Composites at the Summer Olympics

Fast-Cure Prepreg

Compliance Update
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New California EPA and OSHA regulations could impact composite manufacturers. But the effects may be less than originally anticipated, thanks to the efforts of ACMA’s Government Affairs Committee. By Mary Lou Jay

Correction:
The location of a green wall system highlighted in the architecture article in the May/June 2016 issue was incorrectly cited as The Center for Architecture Science and Ecology. The molded GFRP boxes in the wall are installed at the Public Service Answer Center in the Bronx, N.Y.

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About the Cover:
Photo courtesy of Hobie Cat.
From the ACMA Chair

A Mid-Year Checkup

We have passed mid-year, and if you are like me then time seems to be accelerating. I am reminded of what my dad used to say to me as I was growing up: “The days are long, and the weeks are short.” Mid-year is a good time to reflect on your first half progress and any adjustments required to address your challenges for the balance of the year.

This issue of Composites Manufacturing magazine takes a look at the challenges all of our businesses face ensuring we meet compliance regulations in an ever-changing environment. The article on page 26 presents the latest information on California’s Prop 65 and OSHA’s new regulations on exposure levels for respiratory crystalline silica (RCS). We are so fortunate that ACMA continues to play a major role in representing our industry when it comes to legislation and regulations that affect our businesses.

While it is often difficult to stop pending legislation that seems detrimental to our industry, it is critical we have a voice and an opportunity to present information that shapes regulations in such a way as to allow us to continue to operate successfully. Our collective voices have more impact than we could have individually, and you can count on ACMA staff to represent our interests.

No matter our thoughts on the laws, we all have a responsibility to be compliant. I always approach a change by looking at how we can leverage the requirement to improve our business instead of just being compliant. I want our teams to fully embrace the change and understand the regulations and requirements, while focusing on how we can implement them in a way that improves our business. That may include training for our employees, capital investments, product improvements or improvements for our neighbors.

As always, thank you for your support of ACMA. Our association continues to make a difference for us every day. Together, we have the opportunity to represent our industry and ensure our voice is heard. Your participation and support is what makes the difference. Enjoy the rest of your summer, and I look forward to seeing you in September at CAMX in Anaheim, Calif.

Jeff Craney
Crane Composites
ACMA Chairman of the Board
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Gel Coat Basics

By Scott Crump

Unsaturated polyester resins (UPR) were first developed in the late 1920s in the research group of Dr. Wallace Carothers at DuPont. In the late 1940s, coatings made from these resins were applied to molds to protect them during the fabrication process of fiber-reinforced composites. By the early 1950s, several companies were offering pigmented gel coats for sale.

Today, gel coats are a common surface finish, perhaps best known for their ability to improve product appearance, such as the surface of a boat hull. But gel coats are also used to improve weathering, filter out ultraviolet radiation, add flame resistance, provide a thermal barrier, improve chemical and abrasion resistance and provide a moisture barrier. Let’s take a closer look at gel coats.

A Chemical Description

Chemically, gel coat formulations comprise building blocks from five classes of raw materials: resins, pigments, additives, monomers and fillers. The resin impacts almost all application and in-service properties. Gel coats can be formulated from many types of resins, including UPR, vinyl ester, acrylics, epoxies and urethanes.

Colorants and pigments impact color, water and UV-resistance, opacity and so on. Additive packages are used to affect flow and leveling properties, curing, UV-resistance and more. Monomers are used in gel coats as reactive solvents. During the curing process, the monomer reacts with the polymer in the base resin to form the thermoset backbone of the gel coat. Finally, fillers impact spray characteristics, fire retardancy, density and flow properties.

A Functional Description

Functionally, a gel coat is a high-quality finish designed to provide great aesthetics (color, gloss, opacity) as well as

Table 1: Types of Gel Coats and Related Products
A comprehensive list of gel coat types and ancillary products is shown here.

<table>
<thead>
<tr>
<th>Standard Gel Coat Products</th>
<th>Specialty Gel Coats</th>
<th>Ancillary Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanitary gel coats</td>
<td>Surface coats</td>
<td>Colorants</td>
</tr>
<tr>
<td>Transportation gel coats</td>
<td>Sanding primer gel coats</td>
<td>Patching compounds</td>
</tr>
<tr>
<td>Marine grade gel coats</td>
<td>Vinyl ester barrier gel coats</td>
<td>Wax solutions</td>
</tr>
<tr>
<td>Wind energy gel coats</td>
<td>Fire retardant gel coats</td>
<td>UV absorber solutions</td>
</tr>
<tr>
<td>Tooling gel coats</td>
<td>Conductive gel coats</td>
<td>Inhibitor solutions</td>
</tr>
<tr>
<td>Clear gel coats (marine)</td>
<td>Tie coats for epoxies</td>
<td>Promoter packages</td>
</tr>
<tr>
<td>Clear gel coats (marble)</td>
<td></td>
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</tbody>
</table>
UV protection and water resistance to an FRP composite. The gel coat is generally applied to a smooth mold with a release agent. A special class of gel coats known as surface coats can be post-applied to existing parts. By changing the building blocks in a gel coat, a skilled formulator can develop products for a wide range of end-use applications. A comprehensive list of gel coat types and ancillary products is shown in Table 1 on page three.

### Table 2: Gel Coat Failure Modes

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Types of Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheology</td>
<td>Sagging, poor tape line, curtains, thin film, orange peel/leveling, sedimentation, viscosity drift</td>
</tr>
<tr>
<td>Cure</td>
<td>Wrong gel time, low peak, wrong film cure, gel time drift, low hardness, patch will not hold gloss</td>
</tr>
<tr>
<td>Color</td>
<td>Wrong color, color change upon storage</td>
</tr>
<tr>
<td>Surface Defects</td>
<td>Craters, fish eyes, color separation, porosity, resin tear, mottling, low gloss, specs/particles, streaks, blisters, fiber print, patch halo, patch color difference, blushing, pre-release, chalking</td>
</tr>
<tr>
<td>Contamination</td>
<td>Soft gels, hard gels, liquid-liquid phase separation, undispersed powders</td>
</tr>
<tr>
<td>Density</td>
<td>High or low density</td>
</tr>
<tr>
<td>Opacity</td>
<td>Poor coverage/hide</td>
</tr>
<tr>
<td>Dispersion</td>
<td>Poor Hegman grind, undispersed pigments/fillers</td>
</tr>
<tr>
<td>Thermal Mechanical</td>
<td>Fiber print, impact cracking, thermal cracking, cracking during de-mold</td>
</tr>
</tbody>
</table>

Performance Requirements

It makes sense to take a look at the performance of the UPR/vinyl ester gel coat at two different stages – during the fabrication of the part and once the part is in service. During part fabrication, the gel...
Once the part is in service, a properly selected gel coat provides durability by resisting ultraviolet light, water and other environmental stressors.

cocat needs to flow and cure properly. In high-volume shops, the cure speed of the gel coat can be the rate limiting step in the overall process. The flow characteristics of the gel coat will determine how well the product sprays, levels and resists sagging. Special primer gel coat formulations are formulated to maximize the adhesion and prevent cratering of post-applied paints.

Once the part is in service, a properly selected gel coat provides durability by resisting ultraviolet light, water and other environmental stressors (temperature changes, abrasion, etc.). Gel coats do not have the exterior durability of automotive grade paints. A severely weathered gel coat is generally easy to restore to a high-gloss finish by buffing and polishing. Some common failure modes of gel coats are shown in Table 2. Diagnosing and troubleshooting these issues is beyond the scope of this article, and you should consult a gel coat technical service representative if you are experiencing any of these issues.

Maximizing Success with Gel Coats

Let’s wrap up with a checklist of things you can do to make your UPR/vinyl ester gel coat experience a positive one:

- Clearly define your customer’s end-use performance requirements. Make a written list of everything you need the gel coat to do, including allapplication and in-service requirements.
- Work with your seller to select the right product for your fabrication process and end-use application. Follow the supplier’s gel coat usage guidelines on mixing, storage, peroxide choice, etc.
- Thoroughly test and validate the performance of your product.

Ultimately, product performance depends on three things – material selection, part design and usage environment. The gel coat is one of many materials used to make a composite part. It’s up to you to make sure that the design works well in the intended environment.

- Order correct quantities to prevent old gel coat stock. Gel coat properties drift over time (viscosity drops; cure time lengthens).
- Recognize the gel coater job for what it is – a skill position. Applying gel coat uniformly, with good spray pattern, can be more challenging than hand layup. Choose employees for this position with an eye for detail, and structure the workflow so they can focus on applying the gel coat only.
- Maintain application equipment, and set up effective preventive maintenance.
- Manage shop environmental conditions.
- Provide continuous education. Utilize suppliers, trade publications and industry conferences to train your workforce on best practices and new materials.
- Fully leverage your gel coat service representative. A knowledgeable technical service representative can help you in many ways, including with plant audits, product troubleshooting, best practices, product recommendations and training sprayers.

The guest columnist for this issue’s “Best Practices” column is Scott Crump, director of research and development for Interplastic Corporation. Email comments to scrump@interplastic.com.
For the past seven years, San Diego Composites Inc. (SDC) has been working with NASA on the Orion spacecraft, designed to bring humans further into deep space than ever before – even reaching Mars. The company made more than 1,000 parts for Orion’s first unmanned Exploration Test Flight, EFT-1, which orbited Earth in December 2014.

Watching the test flight launch was “an amazing experience,” says SDC President Robert Kolozs. Two of the largest parts that SDC currently makes for Orion – the CFRP Fillet and ogive fairing for the Launch Abort System (LAS) – are clearly visible at the top of the spacecraft. Kolozs says it was thrilling to point across the bay during the flight launch and say, “That cone at the top is ours!”

Founded in 2002, San Diego Composites began working with NASA more than 10 years ago when it helped invent a double-bag vacuum assisted resin transfer molding (VARTM) process to address the volatility that can occur when infusing high-temperature polyimides. In 2009, the company began working on Orion as a subcontractor to Lockheed Martin, which manages and leads the Orion program for NASA.

Ken Mercer, Orion program manager at SDC, says that the company’s first Orion components were CFRP angle brackets used to mount the spacecraft’s outer panels to the aluminum pressure vessel for EFT-1’s crew module and ground test vehicle. SDC supplied more than 100 brackets. “This was a very small part,” explains Mercer, “but we were lucky enough that they have trusted us with larger parts ever since.”

SDC began work on sections of the Launch Abort System in 2011. Positioned at the top of the crew module, the nearly 53-foot-long LAS has several components, including a nose cone, motors, the Fillet and the ogive fairing. If a launch problem occurs, powerful motors pull the launch abort capsule away from the failing rocket within milliseconds.

Mercer says it was challenging to develop a fabrication process for the Fillet. “The first ply down is a lightning strike material,” he says. “The curvatures of the Fillet are such that the copper mesh material is a challenge to put down. We’ve developed techniques over the years to avoid wrinkles and potential damage to that very sensitive material.” The Fillet is a co-bonded structure created by pre-curing the front facesheet and then co-curing the honeycomb sandwich core and back facesheet. Maintaining a good bond line between those two processes requires careful abrading and cleaning to ensure that the interface is not fouled between cure cycles.

The size of the Fillet, which is laid up by hand, also made fabrication tricky. The cone-shaped Fillet is 10 feet long. Fabricated in halves, it is eight feet in diameter when completed. Mercer says that a lot of thought went into how to provide technicians access to all locations on the molds for both the Fillet and the even larger ogive fairings.

The ogive fairing is a large curved structure – positioned below the Fillet and encapsulating the crew module – that shields the crew module from high shear and wind loads and, if necessary, from the launch abort motors. Nearly 30 feet in diameter, the ogive fairing is fabricated in four core panels measuring approximately 15 feet across and about 16 feet long.

To accommodate hand lay up of both the Fillet and ogive fairing, SDC built systems to bridge people over the molds and allow them to lay down the prepregs. “It sounds simple,” explains Kolozs, “but when you talk about getting out in the middle of something 8 feet in and 16 feet across and getting good compaction – and you want to lay down a certain amount of material per hour – it’s not.” SDC developed specialized tooling and used a laser projection system to help lay up
both parts, which were then cured in the company’s new 16-foot diameter, 30-foot long high-pressure autoclave.

Like the Fillet, the ogive fairing is made of a high-strength carbon fiber/epoxy material, but with a thicker honeycomb core to accommodate a higher load profile. The ogive fairing tapers to a solid laminate at the edges and has syntactic foam placed in high shear load areas as well as foaming adhesive between the core segments.

“Lockheed Martin has designed a structure that is best-in-class right now in terms of specific strength and specific stiffness,” Mercer states.

SDC also helped develop a process to infuse NASA’s 3-D Multifunctional Ablative Thermal Protection System (3D-MAT), a new 3-D stitched quartz fiber preform material. After developing the intricate weaving process with Bally Ribbon Mills, NASA discovered that infusion of the dry preform was a challenge. After NASA and several subcontractors struggled to infuse 3D-MAT, they brought the project to SDC. Like others, SDC initially tried to infuse the material using a traditional VARTM process and failed. Mercer says that 3D-MAT’s irregular and non-repeatable shape, as well as its thickness and stitch density, make managing resin flow using traditional VARTM impossible.

So SDC created a process that uses microcontrollers and data recording to control vacuum level, flow path and pressure throughout infusion. “That’s what makes this a really unique process,” says Mercer. “We’re controlling three of these things to a very fine degree in this part, whereas normally you might only control one or two of them. And we’re staging them at times to make sure that we avoid creating voids.”

SDC has since infused 32 billets of 3D-MAT material that will be used to make compression pads and other components for Orion’s next test flight, Exploration Mission 1 (EM-1) in 2018. Last fall, SDC received a special commendation from NASA for its contributions to the development of the 3D-MAT material.

Kolozs says that all of the company's engineers have worked on Orion at some point. “We’ve grown a lot with the program,” Kolozs reflects, adding that he hopes SDC can remain an Orion partner all the way through its ultimate mission – the journey to Mars. That would be quite a journey for San Diego Composites, too.

Melissa O’Leary is a freelance writer based in Cleveland, Ohio. Email comments to mxh144@case.edu.
Architecture students from UCLA showcase the robot that helped them build their “Undulating Gills” award-winning entry for the Composites in Architecture Design Challenge.

Kudashkina, Yifan Wu, Yuekan Yu, Shahr Razi, Simi Shenoy and Marcelo Marcos. Their creation, entitled “Undulating Gills,” was inspired by several buildings, including the composite façade for the San Francisco Museum of Modern Art designed by Snøhetta and fabricated by Kreysler & Associates.

“We were really curious about the composite materials and tried a few experiments, mainly working with closed vacuum bag processes,” says Shenoy. “We figured out a way to configure the materials within the bag and produce a series of panels in one shot.” The team created 8-foot-long CFRP panels utilizing a moldless fabrication technique in tandem with robotics. By robotically twisting a single infusion bag with several panels inside, they produced a series of identical panels.

The UCLA students also shifted the panels within the bag to achieve a gradient effect. “When the panels cured, we had a series of parametric-sized panels – not just one, but three to four,” says Shenoy. The resulting undulating panels “use the natural texture of the composites, so they have a sense of translucency that allows for lighting,” adds Shenoy.

“The unique aspect of this investigation was the attempt to make a flexible mold – or better yet, to eliminate the mold altogether,” says David Riebe of Windsor Fiberglass Inc., who coordinated the Composites in Architecture Design Challenge. “Through the use of robotic arms and a customized mandrel, the students were able to achieve a great deal of flexibility and efficiency during the infusion process. The ability to produce multiple matching parts out of a single infusion was quite ingenious.”

Shenoy is excited by the prospect of designing with composites in her career as

Contest Yields Innovative Designs

Two words repeatedly popped up when students participating in ACMA’s inaugural Composites in Architecture Design Challenge talked about their experiences in the contest – experimentation and excitement. “Giving composite materials to students on an experimentation platform is genius,” says Simi Shenoy, a student in the Master of Architecture II program at UCLA. “We were open to explore what we wanted. That’s how we come up with something new and exciting.”

Students worked in teams on the challenge, which was sponsored by Ashland Performance Materials, to develop an innovative composite architectural component or assembly. They were urged to investigate and invent new – and sometimes radical – architectural designs. The winning designs, highlighted here, were on display in ACMA’s Composites Pavilion at the American Institute of Architects’ Convention in Philadelphia in May.

1ST Place: UCLA

UNDULATING GILLS

Six students in a seminar class on animated fibers, taught by Julie Koerner, created the winning entry: Anna

Architecture students from UCLA showcase the robot that helped them build their “Undulating Gills” award-winning entry for the Composites in Architecture Design Challenge.
an architect. “The possibilities are endless,” says Shenoy. “I definitely think composites are the future.”

2nd Place: Temple University

A trio of students from Temple University – Daniel Cruz, Sean Moss and Kerry Hohenstein – designed semi-transparent, webbed columns for placement on the grandstands on Philadelphia’s Schuylkill River. The columns, which start as a small footprint at the ground then expand upward like a blossoming flower, could support a roof or deck above hundreds of spectators at the finish line for intercollegiate crew races and other events on the river.

“Each composite column is meant to work in tandem with about 20 other columns to support a pavilion,” says Cruz. “They are lightweight, see-through and allow for air and light to come through so they create beautiful shadows on the ground.” The students conceived the idea for the shape of the columns after studying other similar designs, such as the dendriform columns on the Johnson Wax Headquarters in Racine, Wis., which begin with a small diameter at the bottom and rise to 18 feet across the top.

The students used a modified pultrusion technique to make model columns. They stacked a series of increasingly larger medium-density fiberboards (MDF) with threaded steel rods, creating the column form. Then they drove screws into the sides of the MDF to act as anchors from which the fiberglass spool could wrap around. Next the students threaded fiberglass roving through the bottom of a recycled water bottle with the cap facing down and poured polyester resin into the bottle. They then pulled the roving through the bottle, saturating it in the resin, and pressed it onto the frame. Once the model columns were heated and catalyzed, the students removed the MDF framework to reveal the webbed column.

“Of all the projects in the composites challenge, this team demonstrated the greatest amount of material control, from the invention of the DIY pultrusion machine made from a soda bottle to the rotisserie jigs for forming, all aspects of the project were expertly developed,” says Riebe. “This project also demonstrated a scalability that many others lacked, further highlighting the design sophistication of this group of students.”

Moss admits, “The idea is a little out there.” Manufacturers would have to develop new machinery and processes to make the columns. But the composites industry was built on visionary thinking, so the students from Temple aren’t deterred.

“As young architects, we’re willing to take techniques and work around them,” says Cruz. “You give us a problem, and we’ll try to find a solution for it. The range of possibilities and the versatility of composites are exciting.”

3rd Place: Georgia Tech

The goal of the balloon panel developed by Georgia Tech architecture students Chantale Martin and Jose Garza de la Cruz was to eliminate the need for a mold while achieving two finished surfaces. Like other teams, they experimented – and failed – before hitting on a solution that worked.

“Originally, we were doing tests with minimal surfaces, so we experimented with stretching textiles,” says de la Cruz. “Then we tried to transfer that to fiberglass, but we failed. That’s when we came up with the idea of using balloons to stretch the fiber while it was curing.” The team’s project statement asserts that “by combining the outward Pushing forces of balloons with the inward-pulling forces...
Architecture students from Georgia Tech added different sized balloons to the interior of its panels to create texture. Of a vacuum, we were able to achieve a beautifully textured form while evenly distributing the resin to create a highly-finished surface.”

Martin and de la Cruz followed a four-step production process to create the panels: First, they impregnated fiberglass sheets with resin. Then they lay the wetted sheets over balloons of varying sizes and added a protective acrylic sheet. Next, the students put wooden frames in place around the panels. Once framed, they used a vacuum process to spread the resin evenly and create the finished surfaces. The resulting 3-D panel is lightweight and easily scalable for various applications, such as a rain screen on a building. “Translucency is one of the properties, so you can use the panels as a veil on buildings,” says de la Cruz.

“The commitment to developing a pressurized and calibrated infusion system through the use of balloons and vacuum bags was extraordinary,” says Riebe. “The ability to make a lightweight cavity panel with two finished surfaces out of one
infusion process is quite sophisticated. Also of note is the (perhaps) unintended side effect of the material quality of the panel with its varying degrees of translucency, which creates a stunning effect when lit properly.”

This was de la Cruz’s first time working with composites. “I compare it to when I learned how to use autoCAD® software – make it available to us, give us a few guidelines and we’ll run with it,” he says. Martin and de la Cruz have proposed an art installation using their composite balloon panels and are already thinking about the next project they can create with FRP materials.

Susan Keen Flynn is managing editor of Composites Manufacturing magazine. Email comments to sflynn@keenconcepts.net.

For more stories like this, visit CompositesManufacturingMagazine.com and check out the Architecture articles under the “Market Segments” tab.
Transportation

Tanker trucks transporting corrosive liquids and gases are a common sight on highways. Often made of steel, the cylindrical tanks are typically dedicated to one type of cargo. But thanks to a composite tanker configuration developed by Australian-based Omni Tanker Pty. Ltd., the next tanker you see rolling down the road could be lighter, enable a quicker turnaround between runs and deliver purer products. Plus, the tankers could be used to move bleach in one trip, then acid the next.

What sets Omni Tanker’s products apart from others is their thermoplastic liners, which absorb almost none of the transported goods, says Dr. Luke Djukic, chief technical officer of the company. It’s standard practice to line the inside of a tank transporting hazardous goods, both to protect the tank and the corrosive chemicals. Most of these nonstructural liners are made of materials such as rubber or thermoset polymer reinforced with glass chopped strand mat. In contrast, Omni Tanker uses a thermoplastic liner encapsulated by CFRP. The liner has high chemical resistance, ideal for transporting sodium hypochlorite, sulfuric acid and other dangerous chemicals.

The liner, which acts as an interior protective skin, works in tandem with an outer shell composed of the same CFRP. The outer section is custom molded to create a smooth exterior tank surface. The space between the interior and exterior skins contains a foam core. “The patented Omni Tanker liner technology overcomes the problems associated with bonding thermoplastics to thermoset composites,” says Djukic. “We have demonstrated bond strengths similar to epoxy-to-steel adhesion.”

Development of the liners began 10 years ago, when company founder Bill Rodgers noted that standard liners tended to degrade and require replacement every few years. The goal was to create a seamless, hollow vessel with high adhesion strength of inner-to-outer shells. Finite analysis helped nail down the design, and utilization of the directional strength of carbon fibers allowed tailoring of the material to create desired properties. The resulting tankers – which Omni Tanker markets as its A and AB tanks – have been in service in Australia since 2011. Each tank typically carries between 12,600 and 15,000 liters of goods, although higher volumes can be achieved based on customer requirements.

Another benefit of the liners is increased chemical resistance, which is achieved via several avenues. First, the manufacturing process and structural configuration minimize the tendency for stress cracks – and resulting weak points – to form during use. Second, the liner materials, including thermoplastics such as polyolefins and fluoropolymers, have very high chemical resistance compared to standard liners and minimal absorption of the chemical cargoes, says Djukic.

The composite tankers provide several advantages to trucking companies, including durability, a longer service life, lower maintenance costs and reduced weight. Djukic says Omni tankers weigh half as much as steel tanks carrying the equivalent volume, which reduces fuel consumption. In addition, since the total weight of truck, trailer, tanks and payload has a regulated maximum, dedicating more of that weight to the payload and less to the tank reduces the cost of transport.

Another advantage is that the foam core provides insulation, which helps...
reduce any chemical breakdown brought on by high outside temperatures. That’s particularly helpful during long hauls, Djukic notes.

The tanks also can be turned around more quickly. With little or no chemical absorption, all they need at the end of a run is a simple washout before being used to transport a different chemical. Since standard liners absorb chemicals much more readily, it’s typical for a traditional tank to be assigned to a specific chemical, making logistics challenging at times.

Omni Tanker has sold approximately 140 tankers in Australia. Djukic says the tanks should soon be available in Europe and North America once they gain regulatory approval. Because of the tankers’ attributes, Djukic also envisions them moving more than hazardous chemicals; they could transport milk and other foodstuffs.

Hank Hogan is a freelance writer based in Reno, Nev. Email comments to hank@hankhogan.com.
This summer, more than 1,000 athletes will descend upon Rio de Janeiro to compete in the 2016 Summer Olympics. From August 5-21, spectators will be riveted by displays of athleticism across a number of sports. While the athletes’ accomplishments are significant, spectators may be unaware that advanced composite technology aids these competitors in their remarkable demonstrations of speed, strength and skill. Let’s take a look at composites in nine key sporting areas.
**Archery**

Composite recurve bows date back thousands of years to when wood was layered with horn and sinew to resist compression and tension. Today’s recurve bows – the only kind of bow used in the Olympics – may resemble these early bows in style, but are far more advanced in engineering.

Bows are comprised of a bowstring and handle fitted with sighting accessories and stabilizer rods that dampen vibrations as the arrow is released. Bows must be stiff and stable to let arrows loose at speeds of nearly 150 mph. Composites provide that stiffness. For example, Hoyt Archery in Salt Lake City – which calls its Formula series “the most-winning new bow design in modern history” – uses triaxial 3-D carbon fiber around a synthetic foam core to improve speed and stability.

Reducing vibration is also critical. Win&Win Archery, a manufacturer in South Korea, infuses its bow limbs with a molecularly-bonded carbon nanotube resin to reduce “hand shock” caused by vibration. And by replacing the glass fiber coating many manufacturers use to protect bow surfaces with a 45º carbon system, Win&Win says it has created a smoother surface for improved arrow speed.

Bows aren’t the only highly-engineered composite component in this sport. Arrows, too, are finely tuned to reach the target. The X10 arrow, produced by Easton in Salt Lake City specifically for Olympic competition, bonds a high-strength carbon fiber to an alloy core. The weight of the alloy balanced with the small diameter and stiffness achieved by the carbon fiber results in an arrow that better resists wind drift than other products, according to the company. It’s apparently a formula that works, since Easton reports that its arrows have been used by more Olympic title winners than any other brand.

**Cycling**

There are several cycling events featured in the Olympics, and the equipment is vastly different for each. But whether competitors are riding brakeless track bikes with their solid disk wheels, more familiar road bikes or highly durable BMX and mountain bikes, the equipment shares one feature – a CFRP frame.

Manufacturers like Felt Racing LLC in Irvine, Calif., note that carbon fiber is today’s material of choice for any high-performance bike, but each manufacturer has its own unique formula for balancing stiffness, weight and strength. For most of its products, for example, Felt uses a varying blend of high and ultra-high modulus unidirectional fiber materials – from its proprietary UHC Performance fiber to TeXtreme® fibers – with its own nano resin matrix to achieve various weights and degrees of durability. It uses modular monocoque construction to mold large sections of the frame for added durability.

This careful engineering leads to significant differences on the course. Mountain bikes need to balance durability against tough terrain with the lightness needed for speed. Track bikes, on the other hand, are all about speed. In fact, these bikes have weight
requirements – they must check in at more than 14.9 pounds – to ensure safety isn’t compromised to achieve lighter weights and faster speeds.

**Kayaks, Canoes and Rowing**

Many athletes at the 2016 Olympics will spend their days skimming across the water in CFRP hulled boats. Rowing boats will seat one, two, four or nine competitors in a lightweight CFRP hull aerodynamically designed to cut smoothly through the water. In the canoe slalom, competitors will navigate whitewater rapids in one or two-person kayaks or canoes, while canoe sprints competitors will race across calm waters in one, two or four-person kayaks or canoes. Athletic skill combined with advanced composite technology will help teams earn Olympic Gold.

Manufacturers report using variations of pre-impregnated fiberglass, carbon fiber cloths and custom-braided graphite around honeycomb and syntactic cores to create lightweight, stiff, strong and durable kayaks, canoes and racing shells. Light and stiff are critical qualities for racing shells, says Ted Van Dusen, a naval architect and president of Composite Engineering in Concord, Mass.

“Stiffer boats provide an advantage because the power that the rower puts in doesn’t get wasted in slightly changing the shape of the hull with each stroke; it gets transferred more fully into boat speed,” Van Dusen says. “The boat weight is also important because as less water is displaced, less water has to be moved out of the boat’s way, reducing wave drag. In addition, less surface area is in contact with the water, reducing viscous drag. Lighter boats also require less power to get moving, which allows for a faster start on a 2,000-meter course.”

Manufacturers blend vacuum bagging and autoclave curing techniques in the fabrication of these racing boats and continually seek innovations in how they blend technologies. The biggest factor preventing lighter boats is the minimum weight requirement set by the International Rowing Federation. That may range from 221 pounds for a coxed eight (in which 8 rowers each hold one oar in two hands) to a mere 26.5 pounds for a single-person kayak.

**Golf**

Club technology featured on Rio’s new golf course will be vastly different from the sport’s last Olympic appearance in 1904. Golf club shaft manufacturers have wholeheartedly embraced composites. A recent report from Markets & Markets says that golf clubs are the fastest growing application of composites in the sports market. By incorporating composite materials, shaft manufacturers can improve both club swing and the distance a struck ball can achieve.

Manufacturers continue to explore the possibilities provided by molding CFRP shafts and crowns. Callaway, which has been making multi-material CFRP drivers and fairway woods for more than a decade, molds carbon fiber compounds to create club heads that it says are lighter and stronger than titanium. This ratio reportedly leads to higher inertia for faster swings and balls that achieve greater distances. Other products use special blends of polymers to absorb vibrations.

The key is balancing lightness and strength, says Chris Hilleary, president of Aerotech Golf LLC in Bellingham, Wash. “Really good players want some weight. But if you make a heavier graphite shaft, you have to add a lot of graphite – and the wall gets really thick and the shaft loses some of its playability.”

Because breakage is common among wood field hockey sticks, players are turning to GFRP sticks for their superior strength and stiffness.
The manufacturer balances its lightweight carbon fiber shafts by winding a steel fiber around the filament wound carbon fiber core to bring the weight up, but keep the wall thickness down. Field hockey players likewise depend on composites to balance lightness and strength. Rage Field Hockey USA in Los Altos, Calif., notes that breakage is a common problem among wood sticks, and the use of fiberglass can significantly reduce breakage. By varying components, manufacturers can highlight stiffness (to assist hitting) or lightness (to improve dribbling). In its molded products, Rage combines fiberglass and carbon fiber for stiffness with Kevlar® aramid fiber’s vibration absorption properties.

**Gymnastics**

Gymnastics blends strength with balance and flexibility – much like the materials used to manufacture the men’s parallel and women’s uneven bars.

When manufacturers first began adding fiberglass to the bars in the 1970s, it was to eliminate bar breakage. In 1952, when the uneven bars were first introduced at the Helsinki Olympics, there were 39 bar breaks. Today, composites add not only strength but also bounce to the bars. Marcello de Carvalho, international sales manager of Gymnova, one of the official suppliers of gymnastics equipment for the 2016 Olympics, notes that his company uses increased amounts of carbon fiber to add “more dynamism to the handrails.”

As athletes move from one bar to the other, demonstrating a series of grip changes and releases, the competitors often rely on a blend of CFRP and GFRP to boost their release time. For example, the handrails of Gymnova’s Rio brand asymmetric...
bars use a blend of pultruded CFRP and GFRP encased in wood veneer to boost athletes’ response times. Spieth, another Olympic bar supplier, notes that its parallel bars use fiberglass inserts within a plywood rail to create the resilience and elasticity necessary to support the gymnasts’ swings.

**Sailing**

Since its introduction in the 1900 Paris Games, Olympic sailing has shifted dramatically toward smaller and lighter dinghies, skiffs, windsurfers and keelboats. Olympics.org notes that this trend puts greater demands on the sailor’s athletic and technical abilities. It also puts greater demand on composite manufacturers to develop new products for each Olympic cycle, hoping that the right mix of technologies will earn their boat the win.

Greg Ketterman, vice president of engineering for Hobie Cat Co., notes that since sailboat Class rules limit design changes, it is the “behind the scenes” composite technology that drives advancement. “Composites lead to a lighter, stiffer product and are the preferred choice for most competitive classes,” adds Pip Baily, marketing manager for RS Sailing, a sailboat manufacturer in the United Kingdom.

RS Sailing uses a mixture of polyester, vinyl ester and epoxy resin systems in all of its sailboats. “We use a mixture of different weights of glass and carbon matting in different weaves to make sure we get the maximum strength depending on application,” Baily says. The company uses a variety of fabrication methods to manufacture hulls, including open laminating, vacuum bagging and infusion techniques.

Hobie Cat primarily uses woven and mat E-glass with polyester resin for its Hobie 16 boat. Typically, the company hand laminates the glass foam sandwich to construct a light, stiff structure in a relatively complex shape. But it can achieve greater reductions in weight and improved stiffness by using more “exotic” materials, such as S-glass, Kevlar or carbon fiber, combined with lighter core material, such as honeycomb Kevlar. A higher fiber-to-resin ratio, through vacuum bagging, prepreg

Strong, non-slip starting blocks are crucial for propelling Olympic swimmers to record-setting speeds.

**Strength and durability, combined with lightness and flexibility, are critical for most Olympic sporting equipment.**
or autoclave production, also can boost these benefits. And by replacing thermoset resins with thermoplastic resin, Ketterman says, boat builders are making their hulls more durable than ever.

**Swimming**

Swimmers achieve their highest speeds at the start of the race when they first enter the water. Propelling Olympic swimmers into the water is a simple, yet crucial piece of technology – the starting block. There are strict rules governing construction and use of these platforms, but among the most important criteria is that the starting blocks are stable and slip-resistant.

“Of course a strong, non-slippery footboard is important for swimmers, but as important is a solid, stable anchoring system into the pool deck so the block doesn’t rock or wobble upon a swimmer’s takeoff,” says Karen Andrus-Hughes, marketing manager for S.R. Smith LLC in Canby, Ore.

Manufacturers like S.R. Smith rely on fiberglass and textured composite coatings to create these solid, nonslip blocks. The company’s newest starting block, Velocity, is comprised of a GFRP top block and start wedge created through resin transfer molding. Another layer, a proprietary textured composite material called TrueTread, covers the surface of the block to provide a durable foot grip. Polypropylene and gel coats have proven popular as a nonskid top for starting platforms.

**Tennis and Badminton**

Given that tennis greats such as Venus Williams can hit balls at speeds reaching nearly 130 mph, strength and durability are key when it comes to the design and manufacture of tennis rackets. Pierre Mace, connected Experience research and development manager for French tennis and badminton racket manufacturer Babolat, notes that composites are the ideal choice for creating rackets because they provide the best possible balance of rigidity and strength with light weight.

“To manufacture tennis rackets, we create a hollow preform by hand lay-up, then bend it to the shape of the racket and place it in a mold with internal pressure using an air bladder,” Mace explains.

Mace adds that racket manufacturers are constantly making slight improvements in the manufacturing process, the cross section design of the rackets and the general design of the rackets’ frames, but the materials used tend to be consistent. Companies like Babolat primarily use carbon fibers reinforced with epoxy resin to construct rackets.

Many rackets also use synthetic strings made from extruded nylon, polyester, Kevlar or a combination of those fibers. According to the International Tennis Federation, polyester and Kevlar provide a significant boost in durability compared to nylon fibers or natural gut strings.

**Track and Field**

For the pole vault, athletes rely on two factors to propel them as high as possible over a horizontal bar – a solid run-up and a flexible pole. Each competitor has only three attempts to achieve their best height, but pole manufacturers have created a number of options to help athletes reach those heights.

Pole vaulters use either a GFRP or CFRP pole. According to manufacturer UST Essx, based in Fort Worth, Texas, vaulters want poles that are light to carry, feature a uniform bend, leave minimal body shock and provide the greatest percent of return.

UST Essx says that carbon fibers add stiffness, and by using more than 100 different types of fibers in its tubular designs it can precisely fine-tune the properties of its poles for incredible lightness balanced with a small handgrip. The manufacturer notes that by minimizing the amount of reinforcing S-glass, it is able to create stronger, lighter poles than have been possible in the past.

But Steve Chappell, general manager of pole manufacturer UCS in Carson City, Nev., points out, “The border [between weight and strength] is very difficult to cross because if you make a pole that’s lighter then it’s going to be more fragile, so it’s going to be more prone to damage and breakage.”

UCS relies on its resin system to increase durability in its prepreg epoxy unidirectional fiberglass poles. “What makes fiberglass the most effective material is that it has the highest elasticity,” Chappell says. “The resin system that we use allows it to be durable. This is a very big issue, because everyone knows that glass can be broken, and if the product suffers a severe impact, it can fail. But under normal use, we find that fiberglass is very durable.”

Strength and durability, combined with lightness and flexibility, are critical for most Olympic sporting equipment. And this high-tech equipment shares one characteristic with the athletes who put these tools to use: It’s a sure bet that the next
Composites Featured in Olympic Architecture

The 2016 Olympics will be spread across 32 venues new and old, both in Rio de Janeiro and five co-host cities. To speed preparations, several older facilities have gotten facelifts and now feature composite technologies.

Among other highlights, composite panels are serving as the base for the restoration of an historic mosaic at the entrance to Rio’s Maracanã stadium, the venue for the opening and closing ceremonies. Supplier Barracuda Advanced Composites explains that the porcelain mosaic, designed by artist Paulo Werneck in the early 1950s for the opening of the World Cup in Brazil, is being glued on composite panels to preserve the authenticity of the mosaic wall and increase its durability. The panels were manufactured using resin infusion, with fiberglass facings and PVC foam core, while the mosaic is adhered with an epoxy adhesive.

Soccer fans able to look away from the field at Estádio Nacional Mané Garrincha in Brasilia, Brazil, may appreciate the GFRP roofing system recently added to the renovated facility.

Fabricator Birdair explains that titanium dioxide is a flame-resistant coating applied to the fiberglass membrane that requires less maintenance due to its self-cleaning capabilities.

And fiberglass-based tensile roofs now cover portions of the Estádio Nacional Mané Garrincha in Brasilia and Estádio Mineirão in Belo Horizonte, two of the venues to host Olympic football (better known as soccer to Americans). The roofing systems feature titanium dioxide-coated polytetrafluoroethylene, a Teflon®-coated woven fiberglass membrane.

Olympic cycle will feature a new batch of composite equipment that will help the next-generation of athletes demonstrate even more impressive physical feats.

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Facing higher Corporate Average Fuel Economy (CAFE) standards of 54.5 miles per gallon in the U.S. and 95g/km CO₂ emissions limits in Europe, automotive OEMs are evaluating every option for lightweighting vehicles. The increasing stringency creates a need for new approaches.

Automotive OEMs and Tier 1 suppliers are well aware of the strong, lightweight properties offered by CFRP prepreg and are eyeing the development of fast-curing prepreg to replace metals for a range of structural and Class A surface automotive parts. The attraction is based on the capability for out-of-autoclave compression molding of CFRP prepreg to reduce cycle times for high-volume production.

Until recently, the potential for CFRP prepreg had a ceiling. Production volumes were inhibited by the time needed for thoroughly cross-linked curing during conventional autoclave processing. Significant manual labor for lay-up is a non-starter, and the steep cost of CFRP prepreg also creates a boundary.

“About 14,000 to 40,000 parts would be considered very high volume for CFRP prepreg, but for automotive applications this is considered low- to mid-volume,” says Adam Harms, marketing manager – automotive for Huntsman Advanced Materials. “Around 20,000 to 25,000 parts per year on a single production line such as the Corvette roof has been the sweet spot for prepreg, an application where it makes the most sense. In automotive, you haven’t reached high volume until about 100,000 parts.”

Several material suppliers have accepted the challenge from OEMs to develop rapidly curing prepregs that can achieve 2- to 3-minute cycle times through compression molding, qualifying prepreg for high-volume production in the area of 80,000 to 100,000 parts per year. The race between material suppliers, Tier 1 suppliers and automotive OEMs is on.
Speed + Quality Control

Compression molding of fast-cure prepregs is being evaluated alongside high-pressure resin transfer molding (HP-RTM) and wet compression molding. In HP-RTM and wet compression molding, the end user places dry carbon fiber into a press, wets it out with an appropriate resin system and applies pressure to form the component. There are disadvantages to these related approaches, says Will Ricci, technical services engineer for Gurit.

“When wetting out the carbon fiber, the fibers may move, compromising directional strength and aesthetic appeal,” he says. “Shifting fibers may cause distortion and negatively impact the distribution of forces within the part, reducing overall part stability, a critical concern especially for structural parts requiring impact resistance. In structural parts positioned where vehicles emit high heat loads, the maintenance of fiber orientation and the polymer’s thermal stability is critical.”

In the curing stage of HP-RTM and wet compression molding, the processor is taking the composite from a high energy state to a low energy state. The difference between the two states is substantial, and, if not handled properly, can lead to high shrinkage, microcracking and severe or uncontrolled exothermic reaction. “Loading fibers correctly, using the right resin mix, wetting correctly – there are a lot of ways to go wrong in HP-RTM and wet compression molding,” Ricci notes.

Since the carbon fiber in fast-cure prepreg is fully impregnated, this approach offers reliability advantages by maintaining fiber direction for long-fiber composite parts. Pre-staged, the difference in energy states from the start to the end of the process reduces the risk of microcracking and offers better quality control over tensile strength and visual aesthetics. In a market that is less familiar with CFRP, the compression molding of prepreg can be a less formidable challenge. Most importantly, prepreg compression molding can reduce the forming cycle time from as much as four hours down to five to 10 minutes.

Outlife of the prepreg material, frequently a concern for small run parts, poses little risk for these fast-cure, high-volume applications. The material is quickly used once outside of a cooling room. In any case, most fast-cure prepregs exhibit low reactivity, with an outlife of two weeks at 20 °C.

It may take hours for a standard prepreg cure process, allowing enough time for the resin system to heat to temperatures between 80 and 150 °C, reach its gel point, begin to flow and cure so that chemical linkages form and the full mechanical properties of a cured state are attained. With rapid-cure prepreg, production time for all three stages – polymer flow, gel point and final cure – is measured in minutes.

Chemically, the difference between standard and fast-curing CFRP prepreg is slight. For example, Gurit is using a host of polymers and catalysts which are staged to allow the total cure process to be condensed. The initial catalyst activates at a lower temperature, while a second catalyst kicks in at a mid-temperature and so on, maintaining precise control over the cure process. Beyond that, Gurit’s formulation and process are confidential, Ricci notes.

Huntsman Advanced Materials, already a supplier to global aerospace prepreg manufacturers, is partnering with existing and new automotive customers to develop fast-curing prepregs by supplying resin matrix building blocks, including epoxy resins, hardeners, diluents and accelerators. The accelerators play the role of speeding up the reactivity of slower acting resin formulations.

“The key is carefully pairing accelerators to allow the use of higher processing temperatures, thereby decreasing the need for epoxy diluents that may decrease thermal and mechanical performance properties and increase cost,” says Harms. “Properly chosen accelerators and their use level in the resin matrix can serve to beneficially influence properties such as modulus, strength and elongation, as well as shorten cure time.”

The formulation of the prepreg fibers – unidirectional tape, woven reinforcements, tow, number of stacks and thickness – is

Hexcel's HexPly® M77 rapid cure prepreg is cut to shape and stacked (together with adhesive) on a fully automated line in Neumarkt, Austria. BMW uses the preform to save weight and reinforce the metal shell of the BMW 7 Series.
Automotive OEMs, Tier 1 and 2 suppliers and suppliers of CFRP materials are forming cooperative teams to push the development of CFRP applications forward in advance of fuel efficiency standards. Some of the partnerships are listed here:

**Mitsubishi Rayon Co. Ltd. (MRC):** In 2014, mass-produced CFRP parts made their commercial debut for deck lid inner and outer panels for the Nissan Skyline GT-R supercar, reducing the part’s mass by 30 percent. Since then, diffusers for the Skyline GT-R have incorporated MRC’s prepreg compression molding (PCM) technology. MRC claims a 2- to 5-minute cure time is possible with heat and high pressure of its proprietary molding process.

In March 2016, MRC signed a memorandum of understanding with Tier 1 supplier Continental Structural Plastics for the development of Class A body panels, as well as non-class A structural automotive applications, including pillars, engine cradles or supports, radiator supports, frames and rails, bumper beams, underbody shields, door inner and intrusion beams using fast-cure prepreg and/or sheet molding compound.

**Cytec Industrial Materials:** Cytec is working in tandem with Jaguar Land Rover to develop fast-cure prepreg applications with 5-minute cure cycles such as floor pans, sidewall panels, crush cans for bumper beams and body panels.

**Hexcel:** One of the most intriguing components of the BMW 7 Series is the B-pillar – the side post between the front and rear doors. The weight-saving sandwich design features an exterior metal pillar reinforced with an inside preform of HexPly® M77 rapid-cure CFRP prepreg. Hexcel supplies BMW with preforms made of unidirectional carbon prepreg set in various orientations and combined with adhesive. The prepreg cures in 1.5 minutes at 160 C. It requires special attention to the baking process because the temperatures needed to cure the CFRP component approach temperatures that weaken the heat-treated metal stampings.

**Barday Composite Solutions/Zoltek:** These materials suppliers are working with Tier 1 supplier Magna International, using fast-cure prepreg from Barday and carbon fiber from Zoltek, to run a 10-minute cycle to produce 14,000 composite hoods for the Cadillac ATS-V and CTS-V Series.

**Toray Carbon Fibers America:** Tier 1 supplier Plasan Carbon Composites, a U.S. manufacturer and distributor of auto parts, is leveraging its proprietary high-speed pressure press molding technology to supply CFRP-based exterior body panels (hoods, roofs, etc.) for performance and luxury cars of General Motors. Plasan uses Toray’s rapid curing CFRP prepreg for its high-speed pressure press molding.

The CFRP hoods for Cadillac’s 2016 ATS-V and CTS-V high-performance vehicles are more than 27 percent lighter than aluminum hoods and 72 percent lighter than steel hoods. Magna International molded the hoods, which represent the auto industry’s first volume production of CFRP hoods.

Part dependent. Typical processing temperatures are consistent with standard prepreg at around 80 to 150 C.

**Press Makers See Opportunity**

One of the keys to successfully processing fast-cure CFRP prepreg in high volumes is investing in the efficiency and reliability of a manufacturing work cell, consisting of a laser cutter, high-volume mold, hydraulic press and robotic automation for loading the fabric and picking the final part. “The speed of the hydraulic press contributes to the cost-effectiveness of the switch from metal to prepreg,” says Paul Thom, sales and product manager for Schuler Group, a supplier of hydraulic presses to BMW. Typical pressure required by fast-cure prepreg applications ranges from 2 to 10 megapascal (MPa) or 290 to 1,500 psi.

Using an automated work cell not only eliminates time and safety issues related to manual labor, it also offers better part quality control. Hydraulic presses respond to the behavior of both the press and internal processing conditions inside the mold.

“Ram parallelism (the ability to keep all four corners of the press in alignment to apply pressure evenly) controls for parts with small wall thicknesses,” says Thom. “Sensors in the four corner columns or ‘slides’ of the press sense when there is a difference in the distance between the top and bottom mold halves that may be the result of resin accumulating in one area of the part over another. The machine operator is able to adjust the pressure in each corner independently to achieve uniform wall thickness. Most parts are not exactly symmetrical. Part loads may vary and the press is able to adjust to load conditions.” Currently, pressure adjustments are made manually by the machine operator via the control, but Schuler Group is working with BMW and the Aachen Center for Lightweighting Technologies at the University of Aachen in North Rhine-Westphalia, Germany, to develop closed-loop control for compression molding and RTM presses.

Traditional automotive suppliers exploring fast-cure prepreg applications may find hydraulic presses offer more familiar technology than composites processes such as autoclave...
production, reducing the learning curve as they convert from stamping of metal parts. It would be convenient if metal stamping presses could be converted for compression molding prepreg, but that is not the case. “The biggest difference is in the control system,” says Thom. “The processing of prepreg requires a more sophisticated control of pressure.”

Presses are specified by tonnage range, and the press size is completely dependent on the part dimensions and shape. A large part – such as a 36-square-foot automotive hood – may require a press in the neighborhood of 3,000 tons, while a part measuring 2 square feet can be produced on a 600-ton press. “Since we are in the early stages of developing expertise in the compression molding of fast-cure prepregs, the size and specifications of the press are still customized for each prepreg application,” admits Thom.

If a supplier is currently using a hydraulic press for RTM, it may be possible to repurpose the press for compression molding of fast-cure prepregs. “Different features are required for the control system to account for varying process behaviors, but generally, yes, this possible,” says Thom.

The Schuler Group is currently building a hydraulic press for placement with the Institute for Advanced Composites Manufacturing Innovation (IACMI) Vehicle Technology Area, where member companies such as Ford and Lockheed Martin will be able to run their own fast-cure prepreg applications tests on the press.

**The Cost Equation**

Fast-cure CFRP prepreg carries a higher price point than steel, but using industrial grade carbon fiber (as opposed to aerospace grade with additives for flame, smoke toxicity and functionality requirements) helps to mitigate the cost differential. Purchasing the prepreg in higher volumes lowers the cost even more.

An important consideration in the decision to use fast-cure prepreg is the capital expenditure for the compression molding infrastructure. Adding up the cost of high-volume capable tooling, hydraulic presses and sophisticated automation, a hefty capital expenditure is required. Ricci notes, “A production tool alone that is capable making 50,000 car hoods can run in the hundreds of thousands of dollars.”

To achieve high production volumes, automated work cells are needed to cut prepreg, precisely orient and assemble the plies, and transfer the multiple plies (preform) to the heated mold, then after curing, take out the part likely using a 6-axis robot for placement on a cooling fixture or for further in-line or downstream processing such as trimming, painting or bonding.

Tier 1 Supplier Magna International has developed an automated work cell that robotically lays multiple plies of standard-width, 0.02 mm-thick prepreg in a 0°/90° orientation, which are then trimmed and robotically transferred to the mold. The mold features a patented design to prevent movement of the stacked plies during the mold close phase and during the application of pressure. According to Magna International, the conversion of hoods for the Cadillac ATS-V and CTS-V Series from steel to CFRP resulted in a cost savings between 20 and 30 percent. Potential savings for processors depends on the part and the grade of steel or aluminum being replaced.

It may be five years or so before fast-cure prepreg is used on mass-produced vehicles, notes Dale Brosius, chief commercialization officer for IACMI. “But compression molding of rapid-cure prepreg is creating a successful path. The possible developments down the road are exciting, such as the production of prepreg right in line with the compression molding process. Among composite processing alternatives, rapid-cure prepreg is simpler to achieve and offers the potential to be very, very fast.”

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A state and federal regulatory tag team took swings at composites manufacturers this year. The California EPA will now require cancer warnings for many products made with styrene, while OSHA has introduced stringent new regulations on exposure levels for respiratory crystalline silica (RCS).

But the impact of the new regulations may not be as large as the composites industry originally anticipated. ACMA’s Government Affairs Committee has conducted research to assess the regulations’ possible effects on association members and developed tools to help them comply. It found that while all manufacturers should assess their operations, most will not be affected by these regulatory changes.

Styrene Listed Under Prop 65

Any U.S. company that produces or sells products that could be used in California must comply with the provisions of Proposition 65, so California Environmental Protection Agency’s (CalEPA) inclusion of styrene on its list of possible carcinogens could affect composite manufacturers throughout the country. (For more information on Proposition 65, see the sidebar on page 28.)

For more than a decade, both CalEPA and the National Toxicology Program (NTP) have been looking at styrene as a possible carcinogen. While several large studies of composites industry workers have found no link, research in 2011 showed that at relatively low exposure levels, mice exposed to styrene develop lung tumors.

“But neither the NTP nor CalEPA paid much attention to the large number of studies and the large body of robust evidence that shows that the mouse lung tumors occur through a bio-chemical mechanism that doesn’t happen in humans,” says John Schweitzer, ACMA’s senior advisor to the president on government affairs. “Humans don’t have the enzymes that are used in mice to convert styrene to the tumor-causing chemical.”

NTP included styrene in its 2014 Report on Carcinogens and classified it as “reasonably anticipated to be a human carcinogen.” That resulted in CalEPA adding styrene to the Prop 65 list, which includes hundreds of chemicals ranging from relatively obscure ones such as methylazoxymethanol acetate to familiar carcinogens like tobacco smoke.

Although the styrene industry had presented evidence to both NTP and CalEPA supporting its position that styrene is not a carcinogen, the Government Affairs Committee realized it needed to develop a strategy in case the organizations rejected its viewpoint. Working with an experienced Prop 65 consultant, the committee created a program to help members comply. Researchers developed a method that composite manufacturers can use to estimate their products’ styrene emissions, then employed that process to test about a dozen typical composite products. They also estimated the likely safe harbor exposure limits CalEPA would set for styrene.

The study found that the type of manufacturing process impacted a product’s styrene exposure levels; open molded products generally have a higher residual styrene content than compression molded products. The composition of additives can make a critical difference as well. In one case, the ACMA researchers traced a product’s unexpectedly high level of styrene exposure to the low-profile additive the company was using.

In April, CalEPA officially added styrene to the Prop 65 list and proposed safe harbor exposure limits of 27 micrograms per day average lifetime exposure. That was good news for the composites industry; in ACMA’s testing, the highest styrene exposure researchers found was 4.5 micrograms per day average lifetime exposure. That means most manufacturers of composite products will not have to use warning labels on their products.

“If a manufacturer’s product and its use are sufficiently similar to the products and uses that we tested in the research report, we think they can use those estimates as direct exposure estimates for their products. That’s a big shortcut for them,” Schweitzer says.

Even if the manufacturers’ products are not sufficiently similar to those tested by ACMA, composite manufacturers can still use the basic approach and methods described in the report to generate...
To ensure their compliance with Prop 65, composite manufacturers should review the ACMA styrene exposure reports and determine if they can use the report’s information or they should run their own tests. If their products’ styrene exposure levels exceed the safe harbor limits, manufacturers should find ways to reduce them. “For example, if you take a molded product and heat it up a bit, you can further reduce the amount of styrene that’s left over,” Schweitzer says. “You can also change the chemistry of the raw materials.”

While some companies might be tempted to simply put Prop 65 warning labels on all their products, Schweitzer believes this
is a bad idea. “We really think it’s misleading people, because we really don’t think that styrene is a carcinogen,” he says. “It’s also very unlikely that the use of composite products would result in high enough exposure to cause a health concern even if it was a carcinogen.”

In addition, composite products with such warning labels could end up in markets outside of California. While Californians may be somewhat inured to Prop 65 warning labels – they are everywhere, including the entrance to Disneyland – people in other states who see the warnings could be unduly alarmed about the safety of composite products.

Although ACMA has made a strong case for excluding composite products from the warning list, it can’t prevent groups from taking a composite manufacturer to court for not including styrene warnings. But Schweitzer considers that unlikely. “First, I don’t think the public is aware of the link between composites and styrene, unlike polystyrene food packaging, where styrene is in the name,” he says. “Second, if anybody does come looking at us, we can show them our data right away and hopefully convince them that we’re not worth pursuing.”

Few Concerns on Silica Exposures

ACMA also conducted a study last year to determine how OS-HA’s recent reductions on the permissible exposure limit (PEL) for respirable crystalline silica would affect composite manufacturers.

“It turns out that most composite manufacturers will not be affected because they don’t use sand as a filler,” says Dave Lipiro, president of Environmental Compliance and Risk Management, who managed the study.

The updated standard sets the PEL for RCS at 50 micrograms per cubic meter of air over an eight-hour shift. That’s almost a 100-fold reduction from the previous standard, according to Lipiro. Companies that exceed the PEL will have to reduce it
through engineering controls (wet cutting or ventilation), by limiting worker exposure to high risk areas, by offering medical exams to highly exposed workers and by training workers on silica risks. The new OSHA standard also includes an action level of 25 micrograms per cubic meter, which requires employers to begin measuring the amount of silica workers are exposed to.

For the ACMA study, researchers looked at a variety of composite manufacturing operations. Companies that use limestone, calcium sulfate, gypsum or other non-quartz fillers don’t have a concern because these materials contain only small amounts of RCS. But companies that use fillers containing sand or silicon carbide, which can contain larger quantities of RCS, should check their workers’ exposure.

“If you are sandblasting, you also have potential issues and should assume that you could be regulated and that you need to take further samples,” Lipiro says. “If you do need to do abrasive blasting, there are alternatives to sand that do not contain quartz, and you should consider those before you use anything else.”

Companies using non-quartz fillers that are compliant with other OSHA regulations, including the respirable dust and combustible dust standards, should not have a problem with the new RCS rules since they are already providing the necessary ventilation and other protections, Lipiro adds.

Since OSHA approved the design of ACMA’s RCS study, composite manufacturers can feel confident in its findings. “The report is objective evidence in the eyes of OSHA that non-quartz fillers will not be an issue,” Lipiro says.

The Complexities of Compliance

The styrene listing and RCS levels are two examples of the many regulations that composites companies must follow. But managers charged with ensuring company compliance are often spread too thin.

“They may be the safety manager and the environmental manager and the compliance manager and may be involved with workers comp and insurance or risk control programs,” says Rob Levandoski, president of manufacturing solutions at Fuss & O’Neill, experts in environmental compliance and permitting. “They are all interwoven, but they are all different. The challenge is to keep the details of each of the applicable regulatory agencies separate and understandable, not only for the environmental, health and safety professional, but also for employees, management, owners or stockholders.”

Help is available. In addition to assistance provided by ACMA, Levandoski points out that there are numerous societies or professional organizations doing outreach at local and national conferences. One particularly good source is OSHA’s Voluntary Protection Program (VPP), which emphasizes collaboration and idea sharing as it helps companies become compliant with OSHA regulations. In addition to on-site audits, the VPP program also holds national and regional conferences open to all.

Owners of non-compliant companies may never have received a good introduction to these business obligations, Levandoski adds. Even if they’ve had an OSHA inspection or received loss control services from their insurers, they might not understand the extent or magnitude of the regulations applicable to their business.

“Companies doing a good job with compliance first of all have a manager or owner commitment,” he says. “They get that the safety obligation is complex and that they need someone on their staff to support the program and to support management in making a high-quality product and making it safely.” Large companies have the resources to hire a dedicated person for compliance issues, but for small to medium-sized businesses it can be a very real struggle. They should consider hiring a consultant, even part time, to educate management on the vulnerabilities of their specific business.

Companies should not treat compliance with safety and other government regulations as an add-on or an extra part of their business. “When it’s designed in, the value becomes part of your culture and your business,” Levandoski says.

Mary Lou Jay is a freelance writer based in Timonium, Md. Email comments to mljay@comcast.net.
ACMA Leads Discussions at ANTEC

A CMA’s John Busel and Composites Manufacturing managing editor Susan Keen Flynn participated in panels at the 2016 SPE ANTEC in Indianapolis. Busel and his panel offered insights into the needs of the composites industry and the progress being made at IACMI. Flynn and her panel addressed global trends in plastics and composites use.

Grab Congressional Attention this Summer

Did you know that Congress is considering many bills that directly impact the composites industry and your company’s bottom line? During the summer, members of Congress will be looking to meet with local business leaders. It’s the perfect opportunity for you to host a plant tour for your senator or representative. ACMA will work with you every step of the way to help plan and execute a successful event. By hearing directly from their constituents, members of Congress know exactly how the policies enacted in D.C. impact their local community. For additional information about congressional plant tours, contact Brooke Wickham at bwickham@acmanet.org.

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Face-To-Face Event Draws 40 Companies

ACMA’s recent Face-To-Face event was held in Philadelphia in conjunction with ACMA’s Composites Pavilion at the American Institute of Architects annual show. Over 40 member company and prospective member attendees met to network and learn about ACMA’s programs and planned activities for the coming year. ACMA’s next Face-To-Face event will be in Elkhart, Ind., in December.

CM Online Now on Apple News

You can now access the latest issue of Composites Manufacturing as well as weekly Industry Digest stories, on the Apple News app on your iPhone or iPad. Under the search tab of your Apple News app, type “composites,” and CM will be the first option that appears under “channels.” Once there, you can create a shortcut to CM on your phone and get the latest composites news at your fingertips.

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For more information on becoming a member of ACMA, email membership@acmanet.org or call 703-525-0511.

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One of the latest pop culture crazes is faux hoverboards – handle-less versions of the early 2000s Segway that don’t actually hover. One company, however, has created a “real” hoverboard that conjures up memories of Marty McFly, the protagonist in the “Back to the Future” movie trilogy.

“It’s like riding a skateboard on air,” says Emilio Perez, one of the engineers from ARCASpace, the New Mexico-based company that created the hoverboard, known as the ArcaBoard. The idea to use composites was conceived while ARCASpace developed its primary project, a large drone called the AirStrato.

According to Perez, the company created eight prototypes of the hoverboard – each one with different materials. The prototype that Perez says offers the highest performance incorporates CFRP or GFRP in several parts, including the main body and thrusters. The boards are made using hand lay-up. “We’re also looking into having paper foam reinforced with carbon fiber to get the weight down,” said Perez. “There are foams that can be used to form an I-beam with the carbon fiber to create strength and rigidity, as well as establish a base mold.”

The hoverboard was officially released to the public April 14 in Monaco. The company has secured strategic partnerships with U.S. and Chinese suppliers like Southwest Composite Works Inc. and Eco Molding Co., both of which helped ARCASpace bring the price of the board down from $19,900 to $14,900.
Now in its 3rd year, CAMX has established itself as North America’s event that connects and advances the world’s composites and advanced materials communities. CAMX is the go-to marketplace for products, solutions, networking and advanced industry thinking. CAMX is the largest global event in North America for the industry.

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