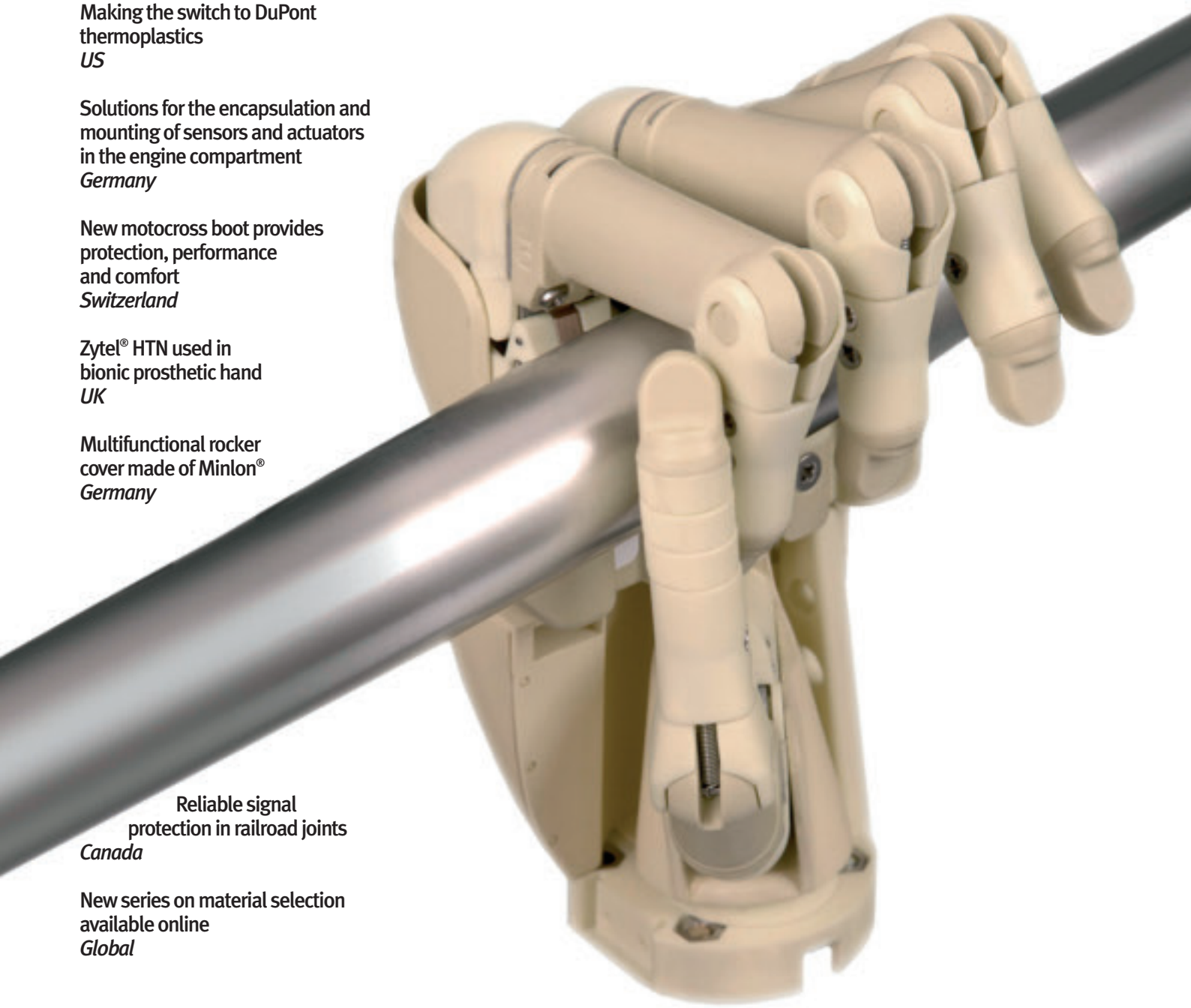
2007/2

DuPont Engineering Design

The Review of DuPont Engineering Polymers in Action



DUPONT®

The miracles of science™

A tailored approach to the Electrical and Electronics market

Editorial by Eric Beyeler, market development manager Electrical and Electronics, Americas

As is the case in many end-use markets for our engineering polymers, the electrical and electronics (E&E) sector is subject to constant change through globalization, regulatory requirements and, of particular relevance to our sector, technological advance. At DuPont we categorize the E&E market in three segments – 'signal', 'building' and 'machines' – and adapt our resources to meet these challenges.

A global electronics market

In the category of 'signal' we include virtually all kinds of signal-carrying components, from connectors to complete devices, such as mobile phones. This market is the most global of all within E&E, with a number of key customers – Sony, Tyco, Hewlett Packard and Nokia, to name but a few – responsible for the majority of applications in Europe, the US and Asia-Pacific. Moreover, similar to the automotive market, there is also a limited group of global Tier 1 suppliers who supply the sub-systems to these OEMs. Previous regional differences in specification and performance requirements (whether through regulation or other local customer-criteria) are now replaced by world-wide requirements, with global players looking to standardize production.

Meeting local challenges in electrics

The electrical side of our business we divide between 'building' and 'machines'. Building electrics are the devices commonly found in the home or commercial buildings, such as lighting, sockets, wiring devices or circuit breakers. As the specification of such equipment will be dependent on local electrical power systems – with regional variances in terms of voltage, etcetera – this market is highly regionalized with few global players, necessitating a more local approach in the provision of material solutions.

There remains vast potential for the replacement of thermoset resins with multifunctional molded parts of high-performance engineering thermoplastics. Associated benefits include manufacturing cost reductions through shorter cycle times, greater design freedom and reduced environmental impact.

A driver of change in lighting systems is the environmentally-led transition from incandescent to fluorescent, due to their lower electricity consumption; while continued developments in LEDs (Light Emitting Diodes), which promise to be several times more energy efficient than current incandescent lights, will provide further challenges in terms of their material requirements.

Higher performance machines

Our third category, that of 'machines', can be further subdivided into coil-form based electrical components, such as transformers, relays and motors, and office automation products. For coil-form based components, DuPont already offers a wide range of insulating materials, including thermoplastic materials, films, wire enamels and aramid papers, which are integrated in pre-tested systems meeting IEC/UL (UL 1446) requirements. In terms of office automation,

As developments in consumer electronics, such as smartphones, continue apace, polymer solutions from DuPont can actively help to optimize their shape and structure.

driven by the Asia-Pacific region, our new developments enable more compact and efficient machines, which in turn create greater demands on the polymers used in terms of temperature resistance and structural performance.

A 'glocal' approach

By segmenting the E&E market and identifying key trends we are able to provide an effective response. To support our electronic customers' move to globalization, we have formed global account teams, members of which are spread among the regions to provide "touch-points" to assess customer needs, and feed through the local requirements which may become the global drivers of tomorrow. Our 'glocal' approach ensures the seamless work of our colleagues around the world to meet changing demands and requirements with consistently high-quality and appropriate products. A specific example is the recent introduction of a new halogen-free grade of DuPont™ Zytel® HTN, a 30 percent glass-reinforced PPA with a V-0 UL94 flammability classification which fits well with emerging recycling programs for discarded electronic products.

Opportunity 'hybrid'

Looking to the future, opportunities for growth will also lie in the transfer of knowledge, gained in the industrial and consumer electrical markets, to related markets – no better illustrated than by our current involvement in hybrid electric vehicles (HEVs). Despite currently representing only 1.5 percent of vehicles on North American roads, the quest for sustainable mobility, driven by concerns over global warming and future fuel supplies, means this sector is forecast for rapid growth. This creates a demand for more robust, "high-voltage capable" polymers for use in the 300-600 volt electrical systems of HEVs to address safety and performance requirements. Indeed DuPont has already developed a specific grade of Zytel® HTN, already used in a commercial application for Japanese HEVs, that offers good electrical insulative properties, a high comparative tracking index and excellent heat resistance and strength at elevated temperatures.

Shaping the future

Meanwhile, we see new business within the electronics sector stemming from today's virtually breathless pace of technical development. Just five years ago the business technophile would be equipped with laptop, palm and cell phone, yet today's smartphones can combine them all. In such rapidly changing times we sense an opportunity: through our extended network of contacts with key players in today's electronic industry – be they the OEMs or Tier 1 suppliers – we are not only able to stay in tune with future needs, but can help determine them. By communicating the full extent of what our material solutions can offer, in terms of our own business offering and beyond, we can actively help to optimize the structure and shape of electronics to come.

With demand for hybrid electric vehicles (HEVs) expected to grow, DuPont has responded with a new, specific grade of Zytel® HTN that provides the superior electrical properties for safety and performance required for an HEV's electrical connection system.

contents

Making the switch to DuPont thermoplastics

PowerPact circuit breakers from Square D come with a variety of field-installable options and accessories. Their rugged housings (insert), made from DuPont™ Zytel® nylon, have integrally molded snap-in features that ease assembly and field configuration.

Part of the growth achieved by DuPont within the Electrical & Electronics sector is through the replacement of thermoset resins by high-performance thermoplastics from DuPont. Benefits gained include enhanced protection of electronic components, reductions in the size and cost of parts and greater design freedom as reflected by recent applications from the US.

High-voltage-resistant DuPont™ Zytel® nylon facilitates installation

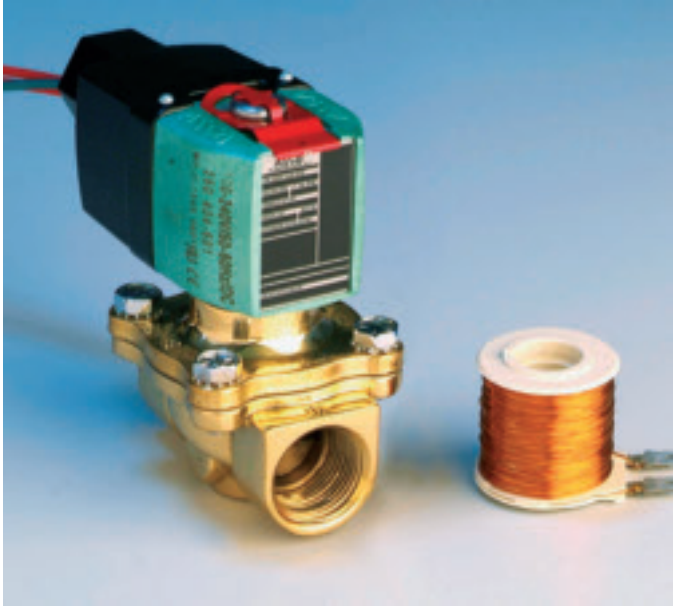
A specially-developed grade of Zytel® nylon, compliant with new, stringent electrical testing requirements, is used by Square D Company for the housings of high-performance circuit-breakers. Zytel® FR82G33V1, based on a PA66/PA6 copolymer with 33 percent glass-fiber reinforcement, is a response by DuPont to the 2005 National Electrical Code (US), the requirements of which include a 100 kA (kiloampere) short-circuit rating at 480 Vac (volts, alternating current) per UL489 – a test which housing parts made of most flame-retardant thermoplastic resins would fail. Hence the new grade was adopted by Square D to provide rugged protection for certain high-interruption-rated models of the company's PowerPact line of circuit breakers, namely H- and J-frame products for 70 to 250 A (ampere) applications.

In contrast to a stiffer, thick-walled thermoset design, the Zytel® nylon facilitated the development of a housing design with integrally molded features allowing snap-in installation of terminals and accessories.

According to Square D, the snap-in design saves time and money during in-the-field configuration of circuit breakers for different applications. Savings in manufacturing costs were also noted by the company: additional integrally molded features reduced total part count and simplified assembly, while the faster cycling and recycling of sprues and runners during molding also saved costs compared with thermoset parts.

Rugged protection from DuPont™ Zenite® LCP

ASCO, the world's leading manufacturer of solenoid valves, has selected Zenite® LCP liquid crystal polymer resin to encapsulate the solenoids of its latest line of valves. The same material is used to mold a coil bobbin enclosed within the valve. The resin grade selected by ASCO, Zenite® 6130 containing 30 percent glass fiber reinforcement, meets this application's needs for resistance to a wide range of aggressive chemicals, a UL94 V-0 flammability classification, excellent stability and cracking resistance in thermal shock testing and excellent performance in the encapsulation injection molding process. Earlier models had used thermoset epoxy for encapsulation.



ASCO's RedHat Next Generation valve can operate reliably in harsh conditions thanks to the solenoid encapsulation and coil bobbin made of Zenite® LCP.

The valves serve in a wide variety of demanding fluid control applications from air compressors to water treatment plants. They meet US standards for use in hazardous locations and water-tight applications as well as all NEMA (National Electrical Manufacturers Association) Types 1 through 4X requirements for water- and dust-tight applications. The encapsulated solenoid withstands ASCO's stringent thermal shock testing and meets service temperature requirements of -40°C (-40°F) to 200°C (392°F).

Redesign in DuPont™ Rynite® PET saves space and cost

The change from thermoset phenolic to Rynite® PET thermoplastic polyester for the production of its Telpower disconnect switch has enabled circuit protection solutions provider, Cooper Bussmann, to meet high performance goals, while reducing switch size to save space in high-density, high-power distribution cabinets. The properties of Rynite® allowed Cooper Bussman to use thinner walls than with the previous phenolic parts – a key factor in reducing switch size by around 47 percent. Further design freedom provided by Rynite® allowed the integration of snap-in assembly features for the handle and fuse contacts. These and other functional features helped reduce assembly costs and part count, while additional cost savings were achieved with faster molding cycles and by recycling sprues and runners – all contributing to an overall reduction of manufacturing cost of over 50 percent, according to the customer.

The redesign of a disconnect switch to use Rynite® PET helped Cooper Bussmann meet high performance goals while reducing switch size to save space in high-density, high-power distribution cabinets. Moreover, the redesigned switch cut manufacturing costs by more than half.

The grade used by Cooper Bussmann is DuPont™ Rynite® FR530L, a 30 percent glass-reinforced grade. It meets this application's requirements for good strength and toughness, a high RTI (relative temperature index) – 155°C (311°F) per UL 746B – and a V-0 flammability classification per UL94 and IEC 60695-11-10.

Leviton engineers took advantage of the toughness, resilience and high flow of Crastin® and incorporated integral features for snap-fit assembly and lamp locking, thus eliminating metal fasteners and simplifying assembly. The use of Crastin® PBT also eliminated runner scrap and deflashing operations routinely required for urea parts. The selected grade, based on DuPont recommendations, further fulfilled requirements in terms of UV resistance and a V-0 UL94 flammability classification and high molding productivity.

Leviton engineers took advantage of the toughness, resilience and high flow of Crastin® PBT and incorporated integral features for snap-fit assembly and lamp locking, thus eliminating metal fasteners and simplifying assembly.

Reliable quality from DuPont™ Crastin® PBT

Leviton Manufacturing met its own quality and reliability goals, while fulfilling customer expectations for high-performance materials, by redesigning the thermoset urea parts of its fluorescent lamp holders to use DuPont™ Crastin® PBT thermoplastic polyester.

CONTACT

ASCO
Tel.: +1 800-972-ASCO
E-mail: info-valve@asco.com
www.ascovalve.com/NextGen

Cooper Bussmann
Tel.: +1 636-527-3877
E-mail: fusebox@buss.com
www.bussmann.com

Leviton Manufacturing
Tel.: +1 800-833-3532
www.leviton.com

Square D
Tel.: +1 800-778-2733
www.squared.com

DuPont has it covered

Housing for a UFS sensor from Robert Bosch GmbH, made of hydrolysis-resistant DuPont™ Crastin® PBT HR (photo with kind permission of Robert Bosch GmbH).

A paper, entitled 'High-performance plastics for sensors and actuators under the hood' and presented during a recent symposium* arranged by the VDI (Association of German Engineers), is now available on the DuPont plastics website. Bringing together DuPont's wide experience in the use of high-performance plastics in the automotive and electrical & electronics industries, it considers cost-effective solutions for the encapsulation and mounting of sensors and actuators in the engine compartment.

By Laurent Zielezinski, DuPont Engineering Polymers, Germany

Principle factors of component success are material selection, component design, processing parameters and mold construction. While standard nylon grades are a traditional choice for underhood applications, high performance polyamides such as DuPont™ Zytel® HTN PPA polypthalamide and thermoplastic polyesters, e. g. DuPont™ Crastin® PBT HR,DuPont™ Rynite® PET thermoplastic polyester resin and DuPont™ Thermx® PCT high performance polyester, can be demonstrated to cope with today's stringent challenges.

Beyond advantageous properties over classic PA66 grades such as lower moisture pick-up, high temperatures and other media typically encountered in the engine compartment, as well as an overall improvement in dimensional stability, high performance polyamides offer optimum characteristics for low-stress processing during encapsulation of sensors and actuators. These include reduced shrinkage rates and thermal expansion, increased flowability and improved overmolding strength for fluid-tight encapsulation.

The document also considers the specially formulated grade Zytel® 612 nylon from DuPont for the encapsulation of sensitive sensors. The material has extremely low water absorption and high dimensional stability and exceptionally good mold filling behavior, with the consequence that reliable encapsulations can be obtained with low injection pressure and minimal stress on the electronic components (referred to as 'soft-fill'). Further topics are so-called 'wire-friendly' grades of Zytel® nylon – a term used if the material has only minimal effect on electrical and electronic components during processing and use – as well as hydrolysis-stabilized Crastin® PBT for enhanced moisture resistance and engineering polymers suitable for laser welding.

The paper's publication is intended to trigger essential discussion between the key players in the encapsulation process. Such is the complexity of the interrelationships between the functioning of highly sensitive electronic components, such as sensors and actuators, the type of encapsulation and the encapsulating materials, that the decision to use a certain thermoplastic is too complex for either the manufacturer or the raw material producer alone. It is therefore DuPont's belief that only the cooperation of both in partnership, and the inclusion of the processor, can provide the necessary competence for successful new and further developments.

Available in both English and German with accompanying illustrations, the paper can be found at plastics.dupont.com for download or is available on demand by using the contact details below.

**„Spritzgießen 2007 - Hybride Bauteile und Elektromechanik / Oberflächen von spritzgegossenen Teilen", Fachtagung der VDI Gesellschaft Kunststofftechnik, 14./15. Februar 2007, Baden-Baden*

CONTACT

Laurent Zielezinski
DuPont de Nemours (Deutschland) GmbH
Tel: +49 6172 87 2712
E-mail:
Laurent.Zielezinski@dupont.com

A work of Genius

The Genius MX Boot is constructed of injection molded pieces of Hytrel® thermoplastic polyester elastomer and polyurethane. Both materials, characterized by their durability and impact resistance, allow the boot to protect the lower leg and foot to a level unattainable by its leather counterparts.

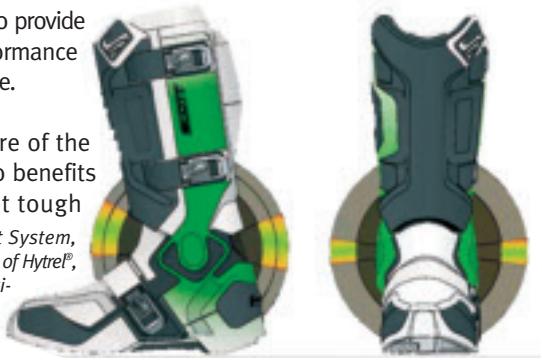
A brand-new motocross boot from sports manufacturer Scott provides a combination of protection, performance and comfort by utilizing the latest engineering materials, an innovative pivot system and forward-thinking design. The first boot to be made entirely from injection-molded plastics, durable and impact-resistant DuPont™ Hytrel® thermoplastic polyester elastomer makes the protection and performance of the Genius MX Boot possible.

By Laurent Hanen, DuPont Engineering Polymers, France

The Genius MX Boot, launched this spring in the US and Europe, has been developed by Scott, a world leader in action sports products, to significantly reduce the rate of injuries amongst motocross riders. Its design is based on critical information about common moto-related injuries, whereby, of the 34 percent involving the lower leg, ankle and foot, the majority were fractures. Thus it was protection of these areas that became fundamental to the boot's development, setting it apart from its leather counterparts.

Key to achieving a high level of protection is the ingenious Scott Pivot System, a hinge system with worldwide patent, which allows the boot to flex while retaining its solid construction. It is made of DuPont™ Hytrel® thermoplastic polyester elastomer, chosen for its excellent fatigue resistance, damping properties and high impact strength over a wide temperature range. "The hinge's design and use of Hytrel® provides both performance and protection, allowing the necessary foot articulation required by the rider while simultaneously limiting ankle motion. Under excessive loads, such as during jumps or falls, the Hytrel® structure absorbs energy and thereby reduces the amount transmitted through to the rider's foot or leg, discouraging fractures and ligament strains," explains Hervé Maneint, project leader at Scott Sports. Moreover, simulated fatigue cycle tests for a period of three years, conducted by DuPont at the request of Scott, indicate that the Scott Pivot System will continue to provide optimal support performance even after prolonged use.

A second, key feature of the Genius MX Boot also benefits from the flexible yet tough properties of the thermoplastic polyester elastomer from DuPont: the hood of the boot, injection-molded in stiff Hytrel® 6356, incorporates a soft overmolded section, combining Hytrel® 7246 with polyurethane, which constitutes Scott's patented Sure-Feel Shifter Pad. The external, copper-colored pad is positioned in the shifting area at the top of the boot and transfers shifter lever pressure through ridges on the interior of the boot, allowing the rider to feel it without compromising protection of the boot. Other elements of the boot are injection-molded from polyurethane.



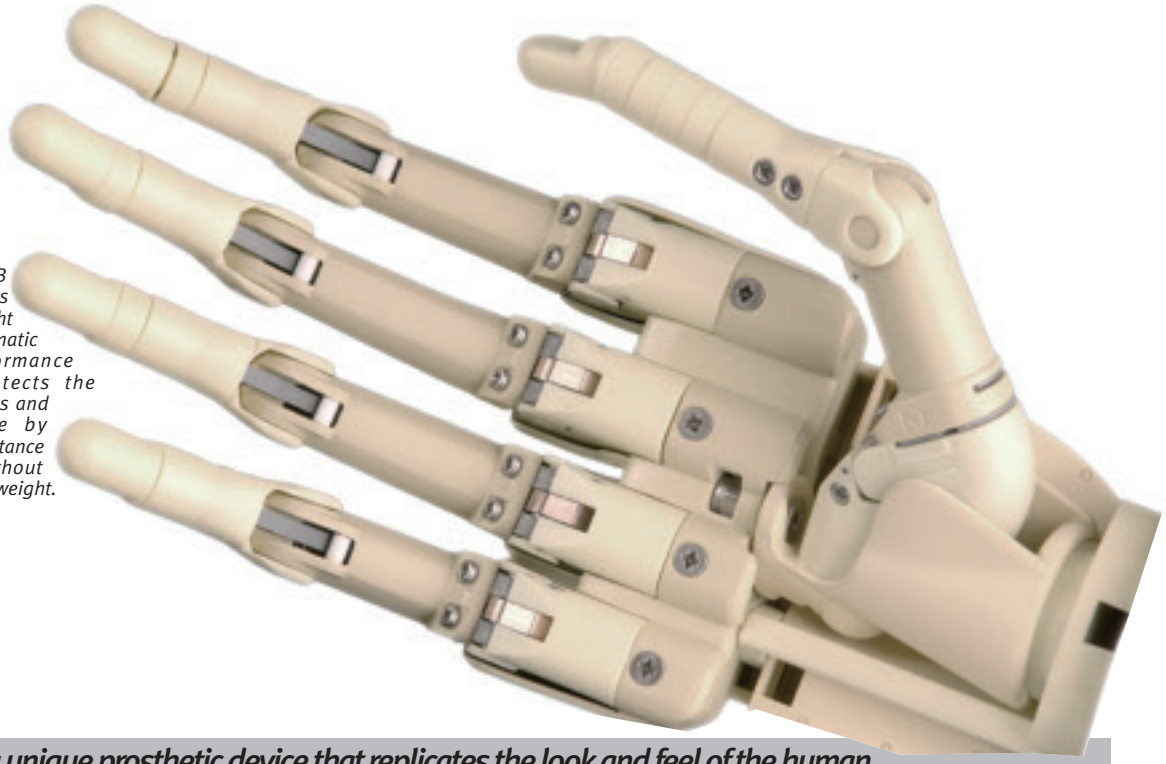
The patented Scott Pivot System, (highlighted in green) made of Hytrel®, allows necessary foot articulation while limiting extreme ankle motion.

In its choice of polymers for the manufacture of the Genius MX Boot, Scott has achieved its priorities of protection, performance and comfort. Twenty separate molded parts are assembled in fewer steps than required for traditional leather boots, and in a process less susceptible to quality issues. Not only is the boot lighter than many industry-leading boots at 1950 grams (4.3 lbs), the Hytrel® and polyurethane boot is able to withstand the rigors of hard riding and exposure to the elements, without losing integrity, and is ride-ready without the need for breaking-in.

CONTACT

SCOTT Sports S.A.
Route du Crochet 17
CH-1762 Givisiez
Switzerland
Tel.: +41 26 460 1616
E-mail:
customersupport@scott-sports.com
www.scott-sports.com

Zytel® HTN provides a helping hand



In its current form, the i-LIMB Hand contains 33 components made of robust and lightweight DuPont™ Zytel® HTN semi-aromatic polyamide. The high performance engin-eering polymer protects the sophisticated system of drives and motors within the device by providing extreme impact resistance and dimensional stability without exceeding the required overall weight.

The i-LIMB Hand is a unique prosthetic device that replicates the look and feel of the human hand. Embracing the very latest in mechanical engineering design, UK company Touch Bionics selected a particularly rigid grade of DuPont™ Zytel® HTN semi-aromatic polyamide to produce a device which is lightweight, robust and highly appealing to both patients and the healthcare professional.

By Ernst Poppe, DuPont Engineering Polymers, Geneva

The i-LIMB Hand, from Scottish bionic technology company Touch Bionics, is the first prosthetic to actually look and act like a real human hand and will be initially available in three sizes – from a full-size adult hand to that of an adolescent. It has five individually powered digits with fully articulated joints, all helping deliver multiple grip patterns which enhance dexterity and support up to 90 percent of all activities of daily living. The motors located within the i-LIMB Hand are operated using a traditional myoelectric two-signal input – a system whereby two analogue sensors are placed close to the skin of the patient to collect muscle-generated signals to make the full range of movements.

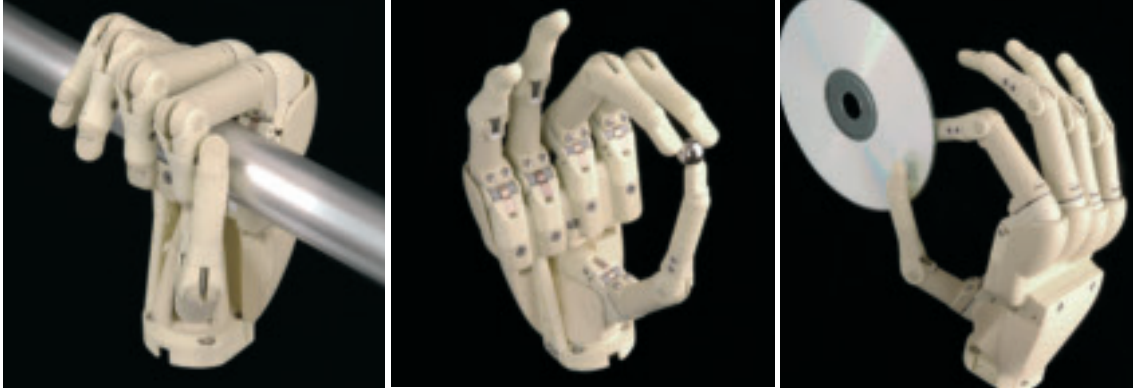
To enhance the appearance of a real hand, the device is covered by a silicone-based 'glove' or cosmesis, which is highly realistic in terms of both skin tone and surface, while also adding extra grip support to the prosthesis.

Low service costs and adaptability

Its modular construction, whereby each finger can be reconfigured to give a range of sizes to match the patient's remaining hand, or individual parts can be replaced if damaged, means patients can quickly return to their everyday lives, with their i-LIMB Hand, after a short visit to the clinic.

Moreover, the modular nature of the design, and the individually powered and self contained digits, mean the clinician can adapt the i-LIMB Hand for users who have a partial hand, either due to congenitally missing fingers or having lost fingers through accidents.

Touch Bionics CEO Stuart Mead (left) and CTO David Gow (right) with the i-LIMB Hand. The company's aim is to apply next-generation bionic technology to create devices that provide a new way of life for amputees.



The Touch Bionics i-LIMB Hand has been developed with the three most common choices of gripping configurations used by humans: the power grasp of articulating digits, (for example to hold a mug of tea), the precision grasp of thumb against first and second finger (for example to pick up a mobile phone) and the key grip of thumb against proximal phalanx of the index finger (for example to turn a key).

Robust, lightweight Zytel® HTN

Fundamental to Touch Bionics' ability to produce the breakthrough device has been the company's willingness to adopt the latest materials and design techniques. This is exemplified by its selection of robust and lightweight DuPont™ Zytel® HTN semi-aromatic polyamide for the device's outer casing – a total of 33 components including the digits and controller housing surface. Protecting the sophisticated system of drives and motors within the i-LIMB Hand, the engineering polymer from DuPont is required to provide extreme impact resistance and dimensional stability without exceeding the required overall weight of the device.

As space was limited for the mechanical structure, a very strong and rigid grade of DuPont™ Zytel® HTN was required which actually has a similar elasticity-modulus to a human bone of 15 to 16 Gigapascal (GPa). Further key requirements, such as an extreme impact resistance and an appealing surface finish could also be met. The grade used in the i-LIMB application, from the Zytel® HTN53 series, is a high-performance semi-aromatic glass reinforced polyamide, developed for structural applications requiring high stiffness and impact resistance, with low moisture sensitivity that can be molded in water-heated tools at temperatures below 100°C (212°F) for an excellent surface appearance.

Stuart Mead, CEO of Touch Bionics, was impressed by DuPont's professional approach during more than twelve months of development work: "We have been working in partnership with DuPont to utilize their very latest materials to create a light and durable product that responds to the needs of the healthcare professional. In contrast to other prosthetics currently available, which are typically manufactured from aluminum or other metals, the ability to injection-mold the components of the i-LIMB Hand in Zytel® HTN enables us to provide lighter weight functionality for patients. In addition, our modular approach to developing common, interchangeable system components will make it viable to develop polymer components for all patient types at a low cost." Beyond provision of its material selection and processing expertise, DuPont has been proactive in its support of Touch Bionics and the i-LIMB project.

"DuPont has helped both in the logistics of having the components molded in Taiwan, as well as in the practicalities of supporting publicity for our new device by providing material for prototypes and assisting with promotional tools," adds Mead.

A new way of life

Touch Bionics is about to commence a marketing preference study of the i-LIMB Hand in the US and Europe. To date more than ten amputees have evaluated the prosthetic hand at different stages during development. "Feedback from study patients has been extremely positive and whilst we have concentrated on the obvious details of the technology, our patients have simply been delighted by the fact that the i-LIMB Hand moves anatomically like a real hand," comments Phil Newman, who runs sales and marketing at Touch Bionics.

While the company is guarded about the size of the market for its i-LIMB system, interest from the potentially massive US market has been "very encouraging indeed".

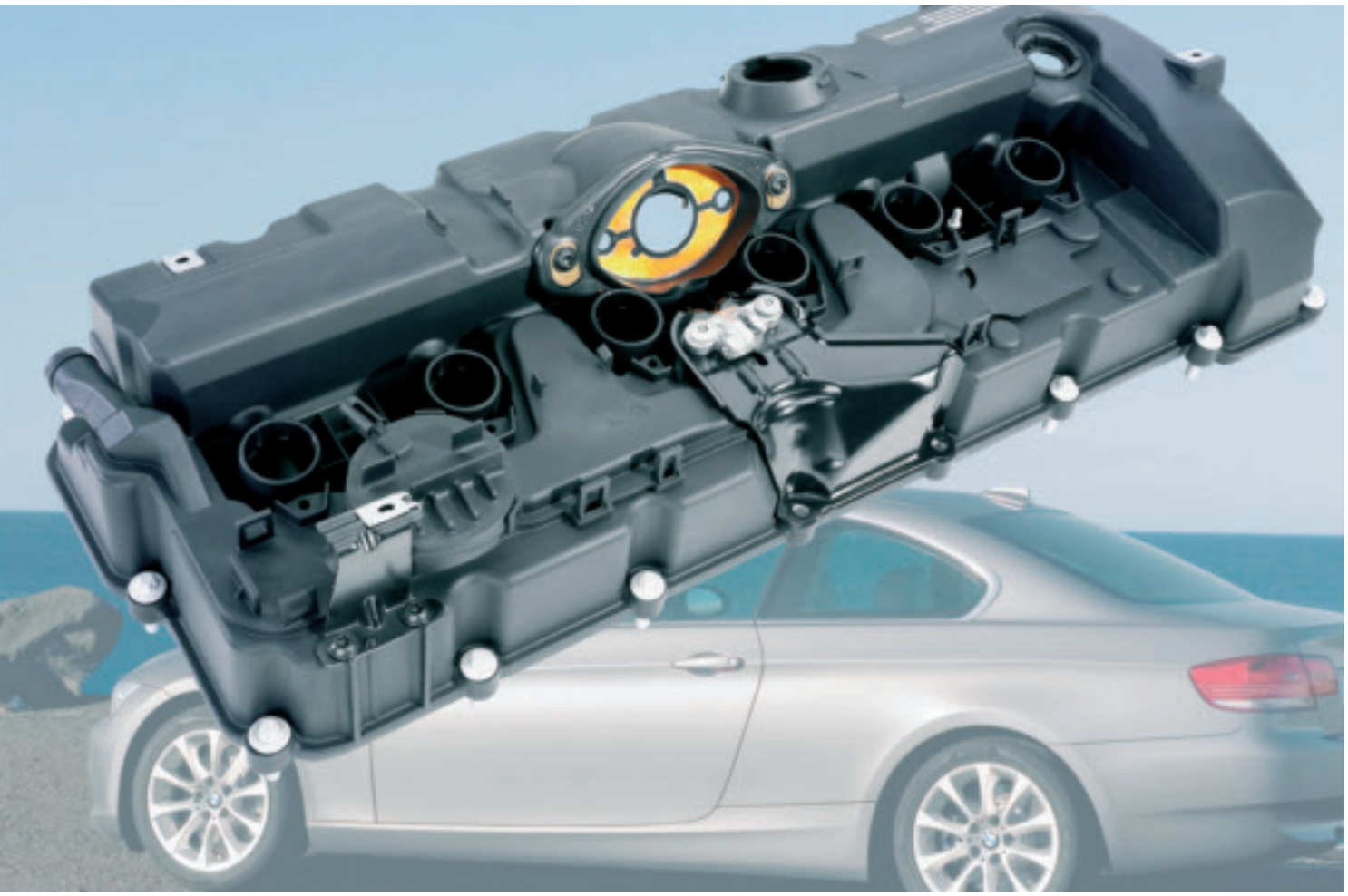
Yet beyond its predicted commercial success, the i-LIMB Hand constitutes a first demonstration of Touch Bionics' goal – to offer a new way of life for many amputees: "People will just be able to do so much more with it. Our product represents the next-generational step in upper-limb prosthetics and we are very excited about the pace at which the market has adapted to this new, enabling technology," concludes Newman.

Feedback from trial patients has been extremely positive, many of whom have simply been delighted by the fact that the i-LIMB Hand moves anatomically like a real hand.

CONTACT

Touch Bionics
19a Rutland Square
Edinburgh
Scotland
EH1 2BB
Tel: +44 (0)870 2251930
Fax: +44 (0) 845 280 5169
E-mail:
phil.newman@touchbionics.com
www.touchbionics.com

Multifunctional rocker cover made of Minlon®



The rocker cover of DuPont™ Minlon®, developed by systems supplier MAHLE for the six-cylinder VVT petrol engines from BMW, measures approximately 700 mm by 330 mm.

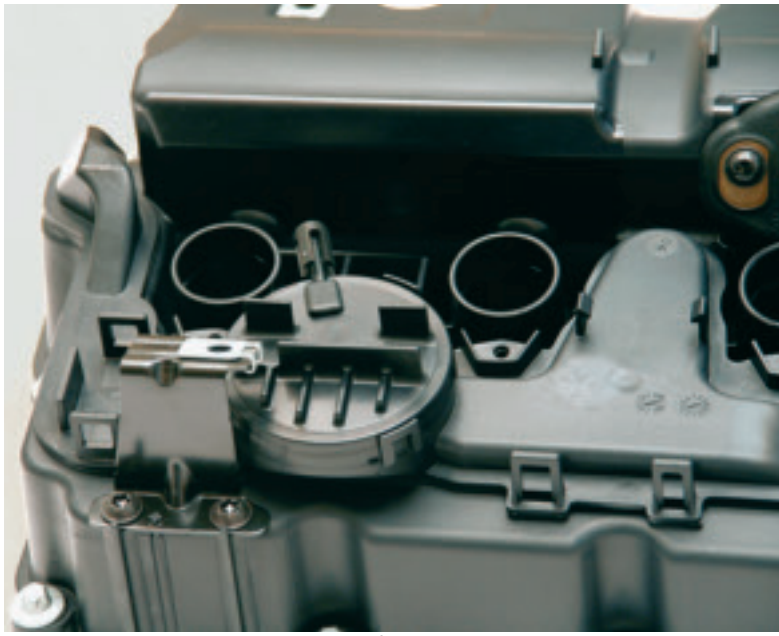
The systems supplier MAHLE has tailor-made a rocker cover for BMW, which performs a multitude of functions. Not only does it protect and seal, but it also cleans the blow-by-gases and provides dependable assembly support. DuPont™ Minlon® mineral reinforced nylon resin plays a significant role in the cost-efficient production of this particularly lightweight and reliable cover.

By Frank Sedler and Thomas Werner, DuPont Engineering Polymers, Germany

Over the last few years, rocker covers made from filled and reinforced nylons have become the established cost- and weight-saving alternatives to those made from sheet metal and metal casting. Yet despite their intensive use, one particular benefit of using injection-molded thermoplastics is still to be fully explored: the integration of various functional elements, thus avoiding the need for their separate manufacture or subsequent assembly. A new rocker cover made of DuPont™ Minlon® mineral reinforced nylon, developed by systems supplier MAHLE of Stuttgart, Germany, provides an impressive example of what can be achieved in this area.

Bringing out the best of PA66, minerals and glass-fibers

MAHLE supplies the cover, pre-assembled and functionally-tested, to BMW for use in its six-cylinder petrol engines with variable valve timing (VVT). The Minlon® nylon-66 grade specified for this highly-integrated, multifunctional part is both mineral-filled and glass-fiber reinforced. This combination of reinforcing material earns the large cover, measuring approximately 700 mm (27.5 in) long by 330 mm (13 in) wide, top marks in terms of stiffness, strength, low-warpage and dimensional stability. Moreover, it ensures such properties are maintained in external temperatures of -40 °C (-40 °F) as well as operating temperatures of up to – sporadically – 150 °C (300 °F).



The highly-integrated functionality of the Minlon® rocker cover makes it a cost-effective alternative to those made of metal.

Further reasons for the selection of Minlon® were its good weldability, enabling the cost-effective and secure attachment of additional components, and excellent surface properties, which means that the partially-visible cover can be used in unpainted form.

Acoustic and mechanical attenuation optimized

Traditionally a rocker cover is used to protect the valve control system and to prevent dirt from entering it, or indeed lubricating oil from polluting the environment. In addition to these basic functions – to provide a cover and secure seal even when the vehicle is at an extreme angle – the current MAHLE developments fulfill various acoustic and mechanical requirements that are tailored to the specific engine.

These include noise optimization, incorporation of sensor technology and – in the model developed for BMW – the six pencil coils, as well as the secure positioning of the flange-mounted servo-motor for adjusting the variable valve timing.

This latter requirement places great demands on the polymer's fatigue resistance, particularly when considering the vibrations it is exposed to and the weight of the servo-motor. Minlon® is inherently suited to such tasks, as it offers not only the required stiffness, but also high rates of attenuation, both in terms of the acoustical and mechanical vibrations that occur in the vicinity of the servo-motor's fixing. Working together with finite element specialists from DuPont, MAHLE was able to optimize the design in those parts primarily affected, and thus achieve the desired acoustic and mechanical properties with minimal material volume. Despite its large size, the cover only weighs just less than 3.8 kilograms (8.4 lbs).

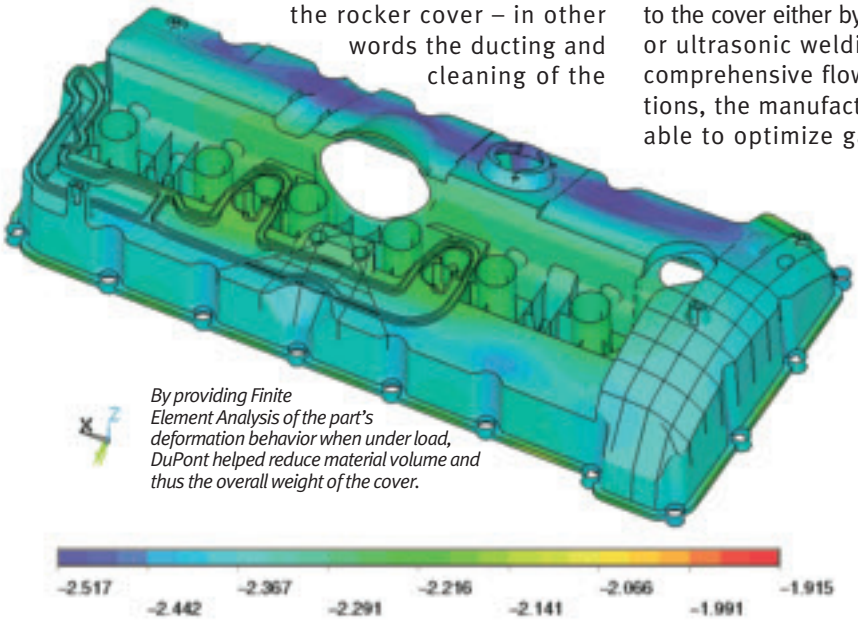
Functional diversity in one shot

In its design for BMW, MAHLE was also able to integrate blow-by-gas management into the rocker cover – in other words the ducting and cleaning of the aggressive mix of combustion products, oils, water and unburnt fuel. Thus the new cover for the six-cylinder VVT engine is responsible for crankcase ventilation, control of crankcase pressure and the separation of oil mist from blow-by-gases, and its subsequent return to the oil circulation system.

The majority of elements required for the above, such as valve units, cyclones, quick-connectors or snap-connections for the design cover, are produced in a single molding operation. Where this is not possible due to demolding restrictions, the mounted parts are produced separately and then securely and cost-effectively connected to the cover either by vibration or ultrasonic welding. With comprehensive flow simulations, the manufacturer was able to optimize gate positioning and mold flow at an early phase of its development. Application engineers from DuPont provided subsequent support in the stages from mold optimization and initial trials through to successful serial production.

Successful shake test

Finally MAHLE, in cooperation with DuPont, conducted long-term tests on the finished cover, inclusive of mounted parts, whereby it was exposed to extreme conditions on a shaker. Positive results gained from these tests, combined with the resistance of Minlon® to the chemicals found within blow-by-gases, the high temperatures and media found in the engine compartment, indicate that the highly-integrated multifunctional cover will provide reliable performance even when the car reaches the end of its own lifetime.



By providing Finite Element Analysis of the part's deformation behavior when under load, DuPont helped reduce material volume and thus the overall weight of the cover.

CONTACT

MAHLE International GmbH
Pragstrasse 54
70376 Stuttgart
Germany
Tel: +49 (0)711 501-14612
Fax: +49 (0)711 501-441 4612
E-mail: sales@mahle.com
www.mahle.com

Reliable signal protection in railroad joints

The robust NIJ-6 "Hercules" insulated joints play an essential role in current railroad circuit based signal systems by dividing the track into segments that detect train presence and activate trackside signals.

A new and innovative insulated joint (IJ) from Canadian company NorFast Inc. is helping to enhance railroad signal reliability in North America. The modular kit doubles the operational lifetime of the rail joint, reduces stress within the joint by over 60 percent and reduces the cost and time required for its installation – performance benefits which are largely attributable to the company's selection of flexible and resilient DuPont™ Hytrel® thermoplastic polyester elastomer for key insulating components.

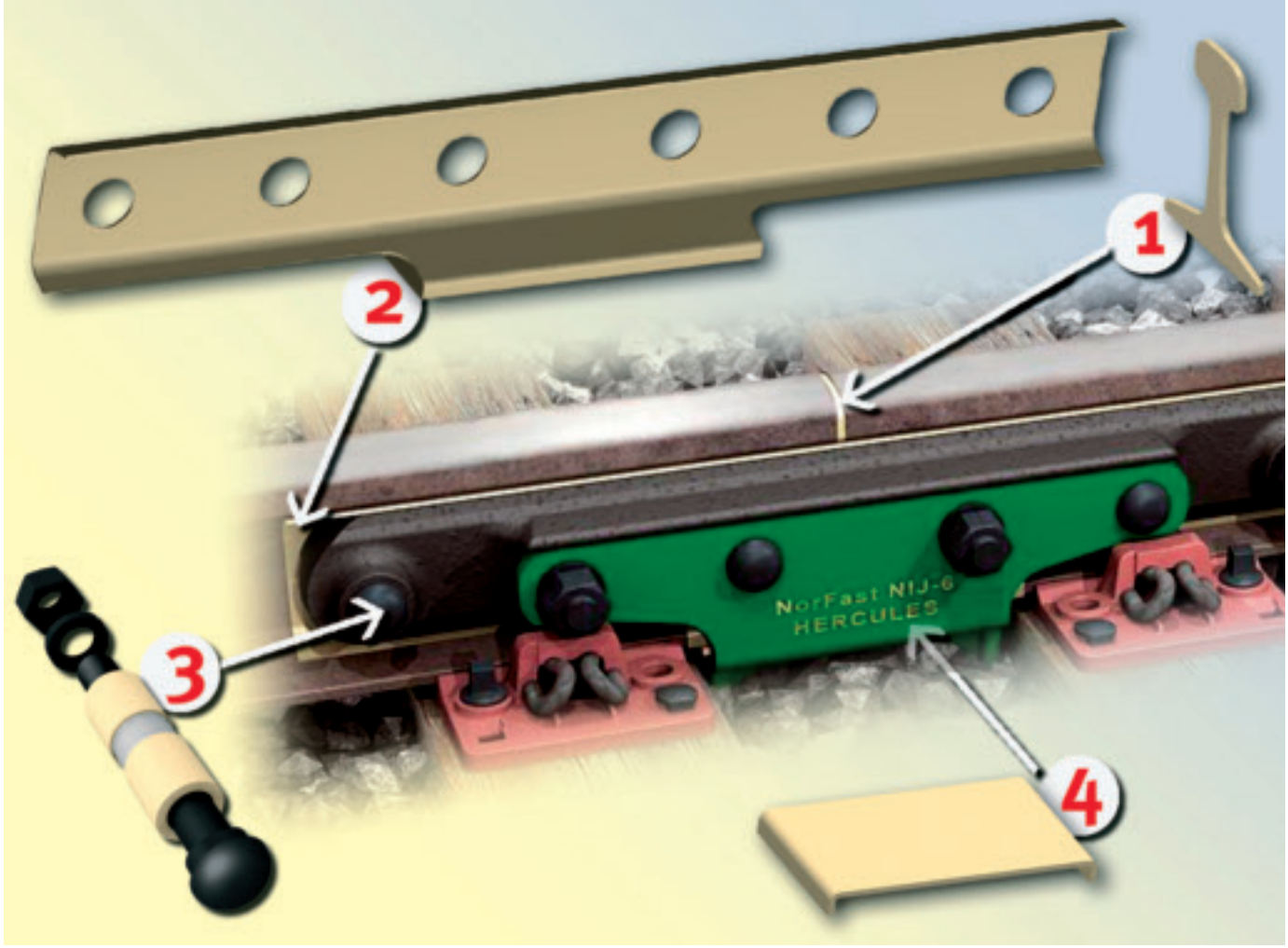
By Helga Plishka, DuPont Engineering Polymers, Canada

Insulated joints (IJs) play an essential role in current railroad circuit-based signal systems by dividing the track into short, electrically isolated segments or 'blocks', usually 2 to 5 miles (approximately 3 to 8 kilometers) in length, that detect train presence and activate trackside signals, as well as assisting railroad operators in the discovery of broken rails. Yet while IJs are essential to the delay-free operation of the track, they also introduce weak points which can cause increased maintenance and service disruptions, thus constituting a potential derailment risk.

Epoxy bonding weaknesses

This was also the conclusion of Canadian railroad fastener-system manufacturer NorFast Inc., which resolved to provide its own innovative solution. Dr. Jude Igwemezie, president of ARRT Inc, NorFast's sister design company, explains: "It was our belief that current bonded IJ designs, whereby a steel joint is bolted and glued into the middle of the rails using an epoxy, were inappropriate for today's high tonnage lines. A key issue was the use of the epoxy resin as an insulating material for isolating rail sections. It is brittle and responds poorly to the high tensile and flexural forces exerted on the rails. As a result the epoxy would start to de-bond, causing the bars or bolts used in the joint to make contact with the rails and short out the signal in each block, which in turn would falsely indicate the presence of the train in the rail section."

As a direct result of the material deficiencies in bonded joints, the expected lifetime of the IJs was only 12 to 18 months on high tonnage



The NIJ-6 "Hercules" consists of seven principle parts, four of which are made from DuPont™ Hytrel® thermoplastic polyester elastomer: (1) for the insulating end post between the two adjacent rails; (2) as a liner between the bar and the rails; (3) in the patented thimble design that isolates and strengthens the six fixing bolts;(4) and as an insulating pad between the rail and integral saddle.

lines, with direct costs of thousands of dollars per mile per year for their maintenance. Furthermore, the installation of repairs required two welds in the track to incorporate a replacement joint, which in turn introduced new weak points in the rail and lengthened track-closure time.

Hytrel®: a tailor-made solution

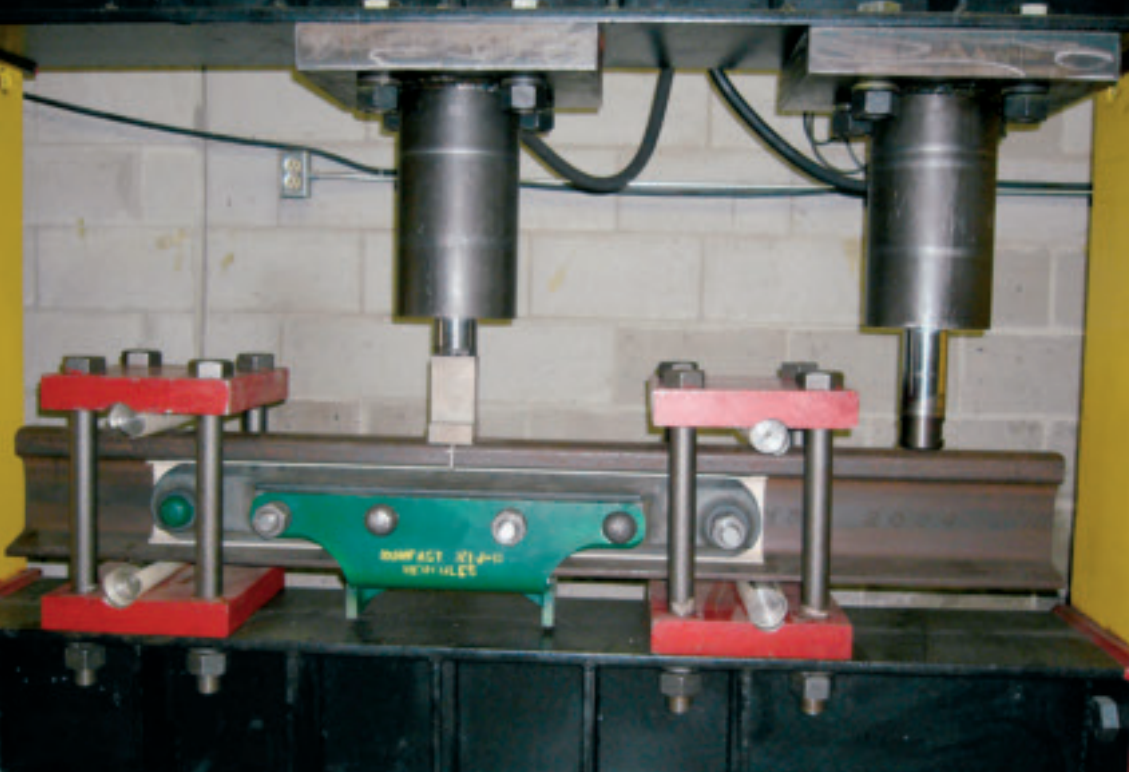
It was against this background that NorFast developed the NIJ-6 "Hercules", a stronger, more resilient mechanical IJ designed to eliminate the need for in-track welding and thus reduce installation times. Fundamental to its two-year development project was the selection of an insulating material able to withstand the severe load environments of modern high tonnage lines, and to reduce stress within the joint's components.

"Following the advice of Canadian polymer distributor CCC Plastics, we briefed DuPont of our requirements and DuPont™ Hytrel® thermoplastic polyester elastomer emerged as the tailor-made solution," says Dr. Igwemezie of the material selection process. A particularly flexible and durable grade of Hytrel® with high resistance to creep, impact and fatigue is used for four parts of the new NIJ-6 kit: for the insulating end post between the two adjacent rails; as a liner between the bar and the rails; in the patented thimble design that isolates and strengthens the six fixing bolts; and as an insulating pad between the rail and integral saddle.

The simple, in-field installation of the NIJ-6 "Hercules" saves two weld points while its modular construction means that worn components can be replaced quickly and with minimal disruption for a brand new joint.

However, the adoption of Hytrel® presented a steep learning curve for Dr. Igwemezie and his team, who had limited experience of polymer processing – an area where DuPont was able to provide invaluable assistance.

Further to support in initial prototype testing, DuPont helped source the material and manufacturing expertise to produce the first 1,000 insulating liners for field testing.



Fatigue testing of the joint at 60,000 pounds (27,000 kilograms) vertical loads for 3 million cycles showed no wear or damage to its parts, including those made of Hytrel®. Parts made with other polymers, and tested by NorFast on the same rig, were destroyed in under half a million cycles.

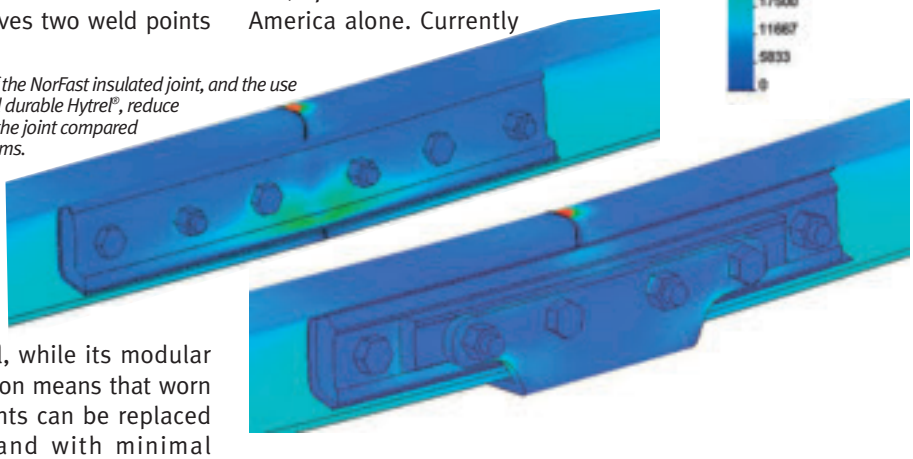
During the course of this work, injection molding was found to be the least economical option for part production due to the associated tooling costs. DuPont therefore investigated extrusion and thermoforming processes with several partner companies, before providing NorFast with data that enabled them to design their own thermoforming tool to produce the liner and pad. The spherical Hytrel® parts for the bolt thimbles were provided by a separate extrusion company.

Outstanding results

The performance of NorFast's NIJ-6 bears comparison with similar systems: the section modulus of the new IJ is greater than that of the rail, while fatigue testing of the joint at 60,000 pounds (27,000 kilograms) vertical loads for 3 million cycles showed no wear or damage to its parts, including those made of Hytrel®. Insulator stress within the joint is reduced by up to 65 percent compared with a standard joint, whereas thimble insulator stress is reduced by up to 75 percent.

Meanwhile, the integration of a saddle in the design provides structural redundancy in the unlikely event of bar failure and increases overall joint strength.

Its simple, in-field installation, which fits any type track and fastener without track modification, saves two weld points in the rail, while its modular construction means that worn components can be replaced quickly and with minimal disruption, creating a brand new joint.



The design of the NorFast insulated joint, and the use of flexible and durable Hytrel®, reduce stress within the joint compared to other systems.

Such is the confidence of NorFast in the longevity of its new system, the company intends to offer a 3-year or 400-million-gross-tons warranty on its continued operation.

The net result for passenger and freight railroad operators will be the availability of a new, innovative system that helps ensure track signal reliability and reduces train delays through IJ failures.

NorFast estimates the market potential of its new IJ at over US$ 70 million in North America alone. Currently over 100 NIJ-6 "Hercules" systems are being tested on passenger and haulage lines across the US and Canada before commercial availability.

The testing period will be defined to include twelve months of summer and winter conditions, whereby the NIJ-6 is expected to be exposed to seasonal temperature variances of between -40°C (-40°F) and 70°C (158°F). Yet Dr. Igwemezie remains confident in the success of the NorFast product, in no small way attributable to the company's cooperation with DuPont: "It would have been a lot more difficult for us to get where we are today, and as quickly as we did, without the polymer engineering and manufacturing logistics of DuPont. It is a wonderful case of management and engineers from both sides working on the development of a railway track safety device."

CONTACT

Norfast Inc.
2-9446 McLaughlin Rd.
North Brampton
Ontario
Canada L6X 4H9
Tel.: +1 (905) 454-8687
Fax.: +1 (905) 452-1640
E-mail: norfast@norfast.com
www.norfast.com

Can you answer the following?

What is the difference between the Charpy, the Izod and tensile impact tests? How does glass-fiber reinforcement affect the elongation of engineering polymers? Do you know the various types of flame-retardant additives and the factors that influence their choice? Why do polyamides show better resistance to gas and diesel fuels than polyesters?

The decoration on these snow-board binding parts made of Zytel® nylon is applied by means of sublimation. The decoration is scratch- and abrasion-resistant, because, with this new technology, the inks are absorbed into the surface of the plastic.

Designers and engineers who are new to the use of engineering plastics probably need some help in answering questions like these. But even the experienced will benefit from refreshing their knowledge; is it still up to date? For the answers to these and many other questions, go to DuPont's new website called "What Can Plastics Do?" Here DuPont recently added a series of articles under the collective title 'Choosing the Right Plastic for the Job' to its huge library of on-line documentation.

The articles cover product selection in general, and a variety of related topics, including:

- *The role played by stiffness and strength*
- *The most important properties in electrical and electronic applications*
- *What flame-retardant additives can do*
- *Heat-resistance and related issues*
- *The effect of reinforcing materials such as minerals and fibers*
- *Brittleness and toughness: the fracture behavior of plastics*
- *Soft, flexible plastics for uses such as automotive hose and CVJ boots*
- *The surface qualities of plastics, and how to enhance them with various decorative processes*
- *The resistance of plastics to fuels, oils and chemicals*
- *Abrasion-resistance and friction*
- *Choosing the right plastics for molding thin-walled parts.*

These on-line articles are not restricted to consideration of DuPont's range of engineering plastics; they provide information about engineering plastics in general.

And, of course, they are accessible to all, not only to DuPont customers.

A design in engineering plastics can succeed only if the designer has a thorough understanding of these high-performance materials: their properties, their astonishing versatility and their ability to replace metals in many applications, as well as their limitations.

DuPont's wealth of on-line information, based on almost 70 years of accumulated experience, can give designers, engineers and plastics processors authoritative help in product selection, design and processing—in short, how to get the best out of these materials.

On the website you will also find case histories, design manuals, trouble-shooting tips, technical brochures and data sheets. For more detailed support and counseling on all aspects of engineering plastics, skilled and experienced DuPont technical service staff are on call – worldwide.

Whether the objective is aesthetic or functional, plastics are problem-solvers in objects of everyday use as well as in industrial equipment, vehicles and industrial machinery. Clockwise, from bottom left: SIM card holder in Zytel® HTN, hair dryer in Zytel®, clutch in Hytrel®, gear drive in Delrin®, connector plug in Crastin®, conveyor chain in Delrin®. In the middle: rocker cover in Zytel®.

For the answers to these questions and many more visit: "What Can Plastics Do?"

EUROPE/MIDDLE EAST/AFRICA

Belgique / België
Du Pont de Nemours (Belgium)
Antoon Spinoystraat 6
B-2800 Mechelen
Tel. +32 15 44 14 11
Telefax +32 15 44 14 09

Bulgaria
Serviced by
Biesterfeld Interowa GmbH & Co. KG.
See under Österreich.

Ceská Republika a
Slovenská Republika
Du Pont CZ, s.r.o.
Pekarska 14/268
CZ-155 00 Praha 5 – Jinonice
Tel. +42 257 41 41 11
Telefax +42 257 41 41 50-51

Danmark
Du Pont Danmark ApS
Skjøtevej 26
P.O. Box 3000
DK-2770 Kastrup
Telefax +45 32 47 98 05
Telefax +45 32 47 98 05

Deutschland
Du Pont de Nemours
(Deutschland) GmbH
DuPont Straße 1
D-61343 Bad Homburg
Tel. +49 6172 87 0
Telefax +49 6172 87 27 01

Egypt
Du Pont Products S.A.
Bldg no. 6, Land #7, Block 1
New Maadi
ET-Cairo
Tel. +202 754 65 80
Telefax +202 516 87 81

España
Du Pont Ibérica S.A.
Edificio L'Illa
Avda. Diagonal 561
E-08029 Barcelona
Tel. +34 227 60 00
Telefax +34 227 62 00

France
DuPont de Nemours (France) SAS
Défense Plaza
23/25 rue Delarivière Le Foullon
Défense 9
92 064 La Défense Cedex
Phone: +33 (0)1 41 97 44 00
Telefax +33 1 47 53 09 67

Hellas
Biesterfeld Hellas Intralink S.A.
Trading Establishment
149, AG. Triados Menidi Acharnes
GR-13671 Athens
Tel. +30 210 24 02 900
Telefax+30 210 24 02 141

Israël
Gadot Chemical Terminals (1985) Ltd.
16 Habonim Street
Netanya – South Ind. Zone
IL-42504 Netanya
Tel. +972 3 526 42 41
Telefax +972 3 528 27 17

Italia
Du Pont de Nemours Italiana S.r.L.
Centro Direzionale "Villa Fiorita"
Via Piero Gobetti, 2/A
20063 Cernusco s/N (MI)
Tel. +39 02 92629.1 (switchboard)
Fax +39 02 36049379

Magyarország
DuPont Magyarország Kft.
HU - 2040 Budaörs
Neuman J.u. 1
Tel. +36 23 509 400
Telefax: +36 23 509 432

Maroc
Deborel Maroc S.A.
40, boulevard d'Anfa – 10°
MA-Casablanca
Tel. +212 227 48 75
Telefax +212 226 54 34

Norway / Norge
Distrupol Nordic
Ostenssjoveien 36
N-0677 Olso
Tel. +47 23 16 80 62
Telefax +47 23 16 80 62

Österreich
Biesterfeld Interowa GmbH & Co. KG
Bräuhausgasse 3-5
P.O. Box 19
AT-1051 Wien
Tel. +43 1 512 35 71-0
Fax +43 1 512 35 71-31
e-mail: info@interowa.at
internet: www.interowa.at

Polska
Du Pont Poland Sp. z o.o.
ul. Powazkowska 44C
PL-01-797 Warsaw
Tel. +48 22 320 0900
Telefax +48 22 320 0910

Portugal
Biesterfeld Iberica S.L.
Rua das Matas
P-4445-135 Alfena
Tel. +351 229 698 760
Telefax +351 229 698 769

Romania
Serviced by
Biesterfeld Interowa GmbH & Co. KG.
See under Österreich.

Russia
DuPont Russia LLC.
ul. Krylatskaya 17/3
121614 Moscow
Tel. +7 495 797 22 00
Fax. + 7 495 797 22 01

Schweiz / Suisse / Svizzera
Biesterfeld Plastic Suisse GmbH
Dufourstrasse 21
Postfach 14695
CH-4010 Basel
Tel. +41 61 201 31 50
Telefax +41 61 201 31 69

Slovenija
Serviced by
Biesterfeld Interowa GmbH & Co. KG.
See under Österreich.

Suomi / Finland
Du Pont Suomi Oy
PO Box 54 (Keilaranta 12)
FI-02150 ESPOO
Tel: +358 207 890500
Fax: +358 207 890501

Sverige
Serviced by
Du Pont Danmark ApS.
See under Danmark.

Türkiye
Du Pont Products S.A.
Buyukdere Caddesi No. 122
Ozsezen Ismerkezi, A block, Kat: 3
Esentepe, 34394 Istanbul
Tel. +90 212 340 0400
Telefax +90 212 340 0430

Ukraine
Du Pont de Nemours
International S.A.
Representative Office
3, Glazunova Street
Kyiv 252042
Tel. +380 44 294 96 33 / 269 13 02
Telefax +380 44 269 11 81

United Kingdom
Du Pont (UK) Limited
Wedgwood Way
Stevenage
Hertfordshire SG1 4QN
Tel. +44 1438 734000
Telefax ++44 1438 734109

South Africa
DuPont de Nemours
Societe Anonyme
South African Branch Office
4th Floor Outspan House
1006 Lenchen Avenue North
Centurion
Pretoria 0046
Tel. +27 0 12 683 5600
Telefax +27 0 12 683 5661

NORTH AMERICA

USA
DuPont Engineering Polymers
Barley Mill Plaza, Building 26
P. O. Box 800026
Wilmington, Delaware 19880
Tel. +1 302 992 4592
Telefax +1 302 992-6713

DuPont Automotive
950 Stephenson Highway
P.O. Box 7013
Troy, MI 48007-7013
Tel. +1 248 583-8000

Canada
DuPont Engineering Polymers
P.O. Box 2200
Streetsville, Mississauga
Ontario, Canada L5M 2H3
Tel. +1 905 821-5953

Mexico
DuPont S.A. de C.V.
Homero 206
Col. Chapultepec Morales
11570 Mexico D.F.
Tel. + 525 557 221 000

SOUTH AMERICA

Argentina
Du Pont Argentina S.A.
Avda. Mitre y Calle 5
(1884) Berazategui-Bs.As.
Tel. +54 11 4239-3868
Telefax +54 11 4239-3817

Brasil
DuPont do Brasil S.A.
Al. Itapecuru, 506 Alphaville
06454-080 Barueri-Sao Paulo
Tel. + 5511 7266 8229

ASIA-PACIFIC

Australia
DuPont (Australia) Ltd.
168 Walker Street
North Sydney NSW 2060
Tel: +612 9923-6111
Fax: +612 9923 6011

Hong Kong/China
DuPont China Ltd.
26/F, Tower 6, The Gateway,
9 Canton Road
Tsimshatsui, Kowloon, Hong Kong
Tel: +852 2734 5345
Fax: +852 2724 4458

Shanghai/China
DuPont China Holding Co. Ltd.
15/F., Shui On Plaza
333 Huai Hai Road (Central)
Shanghai 200021
Tel: +86 21 6386 6366
Fax: +86 21 6386 6333

India
E.I. DuPont India Limited,
"Arihant Nitco Park" Sixth floor,
90, Dr. Radhakrishnan Salai,
Mylapore,
Chennai 600 004
Tel: +91 44 28472800
Fax: +91 44 28473800

Japan
DuPont Kabushiki Kaisha
Sanno Park Tower, 11-1
Nagata-cho 2-chome
Chiyoda-ku, Tokyo 100-6111
Japan.
Tel: +81 3 5521 8500
Fax: +81 3 5521 2595

Korea
DuPont (Korea) Ltd.
4/5 Floor, Asia Tower
#726, Yeoksam-dong, Kangnam-Ku
Seoul 135-082
Tel: +822 2222-5200
Fax: +822 2222-5470

Singapore
Du Pont Company (S) Pte Ltd
1 HarbourFront Place #11-01
HarbourFront Tower One
Singapore 098633
Tel: +65 6586 3688
Fax: +65 6272 7494

Taiwan
DuPont Taiwan Ltd.
Hung Kuo Building, 13th floor
#167 Tun Hwa North Road
Taipei 105
Tel: +8862 2719-1999
Fax: +8862 2719-0852

Thailand
DuPont (Thailand) Limited
6-7th Floor, M. Thai Tower
All Seasons Place
87 Wireless Road
Lumpini, Phatumwan
Bangkok 10330
Tel : +66 2 659 4000
Fax : +66 2 659 4001

CRASTIN® PBT
THERMOPLASTIC POLYESTER RESIN

DELRIN®
ACETAL RESIN

HYTREL®
THERMOPLASTIC POLYESTER ELASTOMER

MINLON®
MINERAL REINFORCED NYLON RESIN

RYNITE® PET
THERMOPLASTIC POLYESTER RESIN

THERMX® PCT
HIGH PERFORMANCE POLYESTER

TYNEX®
NYLON MONOFILAMENT

VESPEL®
PARTS AND SHAPES

ZYTEL®
NYLON RESIN

ZYTEL® HTN
HIGH PERFORMANCE POLYAMIDE

ZENITE® LCP
LIQUID CRYSTAL POLYMER

DUPONT™ ETPV
THERMOPLASTIC RUBBER THAT RESISTS OIL & HEAT

Publisher: Evelyne Schütz,
DuPont Engineering Polymers,
2, ch. du Pavillon
CH-1218 Le Grand-Saconnex
Geneva
Switzerland
Tel: +41 22 717 51 11
Fax: +41 22 717 52 00

Editor: Andrew Wilkins

Layout & production: Johan Hedqvist, Geneva

Engineering Design is published in English, French, German, Italian, Spanish and Russian by Du Pont de Nemours International S.A., P.O. Box 50, CH-1218 Le Grand-Saconnex, Geneva, Switzerland.

Printed in Switzerland

L-13879

www.plastics.dupont.com

To get Engineering Design in an e-format, go to http://www.engineeringpolymers.com/engdesign/

The miracles of science™