

October 2017

PUreview

REPORTING THE WORLD OF POLYURETHANES FOR OUR CUSTOMERS

HUNTSMAN

Enriching lives through innovation

IFS acquisition strengthens Huntsman's downstream capabilities in Europe

**High grip, slip resistant, soft TPU
provides alternative to rubber**

**Low emission solutions for
the automotive industry**

**VITROX® resins used in
high performance motorbike**

**RIMLINE® technology used to build
nine-meter prototype wind turbine blade**



Strengthening our downstream position in Europe

Tony Hankins, President, Huntsman Polyurethanes

Twice a year, *PU Review* showcases the latest innovations and business developments across our global organization. This issue, we give you an insight into our most recent downstream acquisition, IFS Chemicals, one of the UK's leading independent formulators of methylene diphenyl diisocyanate- (MDI) based systems. The business, which is based in Norfolk, England, was acquired in May and is now known as Huntsman IFS.

I recently had the chance to meet the Huntsman IFS team and am excited by the opportunities that lie ahead. With their highly experienced team and loyal customer base, Huntsman IFS provides us with excellent access to the UK's growing downstream MDI systems market. It will serve as a strategic platform to expand our business and consolidate our position as a market leader. The acquisition represents the latest step in our plan to strengthen our differentiated downstream capabilities and we now have almost 30 facilities worldwide, reflecting our confidence in the long-term growth prospects for MDI-based urethanes. I hope you enjoy the interview with IFS founder and Managing Director, Barrie Colvin, and new Director Iain Stanton on pages 8 to 10.

Also in this issue, there's the usual wide range of stories, which cover many different product applications, including low emission solutions for the automotive industry; how thermoplastic polyurethanes are replacing rubber in footwear applications; and how our RIMLINE® technology is being used to build nine-meter prototype wind turbine blades. As regular readers well know, the uses and benefits of MDI are seemingly endless!



New TEROL® polyester polyol for insulation applications

The Huntsman Polyurethanes team has developed TEROL® 573 aromatic polyester polyol – a high-functionality, aromatic polyester polyol for rigid foam systems.

The latest addition to Huntsman's polyester polyol family, TEROL® 573 polyol features enhanced pentane processing and improved fire performance.

Compatible with new blowing agents including hydrocarbons (HCs), hydrofluorocarbons (HFCs) and hydrofluoroolefins (HFOs), TEROL® 573 polyol promotes material efficiencies by reducing the amount of polyether polyols and flame-retardants needed.

TEROL® 573 polyol is ideal for roofing and wall insulation systems for residential and commercial applications, and can improve foam insulation performance in an array of testing protocols. Foam panels produced with this high-performing product can pass the Factory Mutual 4450 Calorimeter test and ASTM E-84 tunnel tests. Additionally, TEROL® 573 polyol is UL validated and contains a minimum of 27% pre-consumer recycled content.

Sheila Patel, Americas Industry Manager at Huntsman Polyurethanes, said: "TEROL® 573 polyol is a great new addition to our already extensive line of energy-saving, aromatic polyester polyols. This enhanced polyol allows our customers to address their needs in a variety of insulation products including boardstock, insulated metal panels and more. Importantly, it can also improve material properties and fire performance through lower stable foam densities."

With hydroxyl values ranging from 120 to 350, Huntsman Polyurethanes offers one of the broadest ranges of aromatic polyester polyols available for rigid foam thermal insulation applications. Polyol solutions available can be tailored to meet customer specifications across the insulation value chain. The business also offers a full line of JEFFOL® polyether polyols. |

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Team awarded SPFA certification

The Spray Polyurethane Foam Alliance (SPFA) has certified Huntsman Polyurethanes as an Accredited Supplier Company.

The designation acknowledges the high level of technical knowledge and professionalism that Huntsman demonstrates, and its commitment to the continual improvement of the spray polyurethane foam (SPF) industry. The certification also recognizes that Huntsman has met all necessary requirements when it comes to SPF training and health and safety.

SPFA Accredited Supplier Company status is part of the SPFA Professional Certification Program (PCP) – one of the most rigorous and extensive schemes for SPF professionals in the world. The program measures essential knowledge, skills and abilities inherent among the highest class of SPF professionals. |

To earn its accreditation, the Huntsman Polyurethanes team had to fulfill a number of criteria, giving evidence that the business provides:

- **Supplier-offered training programs**
- **Designated on-staff personnel including:**
 - **Certified supplier representative(s) to liaise with the SPFA**
 - **Written and field examiner(s)**
 - **Best practice/risk management program verification**
 - **Supplier-offered written and field exam(s).**

To find out more about Huntsman's SPF work, please contact: eric_stebel@huntsman.com



Kevin Buck appointed head of PDA

Kevin Buck, Americas Industry Manager for Huntsman Polyurethanes' Adhesive, Coatings and Elastomers (ACE) division, has been appointed President of the Polyurea Development Association (PDA) – a global organization focused on polyurea training and education.

Established in 2000, the PDA focuses on education and the correct application of polyurea products in an effort to advance and promote polyurea and polyurethane elastomeric technologies. The association offers training via the development and delivery of industry approved education programs.

Kevin joined Huntsman Polyurethanes in 1993, shortly after graduating from the University of Michigan with a B.S.E. in Chemical Engineering. Initially, he worked in the company's automotive business – developing technologies for sound insulation applications – before moving to the Adhesives, Coatings and Elastomers team in 2003.

Commenting on his appointment, Kevin said: "My biggest focus this year as President of the PDA will be to ensure the association is delivering benefits and value to its members. I am incredibly excited to take on this challenge and look forward to using my experience with Huntsman Polyurethanes to bring a fresh perspective and new ideas to the table." |

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PDA focuses on education and the correct application of polyurea products.



Footwear manufacturers looking to produce high grip outsoles with good wet slip resistance properties have a new, soft, thermoplastic polyurethane (TPU) at their disposal – thanks to the team at Huntsman.

New high grip, slip resistant, soft TPU provides alternative to rubber

Delivering a new level of slip resistance for a soft TPU, AVALON® 50 AHG TPU is a suitable replacement for rubber in a variety of outsole applications. Softer than most standard TPU grades, this innovative polyester-based material has a nominal shore hardness of 50A, but can offer slip resistance properties on a par with vulcanized rubber.

Providing outstanding anti-slip performance on both wet and dry surfaces, AVALON® 50 AHG TPU enables footwear manufacturers to make soft, thin, high definition, high grip, non-marking parts in a variety of colors.

Appropriate for use in almost all footwear applications, AVALON® 50 AHG TPU is particularly well suited to the production of safety footwear. Oil and petrol resistant, it has excellent electro-static discharge properties and complies with ISO 13287 – the international benchmark for testing slip resistance in protective and personal equipment.

Alongside its physical performance properties, AVALON® 50 AHG TPU also has a number of

processing advantages. Easy to use, it has excellent fluidity – meaning standard injection molding cycle times can be achieved. Demolding is also very straightforward. AVALON® 50 AHG TPU is suitable for the production of dual density footwear on carousel machines in combination with innovative DALTOPE® polyurethane midsole systems.

Alfons Tremml, Commercial Manager at Huntsman Polyurethanes, said: “We knew, from speaking to our footwear customers, that there was real demand for a soft TPU grade that could deliver comparable slip resistance properties to rubber. Combining the benefits of a TPU with a soft feel, and substantially improved levels of wet slip resistance, AVALON® 50 AHG TPU is designed to satisfy that need. During our in-house slip resistance tests, AVALON® 50 AHG TPU performed up to 30% better than reference materials, which were created using identical molds and evaluated under exactly the same trial conditions. This step forward in grip and wet slip resistance will make AVALON® 50 AHG TPU an attractive

proposition for outsole production across a range of footwear applications.”

The development of AVALON® 50 AHG TPU increases the range of polyurethane-based solutions that Huntsman can offer manufacturers creating safety shoes, casual unit soles and footwear for sports and lifestyle applications. AVALON® 50 AHG TPU is part of an extensive portfolio of products that Huntsman has developed to satisfy the design and production requirements of modern footwear manufacturers. |

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New TPU product selector

The thermoplastic polyurethanes (TPU) team at Huntsman has developed an online product selector tool that is designed to make it easier for customers to find the perfect material for industrial and consumer-focused projects.

The website – www.huntsman-tpu.com – provides a complete overview of all of Huntsman's key TPU brands and includes information about the top 100 or so TPU products available from the business.

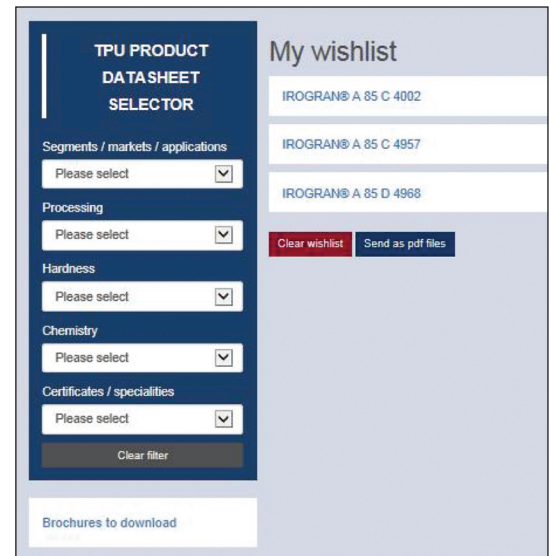
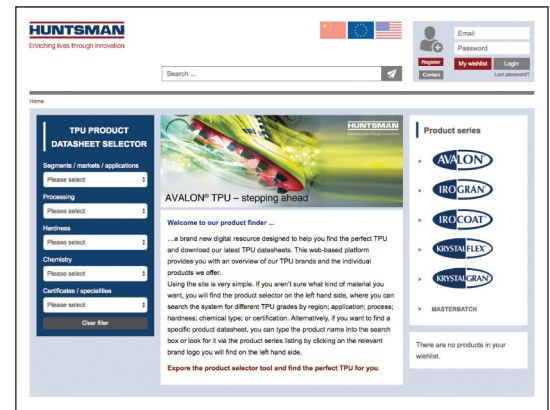
Using the Huntsman TPU product selector tool is really simple. Visitors to the site, who are unsure about what kind of material to use, can search the system for different TPU grades by region; application; process; hardness; chemical type or certification. Alternatively, information about specific products can be found by typing the name into the search box or by looking at the product series listings and clicking on the relevant brand logos.

Once the right TPU has been identified, there are several options – depending on whether an individual is a registered or non-registered user of the product selector. Non-registered users can search the site for product information; add products to an online wish list for future reference or contact the Huntsman team for more information using the on-site button provided. Registered users have the same search, wish list and contact options at their disposal, but can also view and download datasheets, or email them to a colleague for their consideration.

Registering to use the Huntsman TPU product selector tool is easy. Just click the register button at the top of the home page, provide contact details and create a password. Login details generated need to be remembered for next time. However, there is a lost password link at the top of the home page – just in case details get forgotten or misplaced.

Go to: www.huntsman-tpu.com to explore the product selector tool and find the perfect TPU. |

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Huntsman participates in heating efficiency seminar

The promotion of green buildings is a major priority in China – the world's largest construction market.



Faced with continuing, rapid urbanization and industrialization, the Chinese government is committed to the development of sustainable buildings. It is also actively encouraging the adoption of products and technologies that can help deliver aggressive energy savings and new levels of environmental protection.

As a leading provider of insulation systems to the global construction sector, Huntsman recently took part in the 4th (2017) Heating Project Construction and Efficient Operation Seminar – an event co-organized by the North China Municipal Engineering Design & Research Institute Co., Ltd., and *Gas & Heat* magazine.

At the event in Jiaxing City, Bingli Su, Commercial Director of Huntsman Polyurethanes China, discussed the availability of polyurethane-based pipe insulation products. Speaking to construction industry decision makers and journalists, he talked about the benefits polyurethane insulation can bring to the overall efficiency of central heating systems. He also outlined Huntsman's footprint in the sector and shared insights into the development of this important part of the Chinese construction market.

For more information about Huntsman's pipe insulation products, please contact: |

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New low emission solutions for the automotive industry

Combining low VOC and fog emissions with formaldehyde reduction



Emissions from volatile organic compounds (VOCs) used in vehicle interiors have been an area of concern for the automotive industry for some time. Car manufacturers, along with government officials and agencies, are working together to try to reduce and eliminate emissions from seating, headrest and interior trim components that can have a detrimental effect on in-car air quality.

To help automotive manufacturers achieve their objectives, Huntsman has developed a range of solutions that can reduce emission levels in polyurethane foams employed in various automotive applications. The company's latest technologies include low VOC and low fogging amine catalysts, plus a range of novel aldehyde scavenging additives.

PU Review spoke to Huntsman's Frank Rodriguez, Senior Scientist, and Geert Dries, Application Specialist, to find out more about the company's work in this area and the benefits of using these new technologies – both independently and in conjunction with one another.

Providing an overview of the origins of volatile emissions from interior components, Frank Rodriguez said: "When it comes to in-car air quality, there are many different potential VOC sources – some primary, some secondary and some environmental. In the case of polyurethane-based parts, primary VOC sources can include some of the raw materials used to make polyols, surfactants, amine catalysts and isocyanates – core components in polyurethane foam production. Processing aids, used to help achieve higher production yields, are another primary VOC source. VOC emission levels can also be affected by the improper cleaning of vessels, storage containers, transferring equipment and piping.

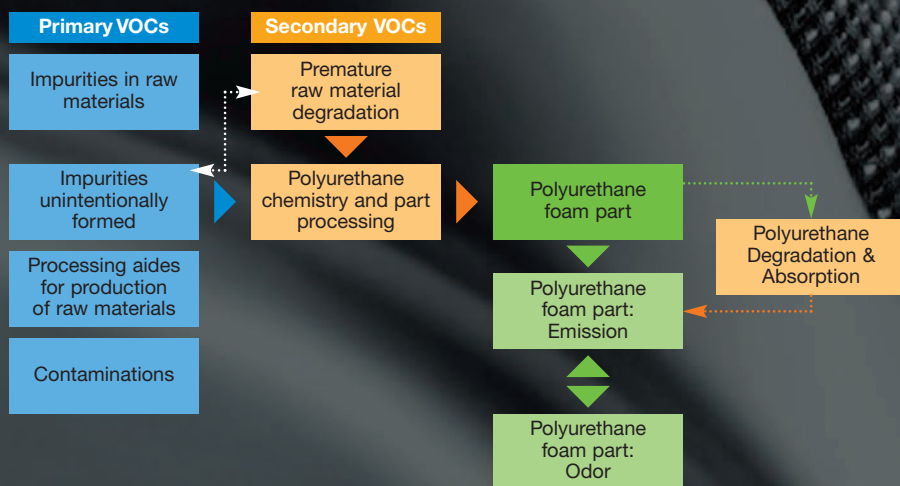
"Secondary VOC sources are defined as emissions arising from the components needed for the manufacture of polyurethane foam, e.g., the actual polyols, surfactants, amine catalysts and isocyanates. Under certain conditions, these components can start to degrade and generate emissions – for example, at low isocyanate indexes, at high mold temperatures or at the high exothermic temperatures required during the polyurethane foaming process.

"Polyurethane foam can also absorb emission-producing contaminants from the manufacturing environment. If this occurs, the result may be an increase in overall emissions and, potentially, costly part test failures. Causes might include improper handling or manufacturing processes e.g., using gas-powered transportation equipment can create exhaust fumes that can be absorbed by a foam. As such, careful management of the polyurethane foam-processing environment is critical."

Responding to the automotive industry's emission reduction ambitions, Huntsman has developed several innovative foam additives, which make it easier to develop low emission formulations that will pass stringent VOC and fog emission tests. The first product is a family of low emission JEFFCAT® amine catalysts.

Explaining more, Geert Dries said: "Typically, two amine catalysts are incorporated into a polyurethane system; the first amine catalyst will catalyze the water/isocyanate reaction, while the second will catalyze the remaining isocyanate/polyol reaction. Our JEFFCAT® amine catalyst is a low emission product line, which can reduce VOC and fogging emissions during the polyurethane manufacturing process. Tested against a conventional amine catalyst, in an MDI-based, high resiliency (HR), molded formulation, our JEFFCAT® package performed considerably better. Emission performance of the new amine catalyst package was benchmarked against a typical VOC specification of 100 ppm; a standard fog specification of 250 ppm; and a conventional amine catalyst."

The multiple VOC sources that may be present during the production of a polyurethane foam.



Huntsman's second innovation is a novel family of JEFFADD® aldehyde scavengers, which can help polyurethane formulators reduce aldehyde emissions in final polyurethane foam products. During scavenger development, strict criteria were put in place to ensure that the new system would:

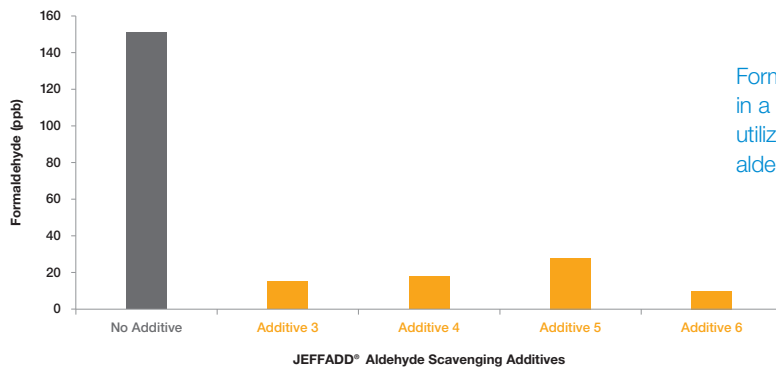
- Be easily miscible in a formulated polyol blend
- Have no adverse effect on the stability of the formulated polyol blend
- Capture aldehydes at $\mu\text{g}/\text{m}^3$ level according to VDA 276
- Have minimal impact on the total VOC value (VOC at 90°C and fog at 120°C)
- Demonstrate foam processing parameters within acceptable ranges
- Maintain foam mechanical properties.

Continuing, Geert said: "To date, we've created four JEFFADD® aldehyde scavengers. Liquid at room temperature and easily miscible with other polyurethane foam raw materials, all four products provide formaldehyde reductions, meeting some of the world's most stringent OEM formaldehyde specifications."

Concluding, Frank said: "With stricter requirements, to reduce interior cabin emissions, it is imperative that polyurethane formulators maintain the low emission integrity of their systems, particularly when incorporating new additives. To illustrate the benefit of combining both low emission JEFFCAT® amine catalysts with JEFFADD® aldehyde scavengers, we produced polyurethane foam samples for emissions testing."

Results of these tests showed that combining low emission JEFFCAT® amine catalysts with JEFFADD® aldehyde scavengers, can help maintain low total VOC and total fog levels in MDI-based HR

Formaldehyde Emissions from PU Foam at 65°C (VDA 276 Method)



Formaldehyde content in a polyurethane foam utilizing JEFFADD® aldehyde scavengers.

molded polyurethane foam. Total VOC and total fog emissions were compared against typical VOC and fog specifications.

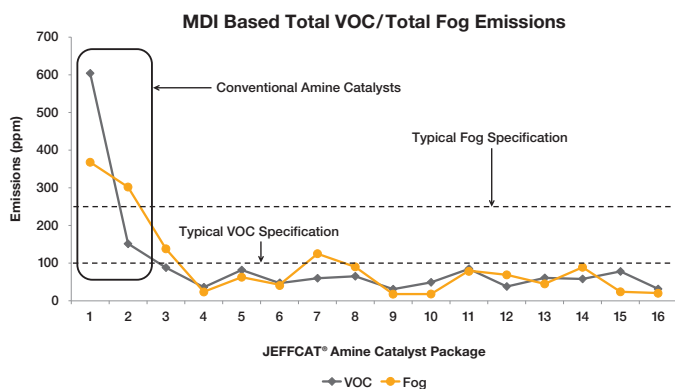
Huntsman's new low emission solutions are available for commercial use and have already received critical acclaim from within the automotive industry. In 2016, the Huntsman Polyurethanes team won a coveted Supplier Innovation Award from the BMW Group for helping to dramatically reduce total emissions from the high performance polyurethane seating foam used in the manufacturer's vehicles. Huntsman was the only supplier able to meet BMW Group's ambitious requirements for its molded foams – delivering a polyurethane-based product capable of reducing total emissions from BMW seating foams by a factor of 10, without compromising comfort or quality.

Driving its work forward, the Huntsman team is now working on additional advances in this important area of the automotive industry. The company's aim is to continue developing next generation, low emission JEFFCAT® amine catalysts and JEFFADD® aldehyde scavengers, which will make it even easier for formulators to achieve specific VOC, fog and aldehyde requirements as set out by government entities and automotive OEMs. |

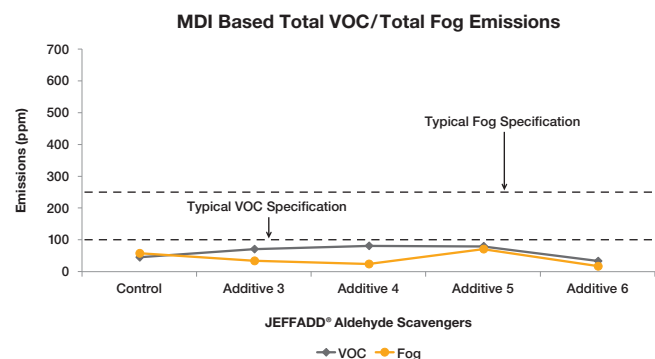


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MDI-based total VOC and total fog emissions levels achieved with Huntsman's JEFFCAT® amine catalyst package.



Total VOC and fog emissions utilizing low emission JEFFCAT® amine catalysts and JEFFADD® aldehyde scavengers in an MDI-based polyurethane foam.



IFS acquisition strengthens Huntsman's downstream capabilities in Europe



At the start of May, Huntsman announced that it had completed the acquisition of IFS Chemicals Limited – one of the UK's leading independent formulators of MDI-based systems. Six months on, the *PU Review* team travelled to King's Lynn in Norfolk, England, to meet the Huntsman IFS team and find out more about the business. *PU Review* spoke to IFS founder and managing director, Barrie Colvin (right) and Huntsman IFS director, Iain Stanton (left) for an insight.



Following Huntsman's purchase of IFS, Barrie and Iain are working side-by-side to integrate IFS into the Polyurethane division's wider network of systems houses. Together, their aim is to preserve the entrepreneurial and highly customer-focused spirit that exists at IFS, while introducing value-adding innovations that will enable the business to grow its position in the UK systems market.

PU Review (PU R): Barrie, first and foremost, thank you for inviting us to Norfolk to meet your team. As founder of IFS, can you start off by telling our readers about the business?

Barrie Colvin (BC): Certainly, IFS Chemicals Ltd, or Huntsman IFS as we are now known, is a speciality chemicals business that provides bespoke polyurethane systems to a wide variety of industries. We develop products and systems for construction and commercial refrigeration. We also produce polyurethane-based foam solutions for use in the automotive industry; in permanent and temporary buildings; for the marine sector; and for general molding applications.

PU R: How did the business start?

BC: After graduating from the University of Manchester, Institute of Science and Technology (UMIST), I worked in the chemical industry for a number of years, but had always wanted to set up my own business. In 1982, I decided to quit my job at a Norfolk-based chemical firm and go it alone. Armed with a second-hand industrial blender and a business loan from the UK government, I put together a small team to manufacture insulation-grade foam. In the first instance, we focused on developing polyurethane-based systems for cold storage applications – mainly for a commercial refrigeration firm in nearby King's Lynn.

PU R: How did the business grow from there?

BC: In the mid-eighties, a contractor working in the construction industry approached us and asked if we'd be interested in becoming his insulation partner. He wanted a company to supply insulating foam that could be installed in flat roofed buildings in Oman. Naturally, we leapt at the chance. The product we developed was a great success, which led to construction projects across the Middle East. This kept us busy for a number of years. Then, in the late eighties, we decided to branch out again. This time we expanded our offering to include foam products for the automotive industry. Employing a sector specialist, we started developing rigid and flexible foam products for use in car arm rests, sun visors, interior trim components and bumpers. We worked hard to forge relationships with many of the UK's major automotive original equipment manufacturers (OEMs) – a strategy that paid dividends. Although our team was relatively small, our products ended up being used in some of the most prestigious British car brands.

PU R: Was there a particular turning point for your business?

BC: Our big break came in 1989. At the time, everyone was talking about the ozone layer. Foam manufacturers were preoccupied with deciding which blowing agents to use to make their products more environmentally friendly. There were two main options: 141B or HCFC123. Never one to follow the crowd, I decided we should go down a completely different route and try to make a foam that was both CFC- and HCFC-free. We succeeded, producing our first CFC- and HCFC-free foam for a car armrest.



As well as a modern quality control laboratory, the site contains a spacious and well-equipped development laboratory where new formulations are derived for all foam and elastomer applications.



Envirofoam Sustain™ is currently supplied to a number of manufacturers producing cold room insulation panels and commercial refrigerators.

At an industry machinery open day, the product caught the eye of a decision maker at Portakabin – a leader in prefabricated, modular and temporary buildings solutions. Earlier that year, Portakabin – another family-run business – had set itself the challenge of eliminating all CFCs and HCFCs from its foams. Keen to find out if our new product could be adapted for their needs, we started working together and the rest, as they say, is history! Today, almost 30 years on, Portakabin remains one of our key customers – operating in seven countries and employing more than 1,750 people throughout Europe.

PU R: So what's the focus of the IFS business today? Is it still largely the same core areas?

BC: Yes, our focus remains pretty mixed. We are still big in insulation, producing products for refrigeration and construction applications, but also for electric water heaters and shower trays. We continue to supply the automotive industry. We also produce products for the marine sector. Typical applications in this industry include pipeline protection and insulation systems for subsea industries; buoyancy products for mid-water applications; negative buoyancy systems for concrete coated gas supply lines; plus, closed-cell polyurethane foam systems for the manufacture of small boats and leisure equipment, such as surf and windsurf boards. We also produce rigid foams for general molding applications, for example, for the production of mirrors and picture frames.

PU R: Supplying so many market sectors, the business must have a vast range of products?

BC: We do have quite a number of products available. Key brands include Envirofoam; Enviromould; Cellafoam and Cellacast. Our most recent product innovation is Envirofoam Sustain™ – a range of formulated polyols derived from vegetable oils and suitable for use in the building, refrigeration, marine and water-storage industries. With between 45-60% bio-based content, Envirofoam Sustain™ is currently supplied to a number of manufacturers producing cold room insulation panels, commercial refrigerators, hot water storage appliances, structural insulated panels and supermarket display cabinets.



Sitting alongside our core portfolio of products, Envirofoam Sustain™ is still a relatively small part of our business – but one that is certain to grow in the future. Bio-based products are something I've been interested in and passionate about for a very long time. The first bio-based polyurethane project that I worked on was as far back as 1979 and I gave my first paper on the topic at UTECH in 1994.

PU R: Are all your products made on site in Norfolk?

BC: Yes, all of our products are made from our 55,000 square foot systems house, which is located close to the Royal Sandringham Estate in Norfolk. The site consists of seven adjoining units. This allows the efficient flow of product from raw material warehousing, through production, to quality control and finished goods

storage. The production area consists of 20 resin-blending stations, ranging in capacity from 25 liters to 25,000 liters. Most of these are mounted on floor standing load cells, accurate to within 0.2% and regularly calibrated. Each blending station is dedicated to a specific type of resin. Some have pressure facilities to allow the introduction of volatile components. Others have vacuum and heating facilities to assist with de-aeration. As well as a modern quality control laboratory, the site contains a spacious and well-equipped development laboratory where new formulations are derived for all foam and elastomer applications. After development, laboratory scale innovations progress to the machinery section, where prototyping can be achieved, often using molds or panel facing materials provided by existing or prospective customers.



A closed-cell, low water absorption rigid, foam system for medium-depth buoyancy applications.



A business machine housing produced using a rigid, integral-skin foam with a molded density of 600kg/m³.



Envirofoam Sustain™ is used to produce refrigerated counters for supermarkets.

PU R: *lain, it's obvious from speaking to Barrie that IFS is a very innovative company. Can you explain how it came to be on Huntsman's radar?*

lain Stanton (IS): IFS has always been on Huntsman's radar. We've been supplying the business with MDI for more than 20 years. As we've grown our network of downstream businesses and systems houses, we've kept a close watch on its work. Barrie is incredibly well respected within the polyurethanes industry, so when we discovered that the business was up for sale we decided to get around the table as quickly as possible and forge a deal.



The development of a flexible foam cushion system with a Crib-5 fire-retardant specification.

PU R: *Why was Huntsman so interested in buying IFS?*

IS: There were a number of factors that made IFS an obvious acquisition target. First and foremost, the business enjoys a strong position in the sizeable UK MDI systems market. At Huntsman, we have a large and rapidly expanding network of system houses around the world. However, until May, we were missing a downstream entity in the UK – the third largest market for polyurethanes in Europe.

With an impressive product portfolio and an enviable client list – including many well-known household names – IFS was a natural company for us to set our sights on. There are not many businesses doing what IFS does in the UK. The company is unique in terms of its products, but also its service levels. Alongside a novel range of foam systems, the team provides in-depth technical and on-site support, which has helped it build long-standing relationships with a variety of high profile customers. In that regard, IFS and Huntsman are already very similar.

IFS' track record for innovation was another key selling point. Barrie is very modest, but over the years, the business has achieved a number of industry firsts. Barrie has been a long-term champion of developing and using raw materials from non-petrochemical sources. The company developed a zero ozone depleting blowing agent in the late eighties. The team was also early adopters of low global warming blowing agents. Culturally, Huntsman and IFS have parallels too.

BC: When we first started thinking about selling the business, there was lots of interest from potential buyers. There were discussions with a number of big chemical companies and several offers on the table. For me, as founder, the final decision rested on finding a purchaser with the same business ethos and company values.

In that regard, Huntsman was the closest match. Huntsman and IFS were both started by individuals with a clear vision about what they wanted to achieve. Obviously, Jon M. Huntsman has had far more success with his family business than I have, but we started from a similar place, which gives us common ground.

Having worked with the Huntsman team for many years, I know our business mentality is also the same. At Huntsman, the team is

ambitious and innovative, but ultimately focused on getting things done and delivering the highest levels of customer support. It's the same here at IFS, which will undoubtedly help with the integration process.

PU R: *What, if anything, will change under Huntsman's ownership?*

IS: Under Huntsman's ownership, very little about the IFS business will change. Product quality, technical support and customer service levels will continue to meet the highest standards our customers have grown to expect. One obvious benefit for existing IFS customers will, of course, be the increase in our size and scale. Being part of a well-respected global chemical company will give IFS customers extra security of supply and access to a bigger network of polyurethane experts and products.

The acquisition will also renew customer confidence in the company's capabilities. Since the deal was announced, there have been lots of positive conversations with existing customers who want to talk about bigger projects.

BC: I'd agree. New prospects have also taken note of the new name above the door. Customers that were reticent about working with us before, because of our size, are now keen to chat about the opportunities that might exist now and in the future. It's an exciting time for everyone connected to the IFS business. Personally, I'm delighted that the business is now part of a wider global network of interconnected downstream systems houses. The opportunities for sharing knowledge, expertise and market experience are enormous. Currently, 90% of our business is in the UK & Ireland. That won't change; we remain committed to supplying the UK systems market. But in parallel, I look forward to working with lain and the rest of the Huntsman Polyurethanes team to see what can be achieved elsewhere in the world with our products and to discovering which existing Huntsman technologies we could leverage and tailor to the UK market.

With the acquisition of IFS, Huntsman now has a global network of almost 30 systems houses worldwide – reflecting its confidence in the long-term growth prospects for MDI-based urethanes. |

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A history of innovation

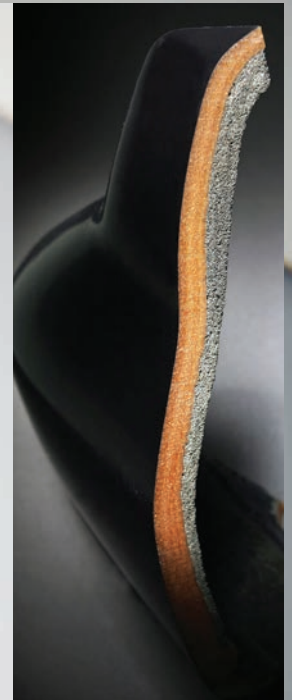


Faux-wood mirror frames

To improve the stability of imitation wood products, Huntsman IFS has developed a foam system that is suitable for replacing natural wood in many applications – including top quality gilt mirrors and picture frames. Frames are produced from a two-part polyurethane resin that is injected into a variety of moulds. The resulting frame remains dimensionally stable for many years, even in high humidity atmospheres. Unlike wood, which tends to warp and split, the polyurethane foam remains stable under all environmental conditions. The formulation developed by Huntsman IFS has been modified to allow exceptionally good adhesion between the polyurethane moulding and gold or silver paint. More recent developments have extended the use of this type of product to the manufacture of wood fascias and decking materials – the latter of which can be used in conjunction with non-slip elastomeric coatings.

Fast-reacting bumper system

Huntsman IFS has developed a fast-reacting, composite polymer for high-performance automotive applications. Originally developed for use in the bumpers of vehicles produced by a famous British luxury car company, the product consists of three major components, manufactured in an open mould, using a spray-applied technique. The first part of the operation consists of a spray-applied in-mould, self-releasing black paint. The second layer consists of a 1:1 polyurea elastomer, providing a very high impact material for the essential bumper structure. This layer cures in about 15 seconds, after which an open cell, energy absorbing polyurethane is applied. The whole process takes about three minutes to complete, resulting in a bumper, which is virtually indestructible.



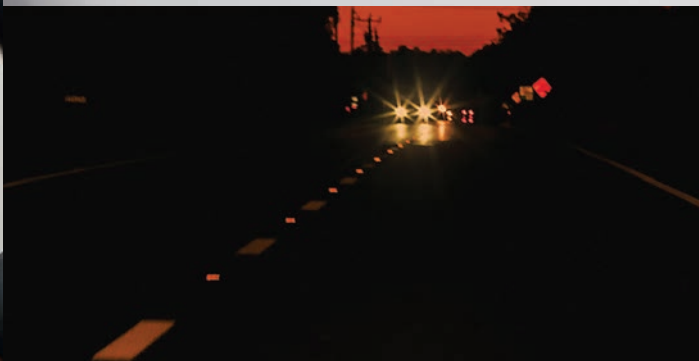
Modern cat's eyes

Modern electronics, particularly the use of LED lighting, has led to the introduction of significantly improved road delineation studs – more commonly known as cat's eyes. Instead of simply reflecting light from car headlights, these new cat's eyes emit light from high intensity LEDs, providing up to 900 meters of visibility. Working with a key customer, Huntsman IFS has developed a clear, impact resistant resin-based product to house the cat's eyes electronics. The low curing exotherm and high mechanical performance of the resin protects the electronics within the device. The resin also remains colorless, even after many years of exposure to high UV loadings.



In-situ pipe support

To help reduce the risk of oil-carrying pipelines rupturing in remote areas prone to seismic activity, Huntsman IFS has developed a foam system that can be used to hold pipes in place. Cellafoam 35 is a strong, spray-applied material, which can support pipes laid in channels. Traditionally, pipes buried in the ground, or on rigid overland structures, are prone to come apart during mild earthquakes. This can result in the loss of vast amounts of oil and contamination to the surrounding land. Highly resilient, Cellafoam 35 allows pipes to move in the event of seismic activity, helping to minimize the risk of rupture. Recognizing that rain water gathering in pipe trenches can lead to foam being damaged or washed away, Huntsman IFS gave Cellafoam 35 an open cell content of more than 95%. This ensures that any rainwater can pass directly through the foam.



VITROX® resins used in complex hollow motorcycle part

Huntsman Polyurethanes' VITROX® resin technology has been used to create an ultra lightweight license plate holder for the KTM 1290 Super Duke R motorcycle – a high performance bike with a powerful 1300 cc/170 HP V-engine.



The innovative license plate holder was created as part of Project R.A.C.E, an industry initiative led by KTM Technologies, an engineering company with extensive know-how about the use of composite and hybrid materials and their application across a wide range of industries.

KTM Technologies cooperated on the project with The Hennecke Group, which designs, produces and installs custom polyurethane mixing machines and innovative systems and technologies. Project R.A.C.E is exploring the industrialization of KTM Technologies' award-winning CAVUS technology – an end-to-end manufacturing methodology for producing complex, hollow, fiber-composite structural parts using automated high-pressure resin transfer molding (HP-RTM). CAVUS technology brings together a range of best-in-class technologies and materials, including Huntsman's VITROX® resins.

To demonstrate the potential of the CAVUS technology to create lightweight, mechanically strong parts that are suitable for high volume production, KTM Technologies and The Hennecke Group are working with a select group of industry partners to produce a range of products. One of the team's first challenges was to create a license plate holder for KTM's Super Duke motorcycle, which is renowned for its acceleration, and therefore requires ultra lightweight, high performance components.

The existing series KTM solution for the license plate holder weighs more than 765 grams. However, using CAVUS technology, KTM Technologies and its Project R.A.C.E partners produced a high performance and high integrative part weighing only 265 grams – a saving of more than 60%. Huntsman's VITROX® resin technology has proved central to Project R.A.C.E and the development of KTM's new license plate holder. Suitable for HP-RTM processing, this innovative polyurethane-based matrix material has unique snap cure capabilities – meaning manufacturers can carefully control the resin curing process and achieve a full cure within minutes.

Hubert Reitberger, Product Manager for Advanced Composite Resins at Huntsman, said: "Project R.A.C.E is an excellent platform where high-speed polyurethane matrix materials, such as VITROX® resins, can demonstrate their full performance.



Self-releasing systems with outstanding mechanical properties, combined with optimized curing times, are the key to mass-producing products with a short cycle time. Project R.A.C.E and the application of KTM Technologies' CAVUS technology is a prime example of how highly specialized partners can come together to create a step change in the production of fiber composite hollow parts."

Alongside KTM Technologies, The Hennecke Group and Huntsman, other companies involved in Project R.A.C.E include H2K Minerals (now REINSICHT); the Institute of Aircraft Design Stuttgart; ENGEL Austria; Persico and Murtfeldt Plastics.

VITROX® demos were integrated into the ENGEL TrendScout 2017 automotive conference, which took place in June in Austria. |

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Boaonda adds Huntsman TPU materials to footwear development



Brazilian footwear brand Boaonda® has qualified a thermoplastic polyurethane (TPU) from Huntsman for use in the production of its injection-molded fashion shoes.

Following rigorous processing, performance and quality assurance tests, Boaonda® has approved one of Huntsman's specialist AVALON® TPU grades for use in future collections of its all-plastic shoes. The AVALON® TPU grade selected joins a number of other materials that Boaonda uses to produce its fashion shoes, which are worn worldwide by men and women.

Boaonda®, which also produces the brand Cherry by Boaonda®, is one of Latin America's most creative footwear manufacturers. The company has designed and manufactured fashionable, molded plastic shoes for almost 20 years, and is best known for its colourful flip flops, sandals and clogs. The AVALON® TPU grade, which Boaonda® sourced and qualified with help from Prisma Montelur – Huntsman's Brazilian TPU distributor to the footwear industry – offers a high level of durability and is ideal for the production of all-plastic fashion shoes. Crucially, it also offers excellent flowability – helping to give Boaonda® greater flexibility in the design of its footwear.

When Boaonda® contacted Prisma Montelur, it wanted to find a material that could be used to create a whole TPU shoe. Boaonda® wanted the TPU to fill its molds faster and demold quickly, helping to reduce cycle times and increase production output. It also wanted the material to be flexible, but incredibly hardwearing. Huntsman's AVALON® TPU met all these requirements, offering clear technical advantages over other plastics, which are traditionally used to create fashion shoes via a one-shot process. Shoes made from TPU will typically last longer due to high levels of abrasion resistance, flex life, tensile strength and elongation. TPU also offers great aesthetic options making it possible to easily combine matte and shiny finishes.

Boaonda® prides itself on sourcing innovative, long-lasting materials that are easy to process and fully recyclable. Its material choices are defined by its in-depth understanding of the footwear molding process; its parent company is Mould Ind de Matrizas Ltda, a leading producer of footwear molds.

Luiz Romani, Director of Mould Matrizas, said: "The use of TPU in the footwear industry has changed since we first diversified and created Boaonda®. Twenty years ago, TPUs were mainly employed in the creation of soccer plates and top pieces or casual outsoles. Now, they are commonly found in midsoles, as well as upper applications. Currently, we use Huntsman TPUs for outsole applications – predominantly in our mens wear collection – but we were keen to qualify a new grade that could, in the future, form the basis of a full TPU shoe."

Geraldo Geniomar da Silva, Director of Boaonda® added: "With Prisma's help, we've found the right material and proven that it is compatible with our equipment. In the years

ahead, this will enable us to expand our product portfolio in line with industry trends and market demands."

Luciano Malinverno, Account Manager at Prisma Montelur, said: "Boaonda® has a reputation for producing high quality, plastic shoes that are practical, stylish and super comfortable. The company is a footwear innovator, creating shoes and sandals that set new trends and offer something different. For example, many of its shoes come with a removable PU insole that offers the wearer extra comfort. We were delighted to work with the Boaonda® team to help identify a material that will help them develop a whole TPU shoe that is fully recyclable and therefore a highly sustainable form of footwear."

Carlos Carvalho, Account Manager at Huntsman, said: "The last few years have seen a resurgence in the popularity of plastic footwear. Originally available in the 1980s, molded shoes have become fashionable again with consumers embracing flip flops, jelly shoes and clogs as an easy-to-wear option. TPU is ideal for creating fully molded shoes. Easily processed, the resulting material is flexible and durable while also providing the aesthetic and physical properties needed for fashion shoes that are worn daily."

Boaonda® is based in Sapiranga, Rio Grande do Sul, Brazil and employs more than 350 people. Alongside its range of molded flip flops, sandals and clogs, Boaonda® produces injection molded flat and tennis-style casual shoes. Separately, it has a range of fully molded 'Works' shoes that are made using a one-shot process. Easy to clean, available in neutral colors and comfortable enough to wear all day, these shoes are worn by healthcare professionals in medical environments where hygiene standards must be meticulously maintained. Boaonda's footwear can be bought throughout Brazil, but also worldwide in countries including Italy, Spain, Turkey, Chile and Venezuela. |

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Cherry
by boaonda®



RIMLINE® technology used to build nine-meter prototype wind turbine blade

An advanced technology, prototype wind blade, which could speed the manufacture of stronger, larger, more energy efficient wind turbines – and reduce associated operating costs – has been produced using components containing a RIMLINE® resin system from Huntsman Polyurethanes.



Nine-meter wind blade

The nine-meter long turbine blade was developed by the Institute for Advanced Composites Manufacturing Innovation (IACMI) – a Manufacturing USA institute lead by the University of Tennessee, Knoxville, USA; and the U.S. Department of Energy (DOE).

Eleven companies, including Huntsman Polyurethanes' Americas Technology & Innovation team, have contributed to the project – providing materials and on-site

fabrication support to assist in the manufacture and assembly of the blade.

The prototype produced is a smaller version of a utility-scale, multi-megawatt blade. Based on an existing blueprint devised as part of previous work conducted by the DOE, the new blade features innovations such as continuous fiber-reinforced thermoplastic parts. It also includes low cost, carbon fiber, spar cap stiffeners – manufactured via high speed pultrusion using Huntsman's RIMLINE® technology. Additionally, it has exterior shell components, produced with less than half the normal CO₂ emissions commonly emitted in wind blade manufacture.

“The Huntsman team believes that pultruded spar cap stiffeners will be a growing trend in wind blade design and manufacturing. We were eager to work with our IACMI partners to demonstrate the ease of processing, high productivity and material strength and durability of RIMLINE® urethane pultrusion in this application,” stated Huntsman's Michael Connolly, Principal Scientist and Program Manager for Urethane Composites.

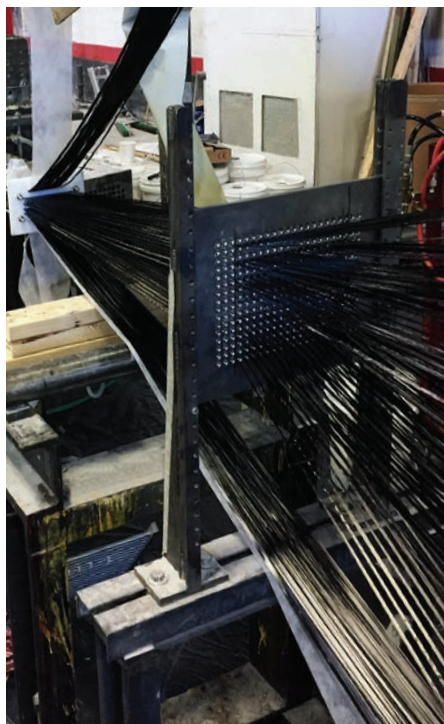
Bryan Dods, CEO at IACMI, said: “This project is a perfect example of IACMI's strength in bringing together partners that represent the entire industry supply chain to demonstrate the latest technologies available to address cost and performance of composites. Wind energy OEMs are showing great interest in the current research and development work, and we anticipate continued collaboration to mature these technologies.”



It is no easy task carrying a nine-meter wind blade.

The nine-meter prototype blade was produced at IACMI's Composites Manufacturing and Education Technology (CoMET) facility located at the DOE's National Renewable Energy Laboratory (NREL) in Boulder, Colorado, USA. The project was led by the IACMI's Wind Technology Area with support from Oak Ridge National Laboratory; the DOE's Advanced Manufacturing Office and the Advanced Industries Program, administered by the Colorado Office of Economic Trade and Development. |

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Pultruded PU profile with low cost carbon fiber



Fostering health and wellbeing in Cartagena

Worldwide, Huntsman Corporation is known for its charitable efforts, and its work in Colombia is no exception.

On the northern coast of the country is El Bosque, a low-income, industrial district of Cartagena – the port city known for its vital contribution to South American trade and commerce. El Bosque is home to 26 Huntsman Polyurethanes associates, who work at the division's local blending facility and warehouse. Operating out of El Bosque since 1998, the Huntsman Polyurethanes team in Colombia is helping to foster growth in the rapidly expanding South American polyurethanes market – while also fulfilling an important, local, philanthropic need.

In parallel to running a busy blending plant and distribution center, the El Bosque team is responsible for the administration of the Huntsman Colombia Foundation. Established in 2004, this charitable trust aims to make a difference to the lives of local people by delivering much-needed healthcare and social support. The Huntsman Colombia Foundation provides a variety of services to children and adults throughout the El Bosque area and beyond. Assistance is offered on pressing social issues such as housing, education, drug addiction and unemployment. The Foundation also provides healthcare services through the San Isidro Health Center – a high-quality medical facility, which Huntsman helped fund the construction of in 2006.

Almost 13 years after it was established, the Huntsman Colombia Foundation is having a really positive impact on the El Bosque community. The San Isidro Health Center has completed more than 28,000 medical consultations and put in excess of 10,650 children



A young patient receiving healthcare services through the San Isidro Health Center.

through its growth and development program – an initiative that monitors the oral hygiene of school-age children and vaccinates them against serious diseases. The center has also delivered almost 500 health awareness campaigns – educating local people about important physical and mental health issues as well as the dangers of drug and alcohol addiction. Separately, the Foundation has organized hundreds of activities to help local young people. One of its most popular events is an annual soccer championship. The foundation also hosts a unique program for children with cognitive impairments. Every year, the charity helps 28 disabled boys and girls secure school uniforms, supplies, transportation and health checks.

Rodrigo, a 53-year-old recipient of the charity's services, said: "I am very grateful to the Huntsman Colombia Foundation. It has provided me with tools and resources that have enabled me to work and have a better life." Rodrigo previously suffered from serious health issues, poor nutrition, and no affiliation to the health system. The Foundation helped him access medical treatment and medication, lab tests and food supplements. Additionally, the team helped Rodrigo secure state health insurance, which ultimately led to a significant improvement in his health and nutrition.

The majority of funding for the Huntsman Colombia Foundation comes from Huntsman Corporation but, given the community's immense need, the company also sources money from other income streams. Huntsman Polyurethanes employees hold fundraisers and make donations from their paychecks. Huntsman's legal entity donates disposable materials such as wood and scrap metal, which are sold to generate cash. Plus, employees of nearby companies are invited to utilize the services of the San Isidro Health Center, which generates money that is put directly into the foundation. |

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Forthcoming events and technical presentations

List of forthcoming events:

- CPI Polyurethanes Technical Conference, New Orleans, Louisiana (2-4 October, 2017)
- IWCS 2017 – The International Cable & Connectivity Symposium, Orlando, Florida (8-11 October, 2017)
- A+A Trade Fair, Dusseldorf, Germany (17-20 October, 2017)
- EWTA Info Fair 2017, Huntington Beach, California (28-30 October, 2017)
- SIMAC Tanning Tech, Milano, Italy (20-22 February, 2017)
- JEC World, Paris, France (6-8 March, 2018)
- Foam Expo North America 2018, Novi, Michigan (6-8 March, 2018)
- American Coatings Show 2018, Indianapolis, Indiana (10-12 April, 2018)
- NPE2018: The Plastics Show, Orlando, Florida (7-11 May, 2018)
- Polyurethane Manufacturers Association (PMA) 2018 Annual Meeting, Naples, Florida (5-8 May, 2018)
- UTECH Europe, Maastricht, The Netherlands (29-31 May, 2018)

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We create better durability. **Together.**

At Huntsman Polyurethanes, we believe that working in true collaboration with customers is the only way to solve complex problems and find the solutions that will deliver real innovation.

So, we strive with a passion and determination to build the deep understanding of our customers that's required to get to the heart of their needs and establish lasting partnerships.

When it comes to creating better durability in critical structures such as bridges, we'll work with you to produce tailored MDI-based coatings that provide enhanced structural integrity and protection against corrosion. Combine our knowledge of coatings with your expertise, and we'll create better bridges... together.

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