NORPLEX MICARTA

High Performance Thermoset Composites

Thermoset composite tubing protects the RD93 dropsonde tracking device from severe hurricane conditions, allowing for accurate monitoring of atmospheric phenomena.

Thermoset Composite Comes to the Aid of Hurricane Hunters

To gather vital data for national weather agencies, hurricane hunters penetrate into the heart of the fierce storms they track using a device called the RD93 dropsonde. The RD93 consists of a package of electronic instruments housed in a tube that must protect the electronics from the worst hurricane conditions. What's more, the tube must be able to withstand the high forces generated when the RD93 shoots out of an airplane.

At first, RD93 tubes were made of coated cardboard. But emissions from this material were found to cause harm to the sensitive instruments inside. So the cardboard tubing was replaced with tubes made of thermoset composite material, which provides the strength and protection necessary for the job but does not endanger nearby electronics. Despite its strength, the thermoset is also easy to machine.

Dropping into Danger

Made by Vaisala, Inc., the RD93 gathers information about atmospheric phenomena for weather forecast calculations. The device is ejected from research aircraft flying above the area of interest. Slowed in its descent by a special parachute, the RD93 measures atmospheric pressure, temperature, relative humidity, wind direction, and wind speed two times each second from the point of launch until the device hits the ground or drops into the sea.

The RD93 sends this meteorological data back to the aircraft via a small 400 MHz transmitter. The device also includes pressure and temperature sensors, as well as a GPS receiver that tracks the dropsonde's horizontal movement for wind-speed calculations.

These instruments are housed in a tube measuring about a foot long and a little more than two inches in diameter. As the RD93 falls through a hurricane, the tube shields the instruments inside from wind, rain, and debris. The tube also protects the delicate electronics from personnel who handle the dropsonde prior to launch.

The RD93 is designed for high-altitude deployment from a variety of aircraft. One of these planes ejects the dropsonde using a spring launcher that generates about 75 pounds of force, which is applied to one end of the tube. Instead of using a launcher, other planes simply drop the RD93 by opening a hatch. In these cases, the dropsondes are sucked out of the aircraft at speeds of about 500 miles per hour and then slow down very quickly when their parachutes open. This rapid acceleration and deceleration can subject the tubes to forces of up to 80 g, according to Vaisala.

Besides a tube with the strength to handle these forces, Vaisala needed a material that could survive soaking rain as the dropsonde falls through a storm. In the 8-15 minutes it takes the RD93 to complete its descent through a hurricane, a regular cardboard tube would soak up so much water that it would start disintegrating before it completed its mission. So Vaisala's first material choice was a cardboard tube sprayed with a water-resistant exterior coating.

This combination solved the water-absorption problem. But to Vaisala's dismay, it created another by outgassing. Gases emitted by the tubing material damaged the dropsonde's humidity sensors, which are very sensitive to contamination.

Problem-Solving Thermoset

Vaisala soon found the properties needed for the dropsonde in tubes made of thermoset composite material. Composite materials consist of a reinforcement in a polymer resin. Composite resins start out as liquid polymers, but they are changed to solids during the molding process. Exposure to thermal energy causes the formation of three-dimensional covalent bonds between the polymer molecules. This process, known as crosslinking, is irreversible.

Since crosslinking permanently solidifies the materials, they are known as thermosets. Crosslinking creates a rigid molecular structure that allows thermosets to maintain good physical and electrical properties. Most thermoset resins are polyester, vinyl ester, or epoxy. As for reinforcement, both paper and glass fiber can be used in thermosets, depending on the product's strength requirements.

The thermoset tubing material chosen for the RD93 consists of paper reinforcement and a phenolic resin system. Though the wall thickness of the tube is less than 0.1 inch, it is strong enough to handle the forces generated by dropsonde launches and to protect the device's instruments from the elements during descents through a hurricane. Unlike cardboard tubing, thermoset tubes do not absorb excessive amounts of water, ensuring the survival of the RD93 until the end of its mission. And thermoset material does not outgas like its coated cardboard predecessor, so it is no threat to the sensitive instruments inside the tube.

RD93 tubes are machined for Vaisala by EPTAM Plastics, a contract fabricator of plastic components. Using a CNC saw, EPTAM cuts the thermoset material to the exact length required for the application. Then the company uses a CNC lathe to mill several holes into the tubes. These holes give RD93 users access to the instruments inside the tubes in order to program the dropsondes and turn them on and off.

According to EPTAM, the thermoset material is easy to machine with standard equipment. It also provides good dimensional stability, allowing EPTAM to hold very tight tolerances during machining operations.

In the field, the thermoset tubing material has proven itself during a long and successful period of service. Since the material switch, Vaisala has received no reports of tubing-related problems with the RD93 either in storage or in use.

Conclusion

Thermoset composite tubing materials offer an attractive combination of properties for product manufacturers. Though relatively light, they are strong enough to withstand considerable amounts of force. Despite their strength, however, they are easy to machine using standard equipment. And though they contain paper reinforcement, they will not absorb excessive amounts of water that threaten their survivability in the field. They also will not threaten sensitive electronics nearby by emitting harmful contaminants. Thermoset composites meet the requirements of some of the most challenging conditions, providing the strength and flexibility necessary for storm tracking sensors to function in some of the worst weather on earth.

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