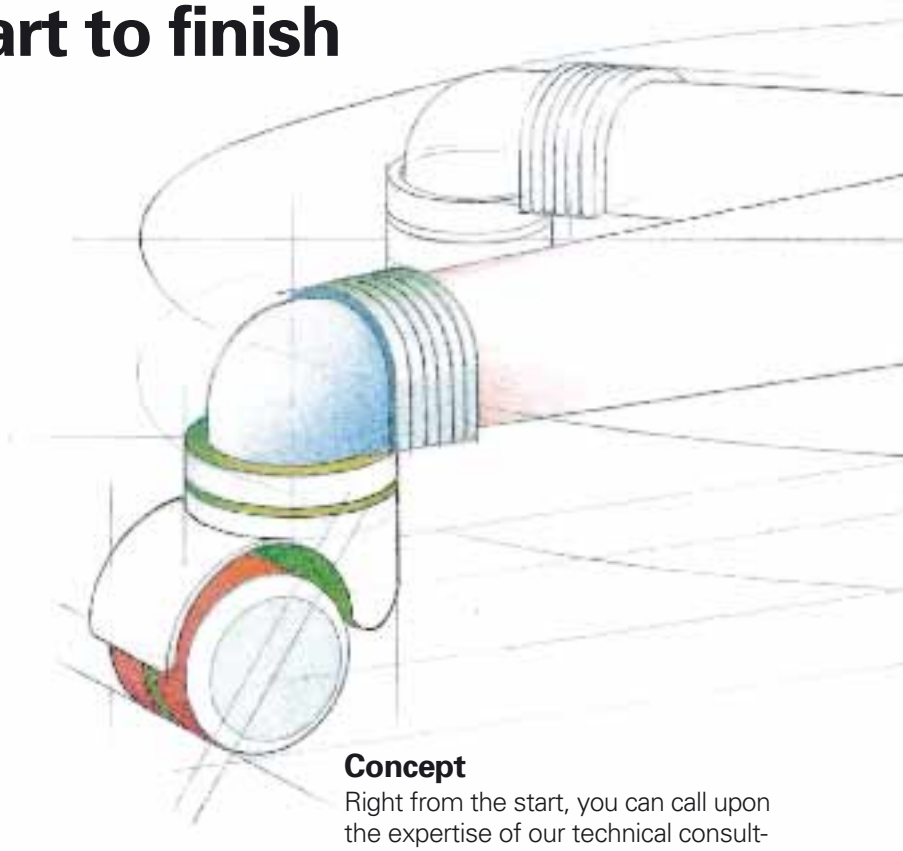
Around the world, research in DuPont technical centres and production plants never stops. Following the commercialisation of super tough and toughened resins with the DELRIN® and ZYTEL® product offerings, our most recent introduction is DELRIN® P, an acetal with new stabilisation technology, resulting in very good processing performance, even under critical operating conditions.

Backing this extensive line of plastics is HYTREL® thermoplastic polyester elastomer. HYTREL® combines many of the most desirable characteristics of high performance elastomers and flexible plastics, yet it can be formed into quality parts by conventional thermoplastic processing techniques.

In today's competitive markets, each new product launch seems to require more and more investment. So it pays, at the earliest stage, to take full advantage of the latest developments in engineering polymers by starting with DuPont and calling us in at the initial concept stage. More than just selling polymers, we share with you a world of practical experience and technological know-how that can help you build a real competitive advantage into everything you design and manufacture.

This brochure contains a great deal of information, but it is by no means complete. For more detailed data, contact your local DuPont representative.

Your partnership with DuPont… teamwork from start to finish



When you purchase resins from DuPont you get much more than quality thermoplastics. You obtain the services of a partner who gives you unrivalled technical support. You open the door to a world of knowledge that can provide valuable practical help at every stage from concept to commercialisation.

We are proud to be able to offer you assistance from the most experienced group of technical service experts in the engineering plastics industry, people who are always up to date with the very latest developments. Our engineers have developed vibration welding methods, runnerless mould designs for semi-crystalline thermoplastics, and ever more exacting methods of quality control and assurance. They are people who can find ways to give your products the extra competitive edge that spells success in the marketplace.

Partnership

Our idea of partnership means working together, combining the best minds of our organisations to produce the best results. DuPont offers you decades of experience, and extensive resources – our people, products, and considerable technical know-how. And we have the will to do what is necessary to help you expand your business.

Worldwide

In today's business world, one must think in much larger terms than ever before. Everything one designs has the potential for application internationally. In this kind of competitive climate, it helps to have a partner that can speak your language – wherever you or your customers are. With our truly global operation, we can work with you in virtually any country, and we can help you expand your business into those countries.

Our people working with yours

From your first phone call to the time your new product is ready for shipment, our people are there with solutions that work. And if we don't have an answer readily available, we'll be the first to tell you.

Computer Aided Technical Services

Our worldwide Computer Aided Technical Service facilities (CATS) can provide you with full computer aided engineering (CAE) and computer aided design (CAD) services, including finite element analysis and 3D modelling. Three core computer systems are linked within the Asia/Pacific, European and American regions. Within each region, CAD servers and Personal Designer Systems are networked with the core systems. The most up to date graphic programmes and data exchange make it possible to exchange drawings with customers using other design systems.

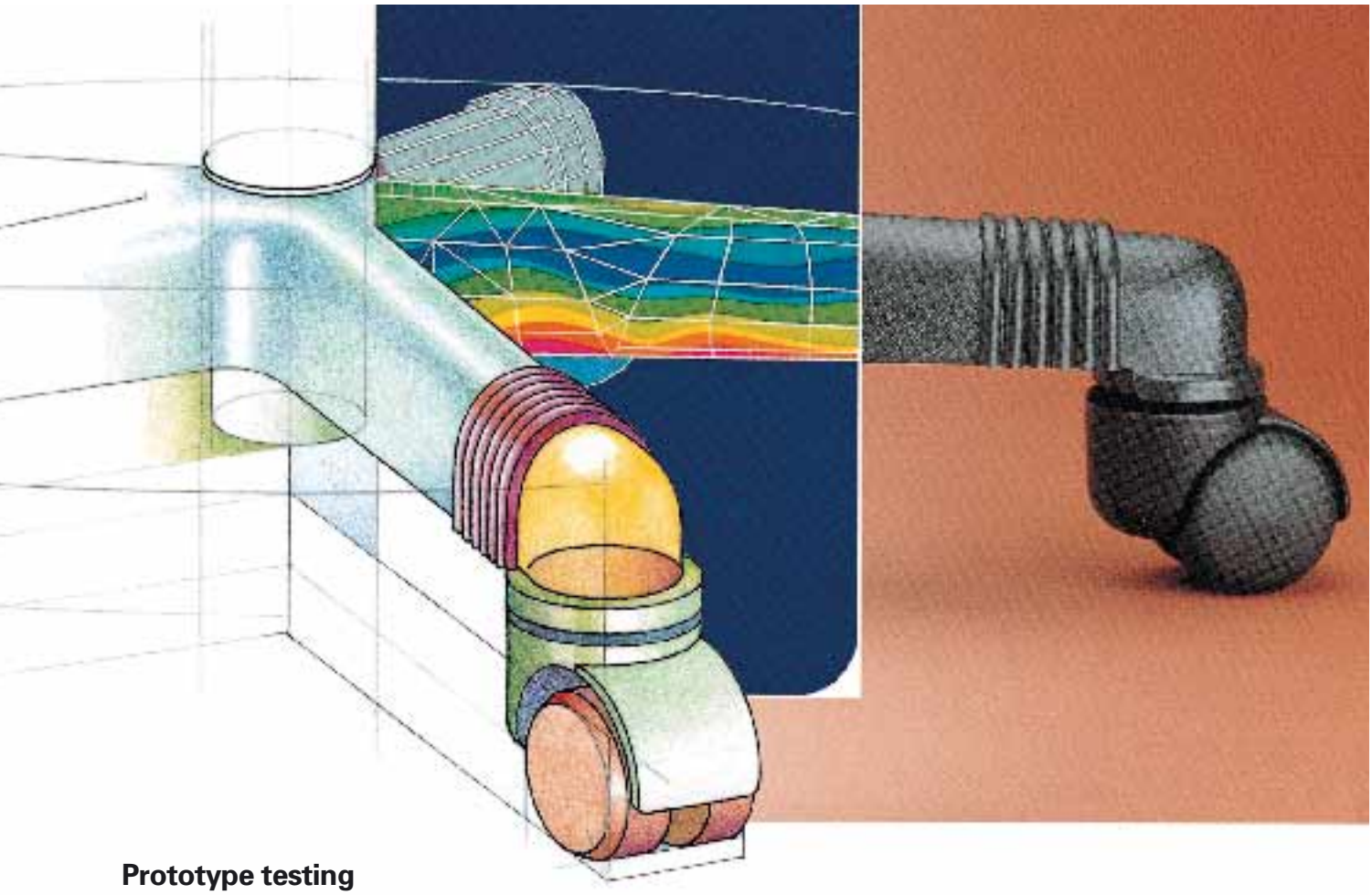
Concept

Right from the start, you can call upon the expertise of our technical consultants for a thorough analysis of your design concept. We'll take a close look, and ask tough questions; but in the end our wide experience with engineering polymers can save you considerable time and money.

We'll work with your designers to arrive at a solution that is both creative and practical. We can suggest the best material for your needs, whether it has been proved around the world or it's a new technology in development. Our technical advisors will even tell you if an alternative material not available from us would be better for your application.

Design

Once your concept has been analysed, fine-tuned and proved feasible, our DuPont Design professionals bring their expertise to the table. They can help you determine the specific design engineering details that will optimise product performance and production economy. And they can often reduce costs by consolidating several parts into a single component.



Prototype testing

We know that a customer can't always stop a production line to do a test run. So we have created a polymers industry in microcosm at each of our worldwide Technical Centres. Here, under controlled conditions, you can test a prototype tool, and modify it if necessary, with a full computer printout monitoring every factor. Our experts will examine your moulds and machines, as well as the way you're using them. And they'll ensure that the rough tooling you need to produce test parts for various analyses is properly designed.

Our expertise in prototype testing and microstructural analysis ensures that any potential process problems are corrected and that your final materials are properly selected. When we have your prototypes in hand, we can help your laboratories analyse performance with mechanical, chemical exposure, heat-ageing, accelerated wear, and environmental exposure testing – again, utilising our own in-house facilities to complement yours.

Production

At DuPont we can provide you with the help you need to make your production start-up as trouble-free as possible, including utilisation of our Advanced Technical Centres' moulding machines. Here, close monitoring of trial production runs helps anticipate and eliminate any potential trouble with final production, and ensures that materials grades are best tailored to meet your requirements.

The same equipment can also help you perfect new production methods, or even create new processes. In addition, our experience in Statistical Process Control can aid you in pinpointing parameters needing close monitoring to maximise productivity and eliminate rejects. As a final bonus, we'll put the industry's most experienced technical field force at your disposal where you need it most – right in your own production facilities.

Commercialisation

With DuPont you get more than broad industry experience and important contacts within it. As your partner in the development of a new product, we're prepared to complement your efforts and help assure its success in the marketplace. This could include access to our national and international marketing, legal and financial expertise for ideas, guidance and direction in the successful commercialisation of your product.

Your current project may simply be an improvement to an existing product or process. Or you may want to do something that has never been done before. Either way, we can be of great help to you. Our people are ready to work with your moulder, your mould maker, and your quality control people right through from prototype test to full production.

Remember, the sooner you start with DuPont, the bigger the contribution we can make.

CRASTIN® PBT… a highly versatile family of thermoplastic polyesters with a wide variety of applications

DuPont CRASTIN® PBT thermoplastic polyesters are based on polybutylene terephthalate.

By making physical and technical modifications, a very wide range of products is available that are ideally suited to an enormous variety of industrial applications, including electronics, electrical, automotive, mechanical engineering, chemical and apparatus engineering, domestic and medical appliances and sporting goods. In fact, this growing family is currently available in over 30 different grades, approximately half of which are flame retardant.

Among the many features of various CRASTIN® PBT grades are mechanical and physical properties of stiffness and toughness, heat resistance, friction and wear resistance, excellent surface finishes and good colourability. They have excellent electrical insulation characteristics and high arc-resistant grades are available.

Processing is simple, with good flow properties leading to short cycle times using standard injection moulding machines. Post-moulding operations such as welding, fastening and glueing are also easy, as are printing, painting, hot stamping and laser marking.

All-in-all, the DuPont CRASTIN® PBT range spells versatility, processing ease and good economics.

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1. The inner and outer housing of this device are moulded of CRASTIN®, all 4 parts are assembled with snap-fits. For this consumer product, DuPont PBT combines the following: good mechanical properties, stiffness, resistance to usual bathroom chemicals and temperature resistance. It has good mould flow-characteristics, an important consideration for a high-precision moulding on which sensitive electronic components are mounted.

2. CRASTIN® PBT with high tracking resistance, replaced epoxy in automotive ignition distributor caps because of its excellent moulding properties. Such high-voltage applications require optimal dielectric performance as well as excellent thermal resistance and dimensional stability.

3. CRASTIN® is used for door handles for automotive applications. It is a 30% glass fibre reinforced PBT that provides excellent mechanical properties and UV resistance.

4. Dimensional stability, chemical and temperature resistance facilitated KATKO in Finland to opt for CRASTIN® SK645FR for this load break switch. It is a 30% glass-reinforced PBT meeting UL94 V0 requirements. Compared to the traditionally used thermoset, CRASTIN® offers higher productivity, an integrated design and significant cost reductions.

5. CRASTIN® FR grade that meets UL94 V0 requirements was used for these modular terminals. Providing outstanding dielectric and precision moulding properties, it permits high-speed data exchange with a reduce number of terminal connections. CRASTIN® is resistant to chemicals and humidity, it is an excellent electrical insulator, has high arc resistance and a high comparative tracking index.

6. Eurometers Ltd. uses CRASTIN® PBT for the main housing and the top cover for their E6 gas meter. DuPont PBT is a good electrical insulator, withstands extremes of temperature, resists to domestic chemicals and has excellent dimensional stability. It also gives an attractive surface finish, which does not deteriorate with time. Flow-tube assembly (foreground) is made from DELRIN®.


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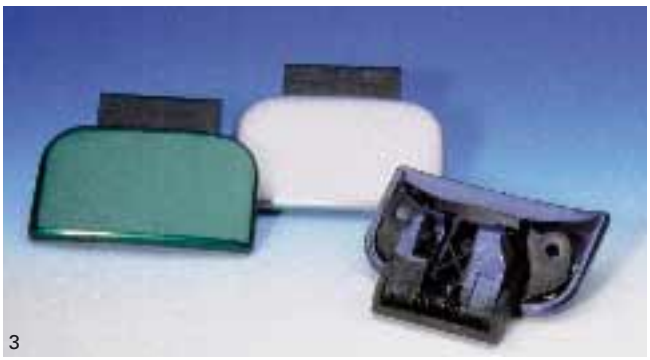
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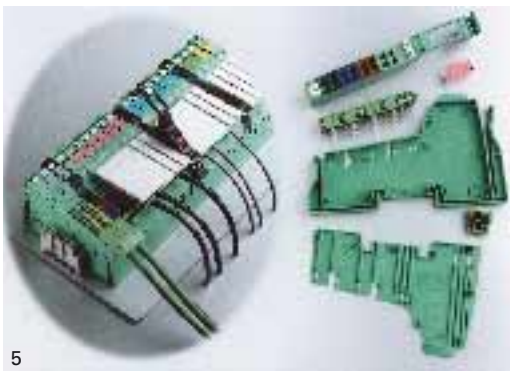
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DELRIN®... versatility in design, moulding and performance

DELRIN® acetal resin is a highly versatile engineering plastic with metal-like properties. It offers outstanding strength, stiffness and hardness, dimensional stability, fatigue, abrasion and solvent resistance, is self-lubricating, and available in a variety of colours and specialty grades.

Its superior mechanical properties compared with acetal copolymer help improve productivity and increase profitability. Its ability to meet European regulations on food contact considerably increases its potential, and because it can be moulded easily into complex shapes with fast cycle times and rapid assembly techniques, production costs are lowered.

The product range includes UV resistant grades, resins for low friction and wear, the DELRIN® P series for optimum processing for highly demanding operating conditions, as well as tough and super tough grades.

DELRIN® 100ST super tough is seven times tougher in notched Izod and falling weight (Gardner type) testing than standard DELRIN® at 23° C. In impact fatigue tests, it is more resistant than toughened polyester and polycarbonate.

With these new generations of versatile DELRIN® acetals, you gain new flexibility and freedom in designing all types of products for all types of applications.

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1. By making different parts from various types of DELRIN®, including tough, lubricated and general purpose grades, Braun's Spanish operation has produced an efficient meat grinding accessory for the company's "Minipimer" hand mixer, which already relies on DuPont polymers for other components.

High mechanical strength, low coefficient of friction, food approval, and special assembly techniques with parts in DELRIN®, have all contributed to giving this appliance high performance at a reasonable price.

2. Excellent fuel resistance and its ability to be moulded into complex shapes make DELRIN® an ideal material for this fuel swirl pot found in automotive petrol tanks.

3. DELRIN® provides the right combination of stiffness, toughness, fatigue and impact resistance needed for reliable gears in literally hundreds of different types of applications.

4. Car makers increasingly adopt DELRIN® to replace metal for loud speakers. It brings good acoustic, colourability, aesthetic, impact resistance. It is also easier to assemble, does not need surface finishing as plating and painting.

5. Ski and snow board bindings of DELRIN® look better because of the integral, moulded-in colours; they benefit from its low-temperature (–40° C) impact resistance and low coefficient of friction, and last longer because they won't corrode.

6. DELRIN® 100 is ideal for automotive door locks as it allows for extensive functional integration due to its unmatched combination of stiffness and toughness.

7. DELRIN®-KEVLAR® eliminates metal machining, tooling and lubrication processes. It provides dimensional stability, toughness, abrasion resistance and a smooth, aesthetic surface for applications such as conveyor belt systems.


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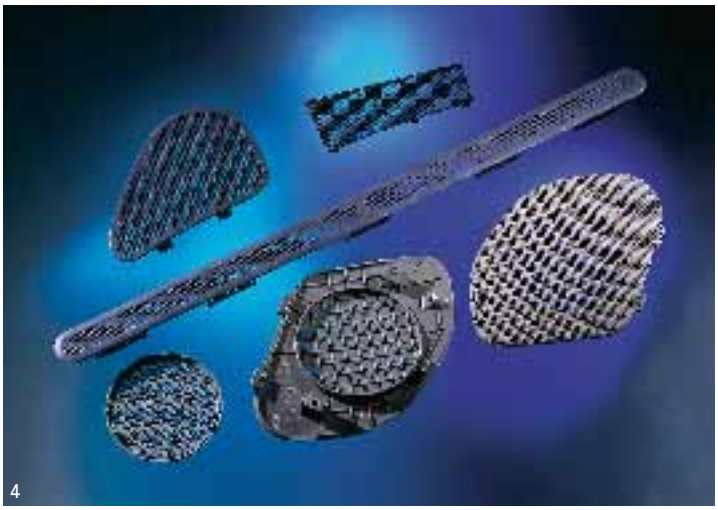
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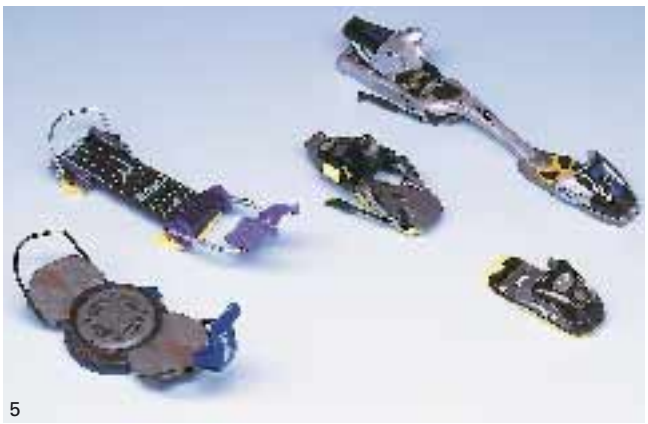
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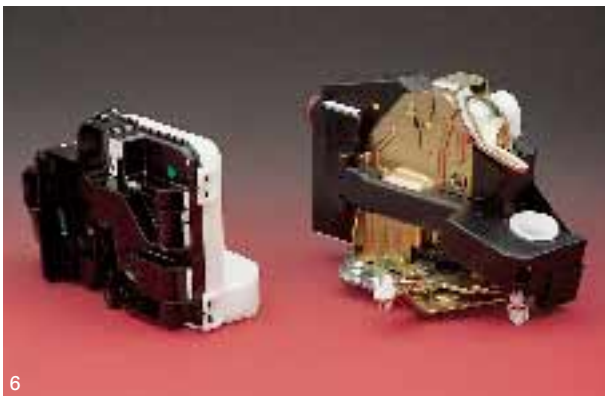
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If you need even more versatility, look to HYTREL®… a thermoplastic and an elastomer all in one

HYTREL® thermoplastic polyester elastomers provide a winning combination for many parts and components. They give the flexibility of rubbers, the strength of plastics, and the processibility of thermoplastics. They can be processed easily on conventional injection, blow and rotational moulding equipment, and can also be extruded and melt-cast.

HYTREL® is ideal for parts requiring low flex fatigue and high load-bearing capacity. It is strongly resistant to tearing, flex-cut growth, creep and abrasion. Its mechanical properties provide the strength and stiffness you need, in addition to outstanding toughness. Its chemical properties make it highly resistant to hydrocarbons and many other fluids.

HYTREL® retains these properties at temperatures from –40° C to +110° C, and even up to +150° C with additional heat stabilisers.

HYTREL® standard grades are available in a full range of Shore D hardnesses from 35 to 82, as well as high performance grades with hardnesses of 30D and 72D. Special grades include heat stabilised, flame retardant, food approved, glass-reinforced, blow moulding and extrusion grades. Concentrates offered include black pigments, UV protection additives, hydrolysis resistant additives, heat stabilisers, and flame retardants.

If you have multi-part or multi-material components that could be made simpler or operate more efficiently with HYTREL® we invite you to learn more about this unique thermoplastic elastomer.

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1. HYTREL® in Airbag Deployment Door application offers a unique consistency of physical properties over a wide range of temperature, it can be used in extreme low temperature environments and withstands the automotive interior requirements including UV, aestetics.

2. Flexibility in design, increased stiffness without adding weight or thickness, and an impeccable performance at all temperatures was reason enough for the people at Salomon to choose HYTREL® for the energy spring of their in-line skate.

3. HYTREL® proved to be the answer for the interior door handle in the restyled SEAT Toledo. Besides a nice, soft touch and matt surface, SEAT was looking for very specific mechanical and chemical properties. The possibility of moulding the DuPont elastomer in a tool that was designed for the previously used acetal copolymer meant a significant cost saving, as HYTREL® has similar mould shrinkage.

4. The Suehiro Industry Co. Ltd knows all about "zapping". Their change to HYTREL®, from the traditional silicone rubber for keypads of remote controls resulted in shorter production cycles, increased design flexibility and an ideal "feel". "An altogether superior class of product" is how Suehiro's development manager describes HYTREL®.

5. Using HYTREL®, Paguag developed a range of flexible coupling with longer service life, greater reliability and better performance. HYTREL® has very good resistance to synthetic oil, water, grease, ozone and many other chemicals. It also has excellent resistance to flex fatigue and crack propagation and maintains these properties over a wide range of temperatures.

6. The HYTREL® HTR8105 BK in CVJ boots put an end to a very costly and complicated repair in case of failure during the life of the car. These CVJ boots for the Ford Mondeo moulded by ContiTech in Germany, are extremely cost-effective compared to their rubber counterparts, and offer superior toughness and resistance to greases.


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7. Another HYTREL® application in automotive components is the blow-moulded air-duct made of HYTREL® HTR4275 BK. VW has adopted this innovative technology and benefits for noise reduction, light weight and an overall reduction of the number of parts in the engine compartment, due to its multi-functionality.

By using these parts, engine performance can be improved by as much as 2%.

Impact resistance, dimensional stability and outstanding functional flexibility make MINLON® the choice for critical components

The MINLON® range of mineral and mineral/glass-reinforced nylons offers a unique balance of properties that allows designers to maintain the optimum balance of strength and rigidity, while minimising the effects of warpage.

A major benefit of MINLON® is its dimensional stability low warpage and distorsion. This is due to the fact that its shrinkage is isotropic – even over varying wall thicknesses within the same application.

DuPont's experience in the area of mineral-reinforced nylons has led to the development of a wide range of compositions tailored for a variety of demanding applications. Mineral-reinforced resins for automotive wheel covers feature an excellent surface for painting, together with easy flow, fast cycle times, fatigue resistance and resistance to repeated high impacts.

For under-bonnet applications such as engine styling covers, where a combination of low warpage and excellent surface finish is required, a range of mineral or mineral/glass-reinforced resins, based on PA6 and PA66, have been developed.

Even for the most demanding under-bonnet applications, MINLON® grades featuring a specially-developed glass and mineral combination and a nylon 66 matrix provide the ultimate combination of strength, stiffness and creep resistance at elevated temperatures. Resistance to hot oil and hot air ageing, combined with precision moulding and low warpage are additional benefits.

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1. MINLON® has established itself as the leading material for automotive wheel covers. Mineral-reinforced, impact-modified products such as MINLON® 13MM and EFE6096 are optimised to provide the needed balance of properties for the application. VW, Peugeot, Citroën, Renault, Volvo, Audi and Honda are among the many car manufacturers around the world who use DuPont MINLON® resins for wheel covers.

2. MINLON® is used for automotive rocker covers because it provide high stiffness, heat stability, oil and chemical resistance, while weighing less than the metal it replaces. BMW's rocker cover of MINLON® helps reduce engine noise still further and cuts production costs.

3. MINLON® was chosen for car interior door handles for its mechanical properties and dimensional stability. The very smooth surface of MINLON® allows chrome-plating with very high blemish free quality.

4. The world's first plastic throttle body is part of an air intake manifold from Rover and is made from MINLON®. High stiffness and heat resistance, outstanding dimensional stability and uniform mould shrinkage was needed for accurate dimensional control of the throttle body bore.

5. The combination of toughness and stiffness enables gears of high dimensional precision to be moulded. MINLON® 11C140B is being successfully used in the automotive industry.

6. Easier assembly and lower costs made MINLON® 11C140 the material of choice for motor brackets from Switzerland's Maxon. Multi-functional integration becomes a practical reality thanks to the flexibility of design that is made possible with MINLON®.

7. If any application has to rely on resistance to weather conditions and temperature variations, it must be street lighting. MINLON® is used for the housing of street lighting reflectors by Gewiss in Italy. Easily processable, MINLON® 13T2, a toughened PA66, 30% mineral reinforced nylon, provides the housing with high stiffness, low warpage and a perfect surface aspect.

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RYNITE® PET… takes the heat

When you're looking for the ultimate combination of stiffness, temperature performance, maximum dimensional stability, and a high gloss finish, RYNITE® PET is the most cost-effective answer. It unites the best properties of reinforced polyethylene terephthalate (PET) with easier processability to produce high performance parts that can be moulded conventionally.

RYNITE® is the only PET-based polyester system with the virtue of rapid crystallization. It also has a 20° C heat deflection advantage over PBT. It can be processed over a broad temperature range.

And, because of its low water absorption, parts in RYNITE® PET maintain their properties and dimensional stability. This makes it a prime candidate for the replacement of die-cast metals and thermosets in many demanding applications where stiffness, critical tolerances and exterior finish are key requirements. The outstanding flow characteristics of RYNITE® PET allow it to fill complex, thin-walled moulds with less injection pressure than is needed with other resins. This is a particularly important advantage with miniature parts.

RYNITE® FR530L, widely used in the electrical and electronic component industries, has a UL temperature index of +155° C, among the highest of all thermoplastic polyesters.

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1. This induction hob from BSH Balay is made of RYNITE®, which was chosen for its dimensional stability, stiffness and good mouldability. The RYNITE® FR531 NC used by Balay was specially developed to support temperatures of up to 200° C.

2. RYNITE® 545 was chosen for the connector housing of this Bosch alternator because of the good combination of mechanical properties it offers. In addition it has good thermal and chemical resistance. It also permits high productivity in multi-cavity moulds.

3. This encapsulated oscillating pump for carpet cleaners employs two different grades of RYNITE®: FR530 and HP415. The Class F homologation of these grades permit the use of this pump for export to the USA. The possibility to laser print RYNITE® avoids the utilisation of more polluting solvent-based marking systems.

4. The recent range of irons launched by Braun is using a custom coloured, heat stabilised RYNITE® PET for the iron skirt. RYNITE® gives higher productivity at lower total cost compared to the thermoset which was used previously.

5. An earlier die-cast metal motor with fan (left), and the re-designed unit in RYNITE® (right). The switch from metal to plastics meant simpler manufacturing, weight reduction, fewer components and lower assembly costs, reduced stock inventory and improved performance for a range of vacuum cleaners from Electrolux.

6. Rear windshield wiper arms for cars like the Fiat "Punto" are made out of a RYNITE® grade which is specifically developed for severe weathering conditions. Mechanical properties like creep resistance, as well as superior surface appearance, are of major importance in this application.


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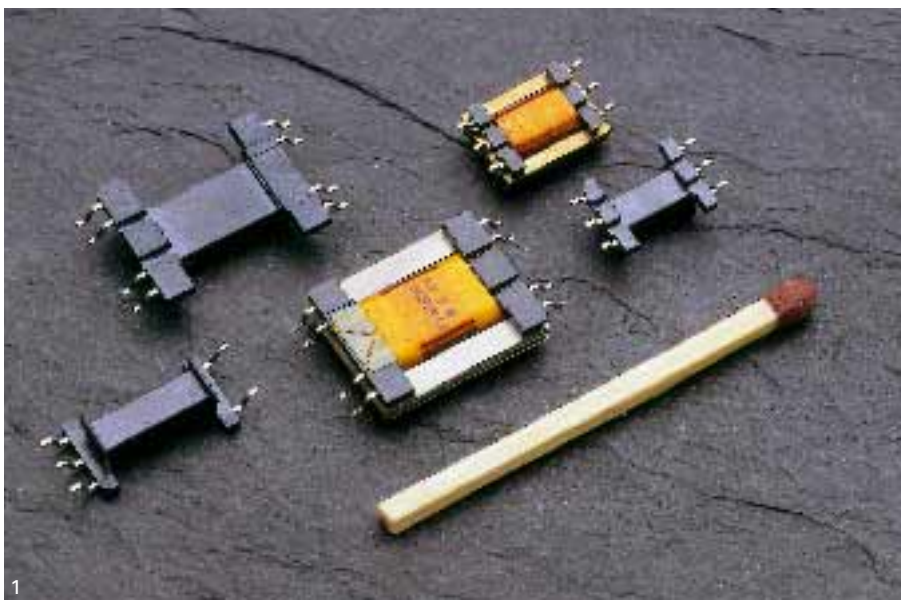
ZENITE® LCP… high heat resistance, and dimensional stability for precision moulding

ZENITE® LCP liquid crystal polymer resins are easily melt processible and have a number of highly desirable properties that make them especially suitable for precision electrical and electronic parts in lighting, telecommunications, aerospace, automotive, fibre optics and other advanced uses. Typical applications include connectors, bobbins, relays, motor components, sockets, imaging and sensor devices, ignition systems, etc.

The ZENITE® LCP family features excellent dimensional stability and creep resistance, especially at very high temperatures. When in a molten state its molecules tend to align with the flow, providing even greater strength in the flow direction; this also contributes to its superior wide-temperature range.

The physical advantage of low thermal expansion and low mould shrinkage-properties is further enhanced in thin-wall sections due to even more pronounced molecular alignment. In addition these resins are highly resistant to many chemicals, including concentrated acids, bases and hydrocarbons. They also display outstanding fatigue resistance and high dielectric strength performance over a very wide temperature range.



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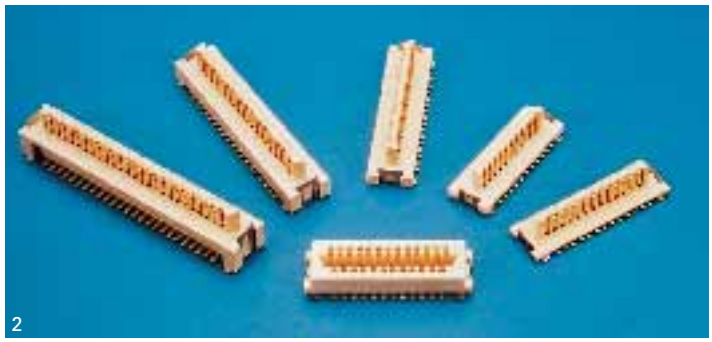
1. Because of its toughness and mechanical strength over a broad temperature range, ZENITE® 6130 liquid crystal polymers as found in compact coil forms, offer United Technical Products Inc. board assembly advantages and result in excellent pin retention. Its suitability for precision moulding in thin sections allows board space saving at equal winding space. The material is UL94 V0 recognized.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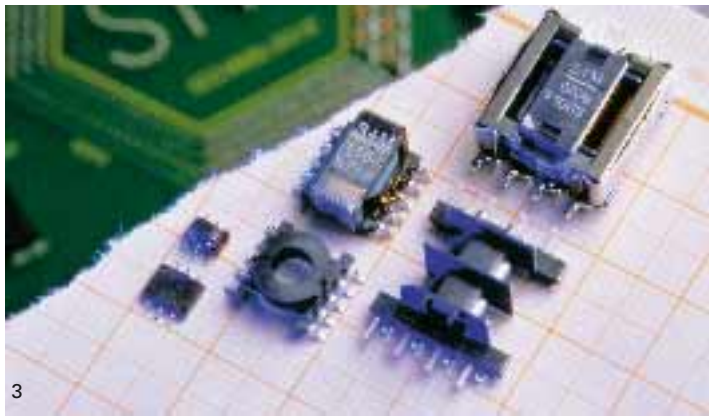
2. Injection moulded microminiature surface-mount Conan™ connectors, used in portable phones and computers, are a classic case for ZENITE®. High thermal stability, precision surfaces and strength in thin walls are crucial factors in the field of micro-electronics.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3. The qualities of ZENITE® permit these bobbin assemblies to obtain increased winding space, excellent pin positioning and to withstand SMT soldering processes.

4. In the miniature world of Littelfuse Inc., ZENITE® LCP is welcomed for use in holders for ceramic fuses and for the encapsulation of glass fuses. It allows assembly by infrared and other soldering processes. The strength of the material is put to the test every time a fuse has to be replaced; a test successfully passed with ZENITE®.


4

5. ZENITE® can also be perfectly and easily metallised. For this reason, this lamp socket, made by VLM, is moulded in ZENITE®, with a very high temperature resistance as a result. Extra high thermal resistance LCP replaces other high temperature polymers, which sometimes melt under these extreme conditions.


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6. The market trend is to design smaller antifog lamps with more powerful bulbs, hence the temperature reached inside the housing has dramatically increased. ZENITE® 6330 BK was selected for its excellent heat resistance, no out-gassing, and good surface appearance.


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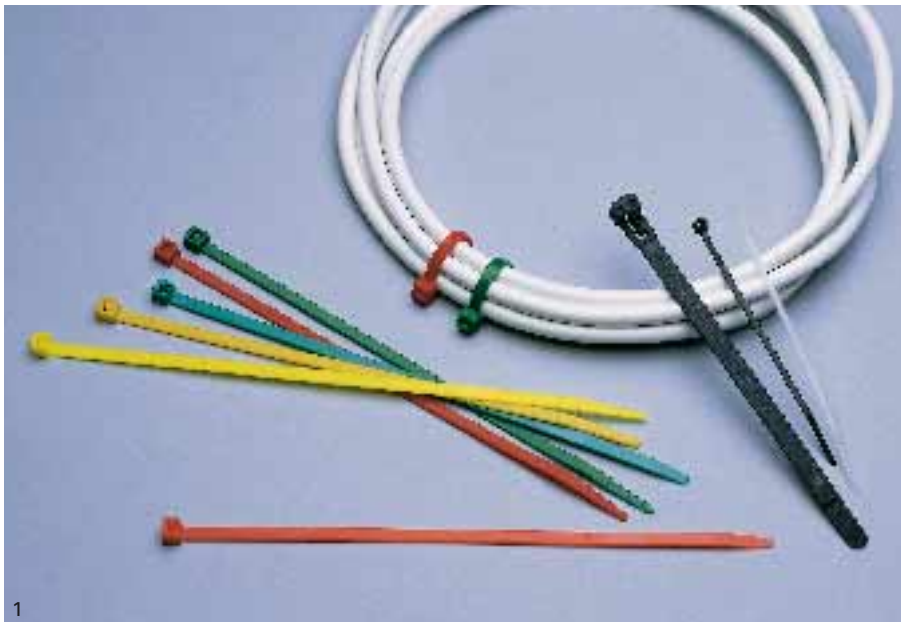
There's always something new in today's ZYTEL®

Since DuPont introduced the first nylon materials nearly 70 years ago, ZYTEL® has become the world's largest selling nylon resin. Today we offer a wide range of unreinforced nylons, providing the right choice for every market need; designers can choose just the right balance of properties to do the job in the most cost-effective way.

ZYTEL® resists hostile environments. It can withstand high temperatures and can be modified to meet tough impact conditions. Its electrical insulation characteristics, UL flammability rating, and ability to be coloured are among the other important benefits it offers.

ZYTEL® resins are designed for high productivity. They provide excellent flow properties, reduced moulding cycles, and fast mould release. This can mean appreciable gains in productivity, resulting in more saleable parts per hour.



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1. These cable straps moulded in unreinforced ZYTEL® have good flex strength and creep resistance, and a UL94 V2 rating. ZYTEL® allows easy filling of complex mould cavities, resulting in fast moulding cycles.

2. The Rover 25 Diesel fuel swirl pot is manufactured from an unreinforced heat stabilised ZYTEL® variant. The product was chosen due to the ability of the grade to resist contact with Diesel fuel and elevated temperatures.

3. The body and actuators of these switches are moulded in an unreinforced ZYTEL® resin. The grade withstands the soldering temperatures, meets the relevant flammability requirements and also enables snap fit features to be incorporated. The moulding characteristics lead to fast cycling and general ease of processing.

4. These aerosol valves moulded in ZYTEL® 135F allow fast cycling and economical manufacturing. They show excellent chemical resistance and dimensional stability with a very tight tolerance band. This make possible the continuous production of high precision components.

5. Changing from die-cast zinc to impact-modified ZYTEL® 408 enabled Global to improve their design, and produce the only nylon castors with the required combination of impact and creep resistance to meet British Standards for furniture.

6. ZYTEL® 101F is used in this refrigerator lamp housing for its good elongation, UL94 V2 rating and excellent surface glossiness. It is also unaffected by cleaning materials.

7. Cupboard hinges moulded in ZYTEL® 135F allow fast cycling and economical manufacturing. They show excellent stiffness and toughness, as well as resistance to creep and fatigue.


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It starts tough… it stays tough… it's for your toughest jobs… ZYTEL® ST

Unlike most other engineering thermoplastics, super-tough ZYTEL® ST is insensitive to notching, meaning that it can take a lot of punishment and stay in one piece. Scratches don't concentrate stress and become weak points, parts keep their toughness, and they don't become brittle at low temperatures. In fact, at –20° C, ZYTEL® ST is tougher than most thermoplastics at room temperature.

ZYTEL® ST is a nylon, so it has outstanding resistance to chemicals, solvents, oils and greases.

Designers working with ZYTEL® ST can specify intricate shapes, varying thicknesses and tricky corners – and know that moulders can produce these parts easily and quickly.

And for an even broader range of application possibilities, talk to us about some of the new ZYTEL® ST resins. They include Super Tough glass-reinforced compositions for extra strength, consistent performance and low cost… special, soft resins for longer endurance and repeated flexing in complicated shapes… and extra low temperature resins for winter sport and automotive applications.

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1. What takes more abuse than a skateboard? A *snake*board, a new double-jointed skateboard development that enables riders to perform even more spectacular jumps and spine-jarring manoeuvres. Plastic was an obvious choice because of its from-the-mould finish and colourability. But finding one that's light, resilient and very, very tough was less easy, and for Clausen Plastics (Pty) Ltd, the choice narrowed down to just one that met all their requirements – ZYTEL® ST801 Super Tough nylon.

2. ZYTEL® ST overcame production problems posed by this Jaguar cooling fan's aerodynamic and structural requirements. Using ZYTEL® ST cut one third of the original steel fan's weight, and eliminated costly spot welding.

3. High stiffness and impact resistance were the key criteria that led Hilti AG of Liechtenstein to choose DuPont ZYTEL® resin for their unique stand-off curtain-wall fasteners. This DuPont nylon is suitable for use between –40° C and 80° C, resists weathering, has low humidity absorbtion plus excellent creep and stress-crack resistance.

4. Italian sport manufacturer MGM chose ZYTEL® for the plate system of its new In-line roller/Ice skating shoe. The excellent impact and abrasion resistance of DuPont ST nylon easily withstands all the knocks and scrapes to which ice-skates and in-line rollers are subjected.

5. ZYTEL® ST replaced expensive fabricated metal for a range of Gas Cylinder Valve Guards produced by Norton Plastics in the UK.

The guard protects the gas cylinder valve from damage, which can occur particularly when the cylinders are accidentally dropped during transportation. The low temperature impact resistance of ZYTEL® ST is a key reason for using the product in this application, combined with the materials ability to be easily injection moulded and coloured.


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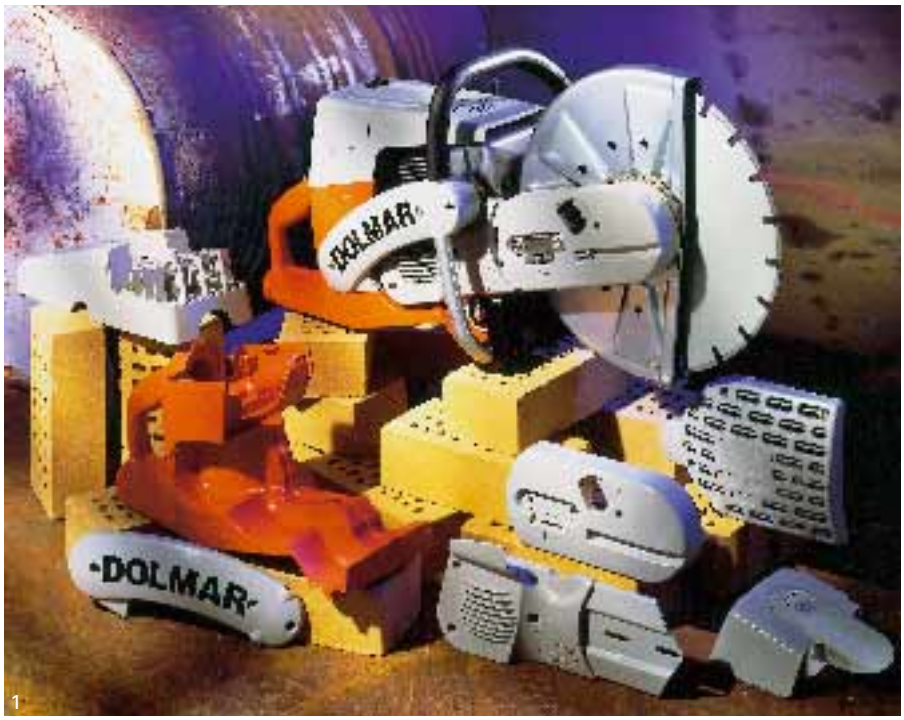
6. Carbon canisters are devices incorporated into modern vehicles, which help to minimise fuel emission levels. They are often located low down in the engine compartment, being exposed to flying road surface debris, high temperatures, oil and fuel vapour. Tennex (UK) have chosen to produce a canister housing and lid in ZYTEL® ST which readily resists this highly demanding environment and provides an excellent barrier to fuel vapour.

Don’t settle for ordinary glass-reinforced nylon… move up to the extra performance of glass-reinforced ZYTEL®

For designers who need high strength, stiffness, and the highest deflection temperatures, ordinary glass-reinforced thermoplastics are not enough; for the really tough jobs, they need glass-reinforced ZYTEL® – the world’s top selling glass-reinforced nylon.

During formulation, we upgrade the base resin’s rigidity, tensile strength, creep resistance, heat distortion temperature, low temperature impact strength, and dimensional stability by combining it with selected glass fibres. The result is a range of products that finds increasing use – especially in car engine compartments, where it is replacing metals and other plastics.

Fan wheels for freezer rooms, dishwasher pump housings and typewriter daisy wheels are other applications proving the ability of glass-reinforced ZYTEL® to measure up to any challenge. The possibilities of this material are virtually endless. That’s why it is finding such a broad range of uses – not only in the automotive industry – but also throughout the electrical, appliance and furniture industries.



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1. Dolmar reduced the weight of its former grinder-cutter by about 25% by using ZYTEL® for the housing and the double-bottomed fuel tank. In this application, DuPont nylon's excellent mechanical strength, balance of stiffness and toughness, high heat distortion temperature, good abrasion resistance and chemical resistance play important roles.

2. Reducing complexity and improving cost-effectiveness are always high on the agenda at Audi. Together with DuPont and the system supplier Mann+Hummel an air intake manifold, using ZYTEL® 70G35, ensured rigidity and mechanical strength that the manifold needs under extreme vibration loads at high temperatures.

3. The ability to resist fatigue in the presence of pressurised antifreeze at 120° C makes glassreinforced ZYTEL® the ideal material for radiator end tanks.

4. Glass-reinforced, flame-retardant ZYTEL® has helped Braun design a multifunctional coffee grinder motor bracket with far fewer components than the aluminium bracket it replaced. ZYTEL® complies with the arc tracking and flammability requirements of European and American specifications, and provides all the stiffness and heat resistance demanded by this application.

5. Glass-reinforced ZYTEL® was chosen for this circuit breaker made by Medex, Spain. Its flame retardant properties (GW960 at 3 mm), good surface appearance, low warpage and high tensile modulus are the main reasons for selecting this flame retardant nylon.

6. ZYTEL® is often used for automotive rocker covers because it provides the high stiffness, heat stability, oil and chemical resistance required, while weighing less than the metal it replaces.

7. A special glass reinforced, heat-stabilized, hydrolysis resistant grade of DuPont ZYTEL® helped Grundfos to develop new domestic circulator pumps that are lighter than cast iron pumps. ZYTEL® also resists cleaning fluids and other aggressive substances found in domestic heating systems.


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ZYTEL® HTN… the reliable high performance polyamide resin for critical applications

ZYTEL® HTN (high performance polyamide resin) features excellent physical and electrical properties at the shorter-term elevated temperatures encountered with SMT Surface Mount Technology components, connectors, fuse holders and coil forms, etc. For the automotive industry, ZYTEL® HTN's resistance to lubricants, fuels, salt, anti-freeze, transmission fluids, etc. makes it ideal for a broad range of under-bonnet applications. The ZYTEL® HTN range retains its excellent physical and mechanical properties even in conditions of high humidity and heat.

ZYTEL® HTN displays outstanding high-temperature stability, strength, toughness and low moisture absorption, making it the ideal material where performance reliability in tough conditions is paramount.

For long-term heat ageing applications, ZYTEL® HTN glass-reinforced outperforms PA66 products. It offers a unique combination of high-temperature performance with improved dimensional stability, low creep, lower moisture absorption and higher chemical resistance than conventional nylons.

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1. Schupa-Elektro uses ZYTEL® HTN in its UP-PI protection switch because this material resists deformation at temperatures of up to 260° C, has a maximum operating temperature of 300° C for short periods and also meets UL94 V0 flammability specifications.

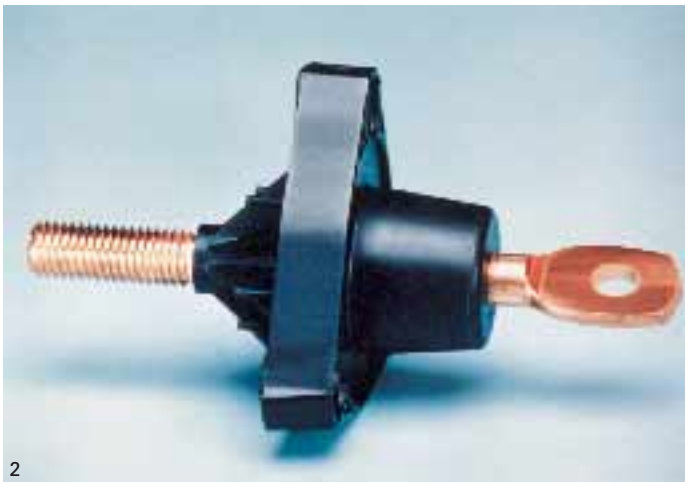
2. Cooper Power Systems looked at the performance of ZYTEL® HTN in a hot and humid environment for their secondary bushings for pad-mounted distribution transformers. In test, it proved to have a higher heat deflection temperature, better high-temperature electrical strength and higher tensile strength than the polymers commonly used in such electrical applications.

3. To prevent these "spiders", or multifunctional armature insulators in windshield wiper motors, from burning or melting in case of an overload (e.g. frozen wipers), ITT Automotive chose ZYTEL® HTN to do the job. Injection moulded, ZYTEL® HTN insulators are of a uniformly high quality that resists extremely high temperatures. In the production process, the material allows a very high throughput and very low scrap rates.

4. ZYTEL® HTN was selected by WOCO for the Mercedes Class A resonator because of its high peak temperature resistance and good heat ageing.

5. AMP chose ZYTEL® HTN because it is suitable for IR reflow soldering and had good flow properties during the moulding process.

6. The use of ZYTEL® HTN has enabled a fan to be designed with excellent air circulation and extremely low noise by taking advantage of ZYTEL® HTN low warpage, dimensional stability and property retention at high temperatures.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Properties of non-flame retardant CRASTIN® PBT thermoplastic polyester resins

	Property	Test conditions	Test method	Units	Unreinforced	
					General purpose S600F20	Super tough ST820
MECHANICAL	Yield stress	23°C	ISO 527-1/-2	MPa	58	38
	Yield strain	23°C	ISO 527-1/-2	%	3,8	7,1
	Stress at break (tensile)	23°C	ISO 527-1/-2	MPa	*	*
	Strain at break (tensile)	23°C, 50 mm/min	ISO 527-1/-2	%		>50
		23°C, 5 mm/min			*	*
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	2500	1700
	Flexural strength	23°C	ISO 178	MPa		67
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	5,5	87
		–30°C				12,5
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m²	NB	NB
		–30°C				NB
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²		58
		–30°C				10
	Izod impact strength (unnotched)	23°C	ISO 180/1U	kJ/m²		NB
		–30°C				215
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	225	225
	Temperature of deflection under load	0,45 MPa	ISO 75 -1/-2	°C	150	105
		1,8 MPa			50	48
		5 MPa, 4 × 100 × 100 mm plate				*
	Coefficient of linear thermal expansion Parallel (in flow direction)	23°C to 55°C	ISO 11359-2	10^{-4}/°C	1,3	1,9
	Normal (perpendicular to flow)	23°C to 55°C			1,3	1,9
TEMPERAT. INDEX	Relative temperature index					
	• Electrical	3 mm	UL 746B	°C	130	
	• Mechanical with impact	3 mm			115	
	• Mechanical without impact	3 mm			120	
	Tensile strength	5000 h	IEC 60216	°C		
	(for stress and break)	20000 h				
ELECTRICAL	Dissipation factor [1]	23°C, 1 mm, 10^2 Hz	IEC 60250	10^{-4}	20	
		23°C, 1 mm, 10^6 Hz		10^{-4}	200	
	Surface resistivity	23°C, 1 mm	IEC 60093	ohm	$>10^{14}$	10^{15}
	Volume resistivity	23°C, 1 mm	IEC 60093	ohm · m	$>10^{13}$	$>10^{13}$
	Electric strength (Dielectric strength)	23°C, 1 mm	IEC 60243-1	kV/mm	26	
		23°C, plate 2 mm, 20 s				
	Comparative tracking index (CTI)	23°C, 1 mm	IEC 60112	V	600	600
		23°C, 3 mm			250	
	CTI M	Plate 4 mm				>600 M
FLAMMABILITY	Flammability classification	0,75 mm	UL 94/IEC 60695		HB	
		1,5 mm			HB	HB
	Burning rate	1,6 mm	ASTM D 635	cm/min		4,6
	Glow wire flammability index	3 mm	IEC 60695-2-12	°C		700
	Oxygen index		ISO 4589-1/-2	%	22	19
OTHERS	Density		ISO 1183	kg/m³	1310	1220
	Water absorption	23°C, saturation, immersed	Similar to ISO 62	%	0,50	0,31
		23°C, equilibrium, 50% R.H.			0,20	0,12

* Properties are not applicable for this material.

1) Specimen of 80 × 80 × 1 mm, measured with silver paint.

Properties of flame retardant CRASTIN® PBT thermoplastic polyester resins

Reinforced				Filled	Unreinforced		Reinforced		
General purpose SK605	Low warp LW9330	Tough T805	PBT/PET SK9230	Glass beads SO655	General purpose S660FR	Super tough ST830FR	General purpose SK655FR1	Low warp LW9330FR	Tough T845FR
*	*	*	*	*	54		*	*	*
*	*	*	*	*	3,2		*	*	*
140	135	113	145	50	*	*	135	120	105
*	*	*	*	*			*	*	*
2,8	2,3	4,2	2,5	3,6	*	*	3	2	3,6
9700	9800	7400	11000	4000	2800		10500	11000	8200
210		160	220	95			210		170
12,4	9	14	11	3,5	3,7		10	9	11,5
11,1		12,5		3,5	4,3		10		10
68	55	77	45	34	67		60	45	60
82		89		50	67		57		65
11	7	12	10	4	4		10		11
9		10		3	4		10		9
56	65	50		26	57		50		44
55		50		25					44
225	220	213	225-250	225	225		225	220	210
220		205		212	165		222		205
205	185	186	205	99	55		213	185	185
179		152							165
0,3		0,3		1					0,3
0,9		1,2		1					1,2
130	130	140		120	140	130	130	140	140
130	130	130		120	120	130	130	130	140
130	130	140		120	140	130	140	140	140
165		155		150					160
145		140		135					145
25		95		136					130
180		218		190			146		170
$>10^{15}$		10^{15}		10^{15}			10^{14}		10^{15}
$>10^{13}$		$>10^{13}$		$>10^{13}$			$>10^{13}$		$>10^{13}$
31		29		25					27
17		17		17					16
450		500		250				375	275
400		450	440	250		600	250		300
200 M		200 M		200 M					175 M
HB	HB	HB	HB	HB	V0			V0	
HB	HB	HB	HB	HB	V0	V0	V0	V0	V0
3		3,5		2,7					*
750		750		750	960		960	960	960
19		19		22	30		32		30
1530	1420	1510	1550	1530	1470		1680	1550	1670
0,37		0,35	0,55	0,35					0,27
0,13		0,14	0,2	0,12					0,10

* = property not applicable for this material.

NB = no break.

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

Properties of DELRIN® acetal resins

	Property	Test conditions	Test method	Units	High viscosity 100/ 107	High viscosity 100P/ 127UV	High viscosity 111P	Medium viscosity 500/ 507
MECHANICAL	Yield stress [1]	23°C, 5 mm/min	ISO 527-1/-2	MPa	73/72	70	72	72
		70°C, 5 mm/min			50	50		50
		100°C, 5 mm/min			36	36		36
		120°C, 5 mm/min			22	22		23
	Yield strain [1]	23°C, 5 mm/min	ISO 527-1/-2	%	21/25	22/23	19	15
		70°C, 5 mm/min			18	18		14
		100°C, 5 mm/min			14	14		11
		120°C, 5 mm/min			9	9		8
	Strain at break [1]	23°C, 5 mm/min	ISO 527-1/-2	%	*	*	*	*
		23°C, 50 mm/min						45
	Nominal strain at break	23°C	ISO 527-1/-2	%	45/50	45	40	30
	Tensile modulus [2]	23°C, 1 mm/min	ISO 527-1/-2	MPa	3100	3000	3200	3200
		70°C, 1 mm/min			1500	1300		1500
		100°C, 1 mm/min			900	900		1000
		120°C, 1 mm/min			600	700		600
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	14	15	12	9
		–30°C			11	11	8	8
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m²	NB	NB/400	210	340
		–30°C			NB/350	350	200	300
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²	14/12	14/13	11	9/8
		–40°C			12/8	12/11	11	9/6
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	178	178	178	178
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C	165	160/165	165	165
		1,8 MPa			100	95	100	100
		Annealed, 1,8 MPa			115	110	115	115
	Vicat softening temperature	10 N	ISO 306	°C	174	174	174	174
		50 N			160	160	160	160
	Coefficient of linear thermal expansion		ISO 11359-2	10^{-4}/°C				
	Parallel (in flow direction)	23°C to 55°C			1,1/1,2	1,1	1/1,2	
	Normal (perpendicular to flow)	23°C to 55°C			1,1/1,2	1,11/1,2	1,1	1/1,2
RHEOLOGY	Melt mass-flow rate	190°C/2,16 kg	ISO 1133	g/10 min	2,3/2,2	2,4	2,3	14
FLAMMAB.	Flammability classification	1,5 mm	UL94/IEC 60695		HB	HB	HB	HB
OTHERS	Density		ISO 1183	kg/m³	1420	1420	1420	1420
	Water absorption	– 24 hours immersion	Similar to ISO 62	%	0,27/0,25	0,4	0,3	0,31/0,25
		– 50% R.H., equilibrium			0,2/0,22	0,28	0,22	0,22
		– Saturation, immersed			0,9	1,4/1,2	1	0,9
	Hardness, Rockwell	Scale M	ISO 2039/2		92	92	92	92
		Scale R			120	120	120	120
PROCESSING	Mould shrinkage							
	Parallel (in flow direction)	2 mm	ISO 294-4	%	2,1	2,1	2	2,1/1,9
	Normal (perpendicular to flow)	2 mm			1,9	1,9	1,9	2/1,8
	Chemical resistance		All resins have outstanding resistance to neutral chemicals, including a wide variety of solvents					

1) Testing speed 5 mm/min. 2) Testing speed 1 mm/min.

Medium viscosity	Medium viscosity	Low viscosity	Low viscosity	Low friction and wear	Toughened	Toughened	Toughened
500P/ 527UV	511P	900P/ 927UV	911P	500CL	100ST	100T	500T
71/70	73	71	74	70	43	52	58
50		50		50			
36		35		36			
23		22		22			
14/15	12	12/14	9	14	30	26	16
14		12		13			
11		10		11			
9		8		11			
*	*	*	*	*	*	*	*
40		27		>100	>100	75	55
30	25	25/18	20	23	>50	>50	30
3200	3400	3200/3300	3400	3100	1400	1900	2500
1400		1400		1500			
1000		900		1000			
600		600		600			
9	8	7/8	8	8	100	25	15
8	7	6	6	7	20	14	12
300/270	260	200	180	350	NB	NB	NB
300/260	260	200	180	290	NB	NB	NB
9/8	8	7/6	8	9	90	20	14
9/8	8	7	7	9	20	13	8
178	178	178	178	178	178	178	178
160/165	165	165/159	165	160	100	160	155
95	105	95	110	90	60	80	80
110	115	110	115	105	70	85	90
174	174	174	174	174	168	170	171
157/160	160	160	160	159	116	140	139
1,13/1,21	1,2	1,23	1,17	1,12	1,26	1,2	1,26
1,09/1,2	1,17	1,23	1,17	1,14	1,36		1,18
15	14	25	25	14	2	2	12
HB	HB	HB	HB	HB	HB	HB	HB
1420	1420	1420	1420	1420	1340	1370	1390
0,4	0,3	0,43	0,28	0,27	0,44		0,41
0,3	0,2	0,3	0,2	0,24	0,35	0,3	0,2
1,4/1,2	0,9	1,4	1	1	0,9	0,9	0,8
92	92	92	92	92	58	59,3	79
120	120	120	120	120	105	112,6	117
2,1/1,9	1,9	2,1	1,9	1,9	1,3	2,1	1,8
2/1,8	1,8	2	1,8	1,9	1,4	1,9	1,7
				All resins have outstanding resistance to neutral chemicals, including a wide variety of solvents			

* = property not applicable for this material.

Properties of HYTREL® thermoplastic polyester elastomer resins

	Property[1]	Test conditions	Test method	Units	General purpose grades					
					G3548L	G4074	G4078W	G4774	G5544	6358
MECHANICAL	Stress at break (tensile)	23°C, 50 mm/min	ISO 527-1/-2	MPa	9,7	17	17	17	23	46
	Strain at break (tensile)	23°C, 50 mm/min	ISO 527-1/-2	%	240	250	250	200	300	490
	Stress at 5% strain	23°C, 50 mm/min	ISO 527-1/-2	MPa	1,7	2,5	2,5	3,8	6	12
	Stress at 10% strain	23°C, 50 mm/min	ISO 527-1/-2	MPa	2,5	4,4	4,4	6,8	11	15
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	23	55	55	105	185	280
	Flexural modulus	–40°C	ISO 178	MPa	50	200	170	260	810	1850
		23°C			32	65	65	117	183	296
		100°C			7	30	16	60	100	
	Izod impact strength (notched)[2]	–40°C	ISO 180/1A	kJ/m^2	NB	NB	NB	NB	27	19
		23°C			NB	NB	NB	NB	64	81
	Charpy impact strength (notched)[2]	23°C	ISO 179/1eA	kJ/m^2	NB	NB	NB	NB	90	120
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	154	170	170	208	215	213
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C		50	50	60	77	85
		1,8 MPa						45	45	45
	Vicat softening temperature	10 N, 50°C/h	ISO 306	°C	75	115	115	168	190	195
RHEOLOGY	Melt mass-flow rate	190°C, 2,16 kg	ISO 1133	g/10 min	10	5,3	5,3			
		220°C, 2,16 kg								
		230°C, 2,16 kg						11	10	9
		240°C, 2,16 kg								
OTHERS	Density		ISO 1183	kg/m^3	1150	1180	1180	1180	1220	1220
	Water absorption	23°C, equilibrium 50% R.H.	ISO 62	%		0,4	0,4		0,4	0.2
		23°C, immersion 24 h				2,1	2,1	2,5	1,6	0,5
		23°C, saturation, immersed			5	3,7	3,7	4,1	2,2	0,6
	Shore hardness, Durometer D	23°C, maximum	ISO 868	points	35	40	40	47	55	63
		15 s			26	35	35	43	50	58
	Resistance to flex cut growth, Ross (pierced)	23°C	ASTM D 1052	Cycles to 5× cut growth	>10^6	>10^6	>10^6	>10^6	0,8 × 10^6	
	Taber abrasion resistance		ASTM D 1044	mg						
	23°C, CS-17 wheel, 1 kg, 1000 cycles		modified		30	9	20	13	9	
	23°C, H-18 wheel, 1 kg, 1000 cycles				310	193	260	168	116	
	Initial tear resistance, die C		ISO 34-1	kN/m						
	Normal (perpendicular to flow)	23°C				96			140	145
	Parallel (in flow direction)	23°C			58	86	88	94	123	158

1) All properties were measured on injection-moulded specimens at 23°C, unless specified otherwise.
2) Specimens 6,35 mm thick.

		High-performance grades								Specialty grades			
7248	**8238**	**3046**	**4056**	**4068**	**4556**	**5526**	**5556**	**6356**	**7246**	**HTR 5555HS**	**HTR 4275 BK**	**HTR 5612**	**HTR 8068**
46	50	20	30	22	34	44	42	46	53	42	30	36	14
350	400	900	424	620	550	500	500	490	450	520	300	450	400
14	28		2,4	2,4	4,1	6,9	6,9	12	14	6,9	7,5	5,5	3,9
20	33		4,2	3,5	5,7	11	11	15	23	10,3	10,8	8,9	5,2
525	1180	24	53	30		188	180	280	525	184	150	74	140
2390	2600		155	172	210	760	760	1800	2350	760	750	470	650
544	1116		62	45	87	200	180	296	550	195	170	115	145
	260		27	28	44	100	100	150	200	110	60	45	50
	5,5	NB	NB		NB	115	NB	19	7	110	130	114	
	11,2	NB	NB		NB		NB	81	40	60	NB	NB	
	15	NB	NB	NB	NB	NB	NB	125	120	84	NB	NB	
219	221	172	150	193	193	203	203	211	218	203	196	198	170
95	105		50	55	50	65	70	85	95	60	50	60	48
45	45				35	45	45	45	45	40	45	40	45
205	210		110	135	155	180	180	195	205	177	170	155	109
		11	5,6										
				8,5	8,5	18	8,1			8,5			
								9			0,5	2,6	4,7
13	12,5								12,5				
1250	1280	1070	1150	1100	1140	1190	1190	1220	1260	1190	1160	1170	1420
	0,2		0,2	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	
0,3	0,3		0,6	0,7	0,6	0,6	0,6	0,5	0,3	0,7	0,5		1,9
0,6	0,6		0,7	0,7	0,6	0,6	0,6	0,6	0,6	0,6	0,5	0,6	
72	82	30	40	40	45	55	55	63	72	55	55	50	44
68	74	25	39	33	40	51	52	58	68	52	52	48	
	*		$>10^6$	$>10^6$	$>10^6$	$0,5 \times 10^6$	$0,5 \times 10^6$	$0,5 \times 10^6$	$0,03 \times 10^6$	$0,1 \times 10^6$	$0,05 \times 10^6$	$0,6 \times 10^6$	
	9		3	15	3	7	6	7	13		20	38	25
	20		100	80	72	70	64	77	47	112	227	186	
	212		98		123	133	137	145	167	124	98	106	64
	228		101	95	122	133	137	158	200	134	171	129	68

* = property not applicable for this material.

NB = no break.

Properties of MINLON® mineral reinforced nylon resins

					Mineral reinforced grades					
					PA66		PA66/6 blend		PA66	
			Test		MINLON® 10B140		MINLON® 11C140		MINLON® 13T2	
	Property	Test conditions	method	Units	DAM	50% RH	DAM	50% RH	DAM	50% RH
MECHANICAL	Stress at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	MPa	82	54	89	60	72	55
	Strain at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	%	3,5	9	10	24	16	34
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	6600	3900	5800	2500	4300	2200
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m^2	3,5	4,5	6,5	9	9,5	11
		–30°C			3,5	2	5	4	6	5
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m^2	35	60	130	NB	NB	NB
		–30°C			25	25	80	80	115	115
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m^2	3,5	4	6	9	9	11
		–30°C			2,5	2,5	4	4	5,5	4
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	263		256		263	
	Temperature of deflection under load [1]	0,45 MPa	ISO 75-1/-2	°C	240		220		225	
		1,8 MPa			200		140		89	
	Vicat softening temperature	50 N	ISO 306	°C	245		235		230	
	Coefficient of linear thermal expansion Parallel [2]	23°C to 55°C	ISO 11359-2	10^{-4}/°C	0,67		0,86		0,94	
	Normal [3]	23°C to 55°C			0,88		0,86		0,85	
ELECTRICAL	Comparative tracking index (CTI)	23°C, 1 mm	IEC 60112	V	575		550			
	Electric strength (dielectric strength)	23°C, 1 mm	IEC 60243-1	kV/mm	40		36	27	37	
	Surface resistivity	23°C, 1 mm	IEC 60093	ohm		>10^{15}		10^{14}		
	Volume resistivity	23°C, 1 mm	IEC 60093	ohm · m		10^{10}		10^{9}		
	Relative permittivity	10^2 Hz, 1 mm	IEC 60250		4,5	9,4	4,3	12,6	4,2	9,3
		10^6 Hz, 1 mm			3,9	4,5	3,6	4,5	4,1	4,1
	Dissipation factor	10^2 Hz, 1 mm	IEC 60250	10^{-4}	110	2100	120	4400	110	3600
		10^6 Hz, 1 mm			230	550	240	750	200	550
FLAMMAB.	Flammability classification [4]	1,5 mm	UL 94/ IEC 60695		HB		HB		HB	
OTHERS	Density		ISO 1183	kg/m^3	1500		1460		1360	
	Water absorption	23°C, equilibrium 50% RH	Similar	%	1,6		1,8		1,5	
		23°C, saturation, immersed	to ISO 62		5		5,7		6	
	Rockwell hardness		ISO 2039-2							
		Scale M			95		86		80	
		Scale R			121		120		118	
	Ball indentation hardness		ISO 2039-1	MPa	250	169	255	127	200	115
PROCESSING	Mould shrinkage Parallel (in flow direction)	2 mm	ISO 294-4	%	1,2		1,4		1,4	
	Normal (perpendicular to flow)	2 mm			1,2		1,4		1,6	

1) Values are obtained by first annealing test bars for 30 min. in oil at 50°C below melting point of the resin.
2) In flow direction.
3) Perpendicular to flow.
4) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from MINLON® enginnering thermoplastic resins. UL yellow cards available upon request.

Mineral reinforced grades				Mineral glass reinforced grades					
PA66		PA6		PA66		PA6		PA66	
Minlon® 13MM		Minlon® 73M30		Minlon® EFE6053		Minlon® 73GM30HSL		Minlon® EFE6091 BK	
DAM	50% RH	DAM	50% RH	DAM	50% RH	DAM	50% RH	DAM	50% RH
74	51	82	56	157	95	110	60	132	79
19	55	14	46	2,3	4,6	3	4	2,4	4
3800	1800	4900	1800	10400	7200	7000	4000	8200	5600
7,5	13	6,5	13	4,5	6,5	6	8	4,5	6
5,5	4,5	3,5	3,5	4	4	6	6		
NB	NB	125	NB	45	50	45	55	40	45
110	110	85	85	40	40	45	40		
7	12	6	12			4,5	6,5	3,5	3,5
5	4,5	4				4,5	4		
263		223		263		223		263	
220		196		256		214		243	
80		111		245		190, 195			
244		210		250		210			
0,85		0,88		0,28		0,47			
0,85		1,02		0,87		0,79			
				28					
				4,9	13,9				
				4,8	5				
				140	5400				
				130	700				
HB		HB		HB		HB			
1240		1350		1470		1350		1470	
2,1		2,1		1,5		1,8		1,6	
7,7		6,3		5		6,3		5	
				254	149				
1,8		0,9		0,4				0,4	
1,4		0,9		1,1					

NB = no break.

Properties of RYNITE® PET thermoplastic polyester resins

					Glass reinforced		
					General purpose		
	Property	**Test conditions**	**Test method**	**Units**	**520**	**530**	**545**
MECHANICAL	Stress at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	MPa	120	158	182
	Strain at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	%	2,7	2,5	2
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	7200	11000	15500
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	9	11	11
		–30°C			8	11	11
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU		33	60	60
		–30°C			27	45	40
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²	9	10	11
		–30°C			7,7	10	
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	252	252	252
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C	245	245	250
		1,8 MPa			220	224	230
	Coefficient of linear thermal expansion		ISO 11359-2	10^{-4}/°C			
	Parallel (in flow direction)	–40 to 23°C			0,31	0,22	0,18
		23 to 55°C			0,25	0,10	0,13
		55 to 160°C			0,11	0,04	0,05
	Normal (perpendicular to flow)	–40 to 23°C			0,72	0,67	0,54
		23 to 55°C			0,93	0,81	0,71
		55 to 160°C			0,90	1,07	0,95
TEMPERATURE INDEX	Relative temperature index:						
	• Electrical	0,75 mm	UL 746B	°C	140	140	140
		1,5 mm			140		140
		3 mm			140	140	140
	• Mechanical with impact	0,75 mm			140	140	140
		1,5 mm			140		140
		3 mm			140	140	140
	• Mechanical without impact	0,75 mm			140	140	140
		1,5 mm			140		140
		3 mm			140	140	140
ELECTRICAL	Comparative tracking index (CTI)	23°C, 1 mm	IEC 60112	V	250	250	250
	Electric strength (Dielectric strength)	23°C, 1 mm	IEC 60243-1	kV/mm	33,5	35	32
	Surface resistivity	23°C	IEC 60093	Ohm		10^{14}	10^{14}
	Volume resistivity	23°C	IEC 60093	Ohm · m		10^{13}	10^{13}
FLAMMABILITY	Flammability classification [1), 2)]	0,75 mm	UL 94		HB	HB	HB
		1,5 mm			HB	HB	HB
		3 mm			HB		HB
	Glow wire flammability index	2 mm	IEC 60695-2-12	°C	650	800	750
		3 mm			750		850
	Oxygen index		ISO 4589-1/-2	%		20	20
OTHERS	Density		ISO 1183	kg/m³	1460	1560	1690
	Humidity absorption	23°C, equilibrium 50% RH	Similar to ISO 62	%	0,2	0,2	0,14
		23°C, saturation, immersed			1,1	0,7	0,62
PROCESSING	Mould shrinkage, plates 60 × 60 × 2 mm		ISO 294-4	%			
	Parallel (in flow direction)	2 mm			0,25	0,2	0,25
	Normal (perpendicular to flow)	2 mm			0,85	0,8	0,85

1) 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.

2) 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.

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

Glass reinforced

Tough		Colour stable		Flame retardant			Colour stable glow wire (flame retardant)		Mineral reinforced
415HP	**408**	**530CS**	**936CS**	**FR515**	**FR530L**	**FR543**	**GW520CS**	**GW525CS**	**935**
79	125	180	120	107	135	170	140	165	85
5	3,3	2,3	2	2,6	2	1,8	2,3	2	2
4700	9500	11000	11200	6800	11500	17000	9000	11000	10200
11 8 55 25	12 12 70 86	11 50	5 20	8 7 40 35	8,5 8,5 40 33	10 10 43 30	10 35	10 40	6 4 25 20
13 7,7	13	9,5	4	7,7 6	8 9,5		7,5	9	5,9 4
250	252	245	247	254	252	254	252	250	252
238 207	 220	245 225	 205	240 200	243 222	240 224	 220	 235	230 200
0,40 0,20 0,32 0,98 1,17 1,09	0,24 0,14 0,08 0,85 0,85 0,92			0,33 0,18 0,12 0,70 0,88 1,05	0,22 0,19 0,1 0,68 0,92 0,98	0,16 0,11 0,07 0,55 0,79 0,96			0,26 0,16 0,14 0,53 0,52 0,81
140 140 140 120 120 120 140 140 140	140 140 140 140 140 140 140 140 140	140 140 140 140 140 140 140 140 140		140 140 140 140 140 140 140 140 140	155 155 155 155 155 155 155 155 155	155 155 155 155 155 155 155 155 155	140 140 140 140 140 140 140 140 140	140 140 140 140 140 140 140 140 140	140 140 140 140 140 140 140 140 140
	250	250	250	225	250	250	200		300
				34	33				39
10^{13}				10^{13}	10^{14}	10^{15}			10^{14}
10^{11}				10^{13}	10^{13}	$>10^{13}$			10^{13}
HB HB HB	HB HB HB	HB HB HB		 V0 V0	V0 V0 V0	 V0 V0	HB HB HB	 HB HB	HB HB HB
 750					960 	960 960	 960		 825
19	22	22		32	33	35			21
1390	1490	1590	1630	1530	1675	1790	1580	1650	1580
0,25 2,5					0,17 0,77	0,11 0,62			0,13 0,83
0,35 0,85		0,15 0,6	0,2 0,4	0,35 0,85	0,25 0,9	0,2 0,75			0,3 0,7

Properties of ZENITE® LCP liquid crystal polymer resins

	Property [1]	Test conditions	Test method	Units	ZENITE® 3130L	ZENITE® 6130L	ZENITE® 6140L	ZENITE® 6330	ZENITE® 7130	ZENITE® 7145L
	Thickness		**ASTM**	**mm**	**3,2**	**3,2**	**3,2**	**3,2**	**3,2**	**3,2**
			ISO	**mm**	**4**	**4**	**4**	**4**	**4**	**4**
MECHANICAL	Stress at break (tensile)		ISO 527-1/-2	MPa						
		23°C, 5 mm/min, 4 mm			143	130	123	127	150	120
	Tensile strength at break	23°C, 3,2 mm	ASTM D638	MPa	110	130	135	125	150	119
		150°C, 3,2 mm			35	50		48	60	40
		200°C, 3,2 mm			19	35			56	
	Strain at break (tensile)		ISO 527-1/-2	%						
		23°C, 5 mm/min, 4 mm			1,8	1,8	1,1	4	1,5	0,9
	Elongation at break		ASTM D638	%						
		23°C, 3,2 mm			1,7	2,6	1,3	4	1,7	1,1
	Tensile modulus		ISO 527-1/-2	MPa						
		23°C, 1 mm/min, 4 mm			17200	13000	18700	8800	17000	18000
			ASTM D638	GPa						
		23°C, 3,2 mm			12,5	11,7		10,5	18	18,6
		150°C, 3,2 mm			4,5	5,5		4,8	9	9
		200°C, 3,2 mm			2,8	4,8			9	
	Shear strength	23°C, 3,2 mm	ASTM D732	MPa	46	51			58	
	Flexural strength		ASTM D790	MPa						
		23°C, 3,2 mm			130	170	183	125	174	158
		150°C, 3,2 mm			20	50		42	64	58
		200°C, 3,2 mm			11	33			48	43
	Flexural modulus		ASTM D790	GPa						
		23°C, 3,2 mm			10,0	12	15,6	9,6	13,1	13,8
		150°C, 3,2 mm			3,1	5,5		3,3	8	8,3
		200°C, 3,2 mm			2	4,8			6,5	8,6
	Charpy impact strength (notched)	–30°C, 4 mm	ISO 179/1eA	kJ/m²	25	30		8		12
		23°C, 4 mm			25	35	12	9	20	10
	Charpy impact strength (unnotched)	–30°C, 4 mm	ISO 179/1eU	kJ/m²	25	25		40		13
		23°C, 4 mm			35	35	20	60	33	18
	Izod impact strength [2] (notched)	–40°C, 3,2 mm	ASTM D256	J/m	46	110			185	
		23°C, 3,2 mm			72	125	80	160	225	60
	Izod impact strength (unnotched)	–40°C, 3,2 mm	ASTM D4812	J/m	327	440			555	
		23°C, 3,2 mm			415	655			740	316
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	330	335	335	335	353	355
	Temperature of deflection under load		ISO 75-1/-2	°C						
		0,45 MPa, 4 mm				275		275		
		1,8 MPa, 4 mm			225	265	280	245 [3]	295	295
	Coefficient of linear thermal expansion [4]		ASTM E228	10^{-4}/°C						
	Parallel (in flow direction)	23-150°C, 3,2 mm			0,06	0,13		0,08	0,14	
	Normal (perpend. to flow)	23-150°C, 3,2 mm			0,45	0,37		0,22	0,36	
TEMPERAT. INDEX	Relative temperature index [5]		UL 746B	°C						
	• Electrical	0,75 mm			130 [6]	240	240 [6]	130	240 [6]	240
	• Mechanical with impact	0,75 mm			130 [6]	220 [7]	130 [7]	130	210	210
	• Mechanical without impact	0,75 mm			130 [6]	240	240 [6]	130	240 [6]	240

Properties of ZENITE® LCP liquid crystal polymer resins (continued)

	Property [1]	Test condition	Test method	Units	ZENITE® 3130L	ZENITE® 6130L	ZENITE® 6140L	ZENITE® 6330	ZENITE® 7130	ZENITE® 7145L
	Thickness		**ASTM**	**mm**	**3,2**	**3,2**	**3,2**	**3,2**	**3,2**	**3,2**
			ISO	**mm**	**4**	**4**	**4**	**4**	**4**	**4**
ELECTRICAL	Dielectric constant		ASTM D 2520 B							
		23°C, 1E3 Hz, 3,2 mm			4	4,4		3,6	4,3	4,6
		150°C, 1E3 Hz, 3,2 mm			5,5	5			5	5,4
		200°C, 1E3 Hz, 3,2 mm			6,2	5			5	5,5
		23°C, 1E09 Hz, 3,2 mm			4,3	4,3		3,9	4,3	
		120°C, 1E09 Hz, 3,2 mm			4,3	4,4		4	4,4	
		150°C, 1E09 Hz, 3,2 mm			4,4	4,4		4	4,4	
		200°C, 1E09 Hz, 3,2 mm			4,6	4,5		4,1	4,7	
		250°C, 1E09 Hz, 3,2 mm				4,8		4,2	0,033	
	Dissipation factor		ASTM D 2520 B							
		23°C, 1E3 Hz, 3,2 mm			0,02	0,013		0,013	0,013	0,013
		150°C, 1E3 Hz, 3,2 mm			0,013	0,007			0,006	0,009
		200°C, 1E3 Hz, 3,2 mm			0,012	0,014			0,012	0,015
		23°C, 1E09 Hz, 3,2 mm			0,004	0,004		0,002	0,004	
		120°C, 1E09 Hz, 3,2 mm			0,015	0,016		0,014	0,016	
		150°C, 1E09 Hz, 3,2 mm			0,024	0,023		0,020	0,022	
		200°C, 1E09 Hz, 3,2 mm			0,045	0,032		0,029	0,030	
		250°C, 1E09 Hz, 3,2 mm				0,034		0,026	0,033	
	Surface resistivity	23°C	IEC 60093	ohm	$>10^{15}$	$>10^{15}$		$>10^{15}$	$>10^{15}$	$>10^{13}$
	Volume resistivity	23°C	IEC 60093	ohm·m	$>10^{13}$	$>10^{13}$		$>10^{13}$	$>10^{13}$	$>10^{13}$
	Electric strength (Dielectric strength)		ASTM D149	kV/mm						
	• Short Time [8]	23°C, 3,2 mm			22	29		26	>28 [9]	21
		120°C, 3,2 mm			21	28			>28 [9]	20
		150°C, 3,2 mm				27			>26 [9]	20
		200°C, 3,2 mm							>27 [9]	20
	Comparative tracking index (CTI)		UL 746B	V						
		23°C			217	175-249		175-249	167	<100
FLAMMABILITY	Flammability classification	0,75 mm	UL 94			V0	V0		V0	
		1,5 mm				V0	V0	V0	V0	V0
		3 mm				V0	V0	V0	V0	V0
	Glow wire flammability index	3 mm	IEC 60695-2-12	°C	960	960			960	
	Oxygen index		ISO 4589-1/-2	%	42	41		47	45	45
OTHERS	Density		ISO 1183	Kg/m³						
		Black			1620	1620	1710	1630	1620	1740
		White			1620	1680	1760		1660	1810
		Natural						1630		

1) Changes to the colours shown by using other colourants and additives may alter some or all of these properties. The data listed here will fall within the normal range of product properties but they should not be used to establish specification limits nor be used as the basis of design. Please note that property values are generally better at lower thicknesses. More data is available in the "ZENITE® Product guide and properties" L-10147.

2) Determined on 127 × 12,7 mm end-gated specimens impacted in the transverse direction.

3) Natural colour; 239°C for black.

4) Determined by Quartz Dilatometer method on 76,2 × 127 × 3,18 mm specimens.

5) Complete UL listing available on request.

6) at 0,75 mm – Provisional value.

7) at 3 mm black.

8) Determined with surrounding medium of a high temperature oil. Use of other mediums including air may alter some or all properties.

9) Arcing around occurred on 65 per cent of test specimens.

Properties of ZYTEL® nylon resins

	Property	Test conditions	Test method	Units	Unreinforced PA66 ZYTEL® 101L DAM	Unreinforced PA66 ZYTEL® 101L 50% RH	Unreinforced PA66 ZYTEL® 103HSL DAM	Unreinforced PA66 ZYTEL® 103HSL 50% RH
MECHANICAL	Yield stress	23°C, 50 mm/min	ISO 527-1/-2	MPa	83	53	85	54
	Yield strain	23°C, 50 mm/min	ISO 527-1/-2	%	4,5	25	4,4	25
	Stress at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	MPa				
	Strain at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	%				
		23°C, 50 mm/min			40	>50	40	>50
	Nominal strain at break	23°C, 50 mm/min	ISO 527-1/-2	%	22	>100	20	>100
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	3100	1200	3100	1250
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	5	15	5	14
		–30°C			4	4	4	4
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m²	NB	NB	NB	NB
		–30°C			NB	NB	NB	NB
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²	5	13	5	14
		–30°C			5	4	6	5
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	263		263	
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C	200		200	
		1,8 MPa			70		70	
	Vicat softening temperature	50 N, 50°C/h	ISO 306	°C	238		238	
	Coefficient of linear thermal expansion — Parallel (in flow direction)	23°C to 50°C	ISO 11359-2	10^{-4}/°C	1		1	
	Coefficient of linear thermal expansion — Normal (perpendicular to flow)	23°C to 50°C			1,1		1,1	
ELECTRICAL	Relative permittivity	10^2 Hz, 1 mm, 23°C	ISO IEC 60250		3,8	10,9	3,8	12,8
		10^6 Hz, 1 mm, 23°C			3,5	4	3,5	4
	Dissipation factor	10^2 Hz, 1 mm, 23°C	IEC 60250	10^{-4}	80	2100	75	5800
		10^6 Hz, 1 mm, 23°C			180	750	165	700
	Surface resistivity	23°C	IEC 60093	ohm	10^{12}	$>10^{15}$	10^{12}	10^{12}
	Volume resistivity	23°C	IEC 60093	ohm · m	10^{12}	10^{11}	10^{13}	10^{11}
	Electric strength (Dielectric strength)	1 mm, 23°C	IEC 60243-1	kV/mm	31	28	31	28
	Comparative tracking index (CTI)	1 mm, 23°C	IEC 60112	V	600		600	
FLAMMAB.	Flammability classification[1)]	1,5 mm	UL 94/IEC 60695		V2		V2	
	Glow wire flammability index	1,5 mm	IEC 60695-2-1	°C	850		950	
	Oxygen index	1,5 mm	ISO 4586	%	28		28	
OTHERS	Density		ISO 1183	kg/m³	1140		1140	
	Water absorption	Equilibrium, 50% RH, 23°C	Similar	%	2,7		2,7	
		Saturation, immersed, 23°C	to ISO 62		8,5		8,5	
	Rockwell hardness		ISO 2039-2					
		Scale M			79	59		
		Scale R			121	108		
	Ball indentation hardness	H 358/30	ISO 2039-1	MPa		85		
		H 961/30			160			
PROC.	Mould shrinkage — Parallel (in flow direction)	2 mm	ISO 294-4	%	1,3		1,3	
	Mould shrinkage — Normal (perpendicular to flow)	2 mm			1,3		1,3	

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.

Unreinforced

PA66		PA6		PA612	
ZYTEL® 135F		ZYTEL® 7335F		ZYTEL® 151L	
DAM	50% RH	DAM	50% RH	DAM	50% RH
98	69	90	55	62	54
4,5	18	4	24	4,5	18
18	>50	30	>50	100	>100
13	>50	8	>50	17	>50
3600	2100	4000	1400	2400	1700
4	9	4	18	3,5	4
3	3	2	3	3,5	3
NB	NB	40	NB	NB	NB
NB	NB	110	60	NB	40
3	6,5	3	1,5	4	4,5
2,3	2	2	1,5	4,5	3
263		223		218	
210		185		135	
88		70		62	
243		200		180	
1,21		0,76		1,1	
1,21		0,92		1,2	
3,9	8,7	4,2		3,6	6
3,8	3,9			3,2	4
70	2400	300		135	
200	600			160	1000
				10^{12}	
		$>10^{13}$		10^{13}	10^{12}
600		600		>600	
V2		HB		V2	
850					
				27	
1140		1130		1060	
2,7		3		1,3	
8,5		9		3	
87	64				
123	116			114	103
0,8		0,5		1,2	
1,3		0,5		1,2	

NB = no break.

Properties of ZYTEL® nylon resins

	Property	Test conditions	Test method	Units	Toughened PA66 ZYTEL® 114L BK097 DAM	Toughened PA66 ZYTEL® 114L BK097 50% RH	Toughened PA66 ZYTEL® 408 DAM	Toughened PA66 ZYTEL® 408 50% RH
MECHANICAL	Yield stress	23°C, 50 mm/min	ISO 527-1/-2	MPa	75	52	61	43
	Yield strain	23°C, 50 mm/min	ISO 527-1/-2	%	7	33	6	26
	Stress at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	MPa				
	Strain at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	%				
		23°C, 50 mm/min			30	>100	55	>100
	Nominal strain at break	23°C, 50 mm/min	ISO 527-1/-2	%	20	>50	35	>50
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	3000	1400	2200	2200
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	12	15	18	25
		–30°C			8	5	15	6
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m²	NB	NB	NB	NB
		–30°C			NB	NB	NB	NB
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²	10	15	19	20
		–30°C			7	5	11	4
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	263		263	
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C	149		155	
		1,8 MPa			75		65	
	Vicat softening temperature	50 N, 50°C/h	ISO 306	°C	225		210	
	Coefficient of linear thermal expansion — Parallel (in flow direction)	23°C to 50°C	ISO 11359-2	10^{-4}/°C	1,21		1,32	
	Coefficient of linear thermal expansion — Normal (perpendicular to flow)	23°C to 50°C			1,21		1,32	
ELECTRICAL	Relative permittivity	10^2 Hz, 1 mm, 23°C	IEC 60250				3,2	7
		10^6 Hz, 1 mm, 23°C			3,2	3,6	2,9	3,7
	Dissipation factor	10^2 Hz, 1 mm, 23°C	IEC 60250	10^{-4}			200	1500
		10^6 Hz, 1 mm, 23°C			200	600	200	500
	Surface resistivity	23°C	IEC 60093	ohm			10^{15}	$>10^{15}$
	Volume resistivity	23°C	IEC 60093	ohm · m	10^{12}	10^{11}	10^{13}	10^{11}
	Electric strength (Dielectric strength)	1 mm, 23°C	IEC 60243-1	kV/mm			33,5	
	Comparative tracking index (CTI)	1 mm, 23°C	IEC 60112	V	575		600	
FLAMMAB.	Flammability classification[1)]	1,5 mm	UL 94/IEC 60695		HB		HB	
	Glow wire flammability index	1,5 mm	IEC 60695-2-1	°C			675	
	Oxygen index	1,5 mm	ISO 4586	%			19	
OTHERS	Density		ISO 1183	kg/m³	1120		1090	
	Water absorption	Equilibrium, 50% RH, 23°C	Similar	%	2,5		2,2	
		Saturation, immersed, 23°C	to ISO 62		7,9		7	
	Rockwell hardness		ISO 2039-2					
		Scale M			76		71	50
		Scale R			118		115	102
	Ball indentation hardness	H 358/30	ISO 2039-1	MPa		85		
		H 961/30			123			
PROCESS.	Mould shrinkage — Parallel (in flow direction)	2 mm	ISO 294-4	%	1,1		1,2	
	Mould shrinkage — Normal (perpendicular to flow)	2 mm			1,2		0,9	

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.

Toughened						Supertough	
PA66		PA66		PA6		PA66	
Zytel® 450		Zytel® 490		Zytel® 7300T		Zytel® ST801	
DAM	50% RH	DAM	50% RH	DAM	50% RH	DAM	50% RH
55	40	55	50	68	40	50	43
5,4	29	5,5	29	4	30	5,7	37
50	>100	50	>100	40	>100	60	>100
28	>50	33	>50	15	>50	32,4	>50
2200	1000	2100	950	2750	890	2000	900
22	67	67	104	14	110	80	115
10	9	20	15	9	5	18	17
NB	NB	NB	NB	NB	NB	NB	NB
NB	NB	NB	NB	NB	NB	NB	NB
25	70	66	83	11	90	80	94
10	8	17	16	13	6	20	20
263		263		223		263	
92		85				132	
65		68		55		65	
195		220		195		205	
1,61		1,52		1,04		1,2	
1,61		1,52		1,22		0,9	
						3,2	8
						2,9	3,6
						80	1800
						140	550
						10^{15}	10^{15}
$>10^{13}$	10^{10}					10^{12}	10^{11}
						31	39
600		600				600	
HB		HB		HB		HB	
						675	
						19	
1080		1080		1100		1080	
2,2		2,3		2,6		2,2	
7		7,1		9		6,7	
						112	89
1,7		1,6		0,6		1,6	
1,3		1,1		0,7		1	

NB = no break.

Properties of ZYTEL® nylon resins

	Property	Test conditions	Test method	Units	Glass reinforced			
					PA66		PA6	
					ZYTEL® 70G30HSL		ZYTEL® 73G30HSL	
					DAM	50% RH	DAM	50% RH
MECHANICAL	Yield stress	23°C, 50 mm/min	ISO 527-1/-2	MPa				
	Yield strain	23°C, 50 mm/min	ISO 527-1/-2	%				
	Stress at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	MPa	195	125	180	115
	Strain at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	%	3,4	5	3,5	5,5
		23°C, 50 mm/min			3	5		
	Nominal strain at break	23°C, 50 mm/min	ISO 527-1/-2	%				
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	10000	7200	9500	6200
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	12	16	12	20
		–30°C			10	10	10	20
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m²	82	93	95	95
		–30°C			70	73	80	85
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²	13	17	14	19
		–30°C			12	10	10	11
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	263		223	
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C	260		220	
		1,8 MPa			255		210	
	Vicat softening temperature	50 N, 50°C/h	ISO 306	°C	250		215	
	Coefficient of linear thermal expansion Parallel (in flow direction)	23°C to 50°C	ISO 11359-2	10^{-4}/°C	0,22		0,22	
	Normal (perpendicular to flow)	23°C to 50°C			1,07		1,02	
ELECTRICAL	Relative permittivity	10^2 Hz, 1 mm, 23°C	IEC 60250		4,4	10,8	4,4	
		10^6 Hz, 1 mm, 23°C			4,1	4,6	4,1	
	Dissipation factor	10^2 Hz, 1 mm, 23°C	IEC 60250	10^{-4}	70	4600		
		10^6 Hz, 1 mm, 23°C			150	650		
	Surface resistivity	23°C	IEC 60093	ohm	$>10^{15}$	10^{13}	10^{14}	10^{13}
	Volume resistivity	23°C	IEC 60093	ohm · m	$>10^{13}$	10^9	10^{13}	10^8
	Electric strength (Dielectric strength)	1 mm, 23°C	IEC 60243-1	kV/mm	38	32		
	Comparative tracking index (CTI)	1 mm, 23°C	IEC 60112	V	400			
FLAMMAB.	Flammability classification[1]	1,5 mm	UL 94/IEC 60695		HB		HB	
	Glow wire flammability index	1,5 mm	IEC 60695-2-1	°C				
	Oxygen index	1,5 mm	ISO 4586	%				
OTHERS	Density		ISO 1183	kg/m³	1370		1360	
	Water absorption	Equilibrium, 50% RH, 23°C	Similar	%	1,9		1,9	
		Saturation, immersed, 23°C	to ISO 62		6		6,3	
	Rockwell hardness		ISO 2039-2					
		Scale M			104	88		
		Scale R			124	117		
	Ball indentation hardness	H 358/30	ISO 2039-1	MPa				
		H 961/30			275	187		
PROC.	Mould shrinkage Parallel (in flow direction) 2 mm		ISO 294-4	%	0,3		0,2	
	Normal (perpendicular to flow) 2 mm				1,1		0,7	

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.

Glass reinforced (Speciality)

PA66		PA612	
ZYTEL® 70G30HSLR		ZYTEL® 77G33L	
DAM	50% RH	DAM	50% RH
195	130	165	135
3,3	5	3	3
10000	7200	9500	7900
12	16	12	12
10	10	10	10
82	92	70	65
70	72	60	40
13	17	12	12
12	10	10	10
263		218	
261		215	
255		200	
250			
0,22		0,17	
1,07		1,13	
4,3	10,8	4,1	
4,1	4,6	3,8	
70	4600	135	
150	650	150	200
10^{15}	10^{13}	10^{12}	
10^{13}	10^{9}	10^{13}	
38	32	27	
		600	
HB		HB	
		673	
		23	
1370		1320	
1,9		0,7	
6		2	
0,3		0,3	
1,1		1	

Toughened glass reinforced

PA66		PA66		PA6	
ZYTEL® 79G13L		ZYTEL® 80G33HS1L		ZYTEL® 73G30T	
DAM	50% RH	DAM	50% RH	DAM	50% RH
118	67	135	95	165	102
4	10	3,5	5	3	5
5100	3700	8500	5800	9600	6200
8	14	20	22	19	25
6	6	16	14	19	25
67	59	90	80	106	98
59	54	100	75	94	94
8	9	20	20	15	20
6	4	15	10	10	11
263		263		223	
260		260		221	
242		245		210	
240		245		215	
0,5		0,15		0,28	
1,3		1,19		1,2	
3,9	9,8	4	9,3	4,1	
3,7	4,5	3,6	4,3	3,8	
65	2500				
130	660	130	600		
		10^{12}	10^{10}	10^{15}	10^{15}
			10^{9}	10^{13}	10^{9}
37	35			35	39
475					
HB		HB		HB	
1210		1330		1340	
2,2		1,5		1,8	
6,5		4,5		6,2	
90	74	70			
120	110	110			
180	100				
0,5		0,3		0,2	
0,8		0,8		0,4	

Properties of ZYTEL® nylon resins

	Property	Test conditions	Test method	Units	Flame retardant			
					PA66		PA66/6 Copolymer	
					ZYTEL® FR70G25V0		FR72G25V0	
					DAM	50% RH	DAM	50% RH
MECHANICAL	Yield stress	23°C, 50 mm/min	ISO 527-1/-2	MPa				
	Yield strain	23°C, 50 mm/min	ISO 527-1/-2	%				
	Stress at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	MPa	125	110	135	100
	Strain at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	%	2	2,6	2,5	3,5
		23°C, 50 mm/min						
	Nominal strain at break	23°C, 50 mm/min	ISO 527-1/-2	%				
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	9000	7500	9200	6500
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	10	10	12	14
		–30°C			9	6,5	11	9
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m²	43	45	55	60
		–30°C			45	10	70	60
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²	6,5	6,5	9	13
		–30°C			6	6	8	8
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	263		242	
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C			241	
		1,8 MPa			243		215	
	Vicat softening temperature	50 N, 50°C/h	ISO 306	°C	235		220	
	Coefficient of linear thermal expansion — Parallel (in flow direction)	23°C to 50°C	ISO 11359-2	10^{-4}/°C	0,26	0,26	0,2	
	Normal (perpendicular to flow)	23°C to 50°C			0,83	0,83	1,06	
ELECTRICAL	Relative permittivity	10^2 Hz, 1 mm, 23°C	IEC 60250		4,3		42	
		10^6 Hz, 1 mm, 23°C					4,4	
	Dissipation factor	10^2 Hz, 1 mm, 23°C	IEC 60250	10^{-4}	160		180	130
		10^6 Hz, 1 mm, 23°C			120			
	Surface resistivity	23°C	IEC 60093	ohm				
	Volume resistivity	23°C	IEC 60093	ohm · m	10^{13}		10^{13}	
	Electric strength (Dielectric strength)	1 mm, 23°C	IEC 60243-1	kV/mm	37	26	35	25
	Comparative tracking index (CTI)	1 mm, 23°C	IEC 60112	V	325	325	325	
FLAMMAB.	Flammability classification[1)]	1,5 mm	UL 94/IEC 60695		V0		V0	
	Glow wire flammability index	1,5 mm	IEC 60695-2-1	°C	960		960	
	Oxygen index	1,5 mm	ISO 4586	%				
OTHERS	Density		ISO 1183	kg/m³	1490		1490	
	Water absorption	Equilibrium, 50% RH, 23°C	Similar	%	0,9		1,1	
		Saturation, immersed, 23°C	to ISO 62		3,4		4,1	
	Rockwell hardness		ISO 2039-2					
		Scale M						
		Scale R						
	Ball indentation hardness	H 358/30	ISO 2039-1	MPa				
		H 961/30			227	133	213	1406
PROC.	Mould shrinkage — Parallel (in flow direction) 2 mm		ISO 294-4	%	0,3		0.3	
	Normal (perpendicular to flow) 2 mm				0,8		0,8	

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.

High viscosity/Extrusion

PA66		PA66		PA66		PA66		PA612	
ZYTEL® FR70M30V0		ZYTEL® E40		ZYTEL® E42A		ZYTEL® E51HSB		ZYTEL® 158	
DAM	50% RH	DAM	50% RH	DAM	50% RH	DAM	50% RH	DAM	50% RH
		85	55	86	52	85	55	62	52
		4,4	28	5	27	4,4	29	4,3	19
73	54								
2	6								
		50	>50	>50	>50	>50	>50	35	>50
8600	4500	3000	1200	3100	1200	3000	1200	2400	1500
2,5	3	6	20	6	20	7	22	4	8
2	2	4	3	5	4			4	4
21	24	NB	NB	NB	NB	NB	NB	NB	NB
21	19	NB	NB	NB	NB			NB	NB
2,1	2,57	5,5	12,5	5,5	12	6	19	4	6
2,1	1,9	3	2	4,5	4			5	4,5
263		263		263		223		218	
240		205		205		205		135	
200		72		72		70		62	
235		242						180	
0,64		1	1	1		1	1	1,2	
0,81		1	1	1		1	1	1,2	
4,1	9,1	3,9		4,3	10,3	3,.9		3,6	6
3,7	4,2			3,6	4,2			3,2	4
140	4100	100		150	2000	100		140	
140	500			240	750			165	1000
$>10^{15}$					10^{12}			10^{12}	
$>10^{13}$	10^{9}	10^{13}		10^{13}	10^{11}	10^{13}		10^{13}	10^{11}
40	33			30,5					
325		600		600	600		600	600	
V0				HB				HB	
960									
38								25	
1620		1140		1140		1140		1060	
1,3		2,7		2,7		2,6		1,3	
4		8,5		8,5		8,5		3	
								114	108
1		1,4		1,4		1,5		1,2	
1		1,4		1,4		1,5		1,2	

NB = no break.

Properties of ZYTEL® nylon resins

	Property	Test conditions	Test method	Units	Specialities			
					PA66		PA6	
					ZYTEL® FN718		ZYTEL® FN727	
					DAM	50% RH	DAM	50% RH
MECHANICAL	Yield stress	23°C, 50 mm/min	ISO 527-1/-2	MPa	30		23	25
	Yield strain	23°C, 50 mm/min	ISO 527-1/-2	%	50	>50	44	>50
	Stress at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	MPa	>50	>50	>50	>50
	Strain at break (tensile)	23°C, 5 mm/min	ISO 527-1/-2	%				
		23°C, 50 mm/min						
	Nominal strain at break	23°C, 50 mm/min	ISO 527-1/-2	%	>50		>50	
	Tensile modulus	23°C, 1 mm/min	ISO 527-1/-2	MPa	960	420	770	350
	Charpy impact strength (notched)	23°C	ISO 179/1eA	kJ/m²	123		131	
		–30°C			35		65	
	Charpy impact strength (unnotched)	23°C	ISO 179/1eU	kJ/m²			NB	NB
		–30°C					NB	NB
	Izod impact strength (notched)	23°C	ISO 180/1A	kJ/m²	NB	NB	NB	NB
		–30°C			NB	NB		
THERMAL	Melting temperature, by DSC	10°C/min	ISO 11357-1/-3	°C	263		223	
	Temperature of deflection under load	0,45 MPa	ISO 75-1/-2	°C				
		1,8 MPa			50		45	
	Vicat softening temperature	50 N, 50°C/h	ISO 306	°C	220		180	
	Coefficient of linear thermal expansion — Parallel (in flow direction)	23°C to 50°C	ISO 11359-2	10^{-4}/°C	1,2		1,2	1,2
	Normal (perpendicular to flow)	23°C to 50°C						
ELECTRICAL	Relative permittivity	10^2 Hz, 1 mm, 23°C	IEC 60250					
		10^6 Hz, 1 mm, 23°C						
	Dissipation factor	10^2 Hz, 1 mm, 23°C	IEC 60250	10^{-4}				
		10^6 Hz, 1 mm, 23°C						
	Surface resistivity	23°C	IEC 60093	ohm				
	Volume resistivity	23°C	IEC 60093	ohm · m				
	Electric strength (Dielectric strength)	1 mm, 23°C	IEC 60243-1	kV/mm				
	Comparative tracking index (CTI)	1 mm, 23°C	IEC 60112	V				
FLAMMAB.	Flammability classification[1)]	1,5 mm	UL 94/IEC 60695					
	Glow wire flammability index	1,5 mm	IEC 60695-2-1	°C				
	Oxygen index	1,5 mm	ISO 4586	%				
OTHERS	Density		ISO 1183	kg/m³	1040		1020	
	Water absorption	Equilibrium, 50% RH, 23°C	Similar	%				
		Saturation, immersed, 23°C	to ISO 62					
	Rockwell hardness		ISO 2039-2					
		Scale M						
		Scale R						
	Ball indentation hardness	H 358/30	ISO 2039-1	MPa				
		H 961/30						
PROC.	Mould shrinkage — Parallel (in flow direction)	2 mm	ISO 294-4	%	14			
	Normal (perpendicular to flow)	2 mm			1,3			

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.

High Performance Polyamide, glass reinforced

PA6T/XT		PA6T/XT		PA6T/XT	
ZYTEL® HTN51G35HSL		ZYTEL® HTN51G35HSLR		ZYTEL® HTN51G45HSL	
DAM	50% RH	DAM	50% RH	DAM	50% RH
220	210	220	210	240	230
2,4	2,1	2,4	2,1	2,4	2,1
12500	12500	12500	12500	15000	15000
12 11	11	12	11	11 12	11
65 56	55	65	44	85 61	75
11 11	11	11	10	12,5 12	12
300		300		300	
275 265		275 265		275 265	
0,15 0,49	0,18	0,18		0,15 0,45	0,15
4				4,5	
120				180	
10^{14}				10^{14}	10^{13}
$>10^{13}$	10^{13}			$>10^{13}$	10^{13}
36	36			35	34
600	600			600	600
HB				HB	
725					
23	23			24	
1470		1470		1580	
		0,4 1,5			
0,2 0,7		0,2 0,7		0,2 0,6	

NB = no break.

High temperature performance data of glass-reinforced ZYTEL® HTN compared to ZYTEL® PA66 resins

Property	Test method	Units	ZYTEL® HTN 51G35HSL	ZYTEL® PA66 70G33HS1L
Melting temperature, by DSC	ISO 3146 C	°C	300	263
Glass transition temperature [1]	ISO 11357-3	°C		
DAM			125	50
50% RH			90	15
Accelerated creep at 427,5 MPa, 100°C [2]	ISO 178			
Flexural creep modulus estimated after 10 years		MPa	4520	2190
% total strain estimated at 10 years		%	0,6	1,2
Flexural modulus [3]	ISO 178	MPa		
DAM at 100°C			9520	4300
Compressive strength [3]		MPa		
DAM at 100°C			220	130
Electric strength [4] (Dielectric strength)	IEC 60243-1	kV/mm		
DAM at 23°C			36	N/A
DAM at 100°C			26,1	N/A

1) The glass transition temperatures are based on the onset of loss in modulus as measured by the Dynamic Mechanical Analysis (DMA) Method.

2) The Accelerated Creep was based on DMA to measure short-therm creep conducted at constant load and at various elevated temperatures. These data were then superimposed to form a "Master Curve", from which the long-term creep behaviour is estimated. Annealed sample were used for the test specimens.

3) Dry as Moulded (DAM) ISO properties.

4) ASTM D 149 Short-Term Method. Test Specimens: 1,6 mm thick, DAM.

N/A = not applicable

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