Testing Devices Garner Data on Insulation Performance

Kennedy Space Center's Wayne Heckle fills a cryostat instrument, developed at the Cryogenics Test Laboratory at Kennedy, with liquid nitrogen. The cryostat instrument tests the thermal performance of insulation materials in a standard, repeatable way.

NASA Technology

Whether you wanted to know how certain insulation would work on a Mars-bound spacecraft or on an Earth-based refrigerator, you would want to test its performance in the very same way: accurately. At least that is how James Fesmire, senior principal investigator of the Cryogenics Test Laboratory at NASA's Kennedy Space Center, sees it. "If you don't have accurate data, you have nothing," he says.

"When we talk about cryogenic tanks and deep spacecraft protection, we can easily talk about hot water heaters and engine compartments for NASCAR at the same time," he says. "Heat goes from the hot side to the cold side. It's the same energy on Earth or in space and that heat always goes in the same direction."

For Fesmire, the accuracy of the technique used for evaluating insulation is at least as important as what the insulation is used for. In the 1990s, while working on the idea of a flexible aerogel, a NASA-derived high-performance insulation material (*Spinoff* 2010), Fesmire's team was at a loss: they didn't have an effective way to verify its performance. "We realized there wasn't anything to test the stuff," he says. "The machines we used didn't have the sensitivity to get meaningful results under the right conditions."

Together with a team at Kennedy's lab, the origin of the future Cryogenics Test Laboratory, Fesmire began developing a test instrument that could garner measurements of the true thermal performance of aerogel insulation as well as other types of insulation under extreme conditions. "We made it really simple," he says. "We didn't invent boil off calorimetry, but we incorporated it into a standardized instrument that anybody can use."

The test instrument uses a cold cryogenic fluid, which boils at a very low temperature, inside a cylindrical chamber. Surrounding the cryogenic chamber is another cylindrical, vacuum environment container. The test material is placed around the cold chamber, and as heat from the outer vacuum container passes through the insulation to the inner container, it causes the fluid to boil. The rate of boil off, or how much liquid is vaporized, is directly related to the insulating performance of the test material.

Through many years in the development process, the team encountered a number of challenges that they had to address, including how to control the environmental conditions, how to maintain a special stability of the cryogenic liquid, and how to ensure the insulation inside the enclosures was installed the same way for each test.

Putting their heads together, the group overcame each one of the issues. The result was Cryostat 1, an absolute thermal measurement instrument that proved capable of testing any insulation material that the team threw at it. This instrument quickly led to a simplified, comparative-type instrument named Cryostat 2, which was complimentary to the Cryostat 1. Over time, the Cryostat 1 and the rest of the Cryostat family became a cornerstone capability for the laboratory. "Now," says Fesmire, "thermal properties can be measured in a standard, repeatable way for both practical and extreme applications."

Technology Transfer

In 2010, the Cryostat 2 (now called Cryostat 200) was being used for testing under a Space Act Agreement with a private industrial materials manufacturing company, which showed interest in acquiring the technology for use in its own business. At the same time, a private aerospace company expressed interest in having its own test capability for product development and certifications. A contractor at Kennedy—McLean, Virginia-based QinetiQ North America (QinetiQ NA)—saw a business opportunity and soon applied for a license to make and sell one of several versions of the NASA Cryostat that was developed over the last two decades.

As Fesmire describes, "The Cryostat 200 is the simplest of the cryostats to operate. The cost and design

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make it reasonable and affordable, which is why we are beginning to license and sell those first."

Benefits

According to Jeff Kohler, a business manager for QinetiQ NA, only a handful of manufacturers offer testing devices focused on insulation for extreme temperatures, and of those, none are equipped to handle the low temperature ranges like the Cryostat 200. More important, most current equipment cannot handle the higher performance materials and systems that are now beginning to proliferate in industry. "As cryogenic technologies advance, energy needs grow and efficiency standards increase. Reliable, precise, and versatile testing devices will be required," he says.

While QinetiQ NA already sees interest from companies that want to purchase the NASA-licensed technology, including the original company that used it under the Space Act Agreement, Kohler says the technology will initially attract aerospace and energy customers. The company plans to market the technology to organizations doing research and development for new materials for industrial and medical uses, as well as new product development for things like piping and storage tank insulation, appliances, and consumer goods.

Another likely application, describes Kohler, is to test insulation that is being used in the food refrigeration industry. "Food is transported in refrigerated containers, and the better you insulate the containers, the better you can maintain cold temperatures and the better your food stays," he says.

QinetiQ NA licensed the Cryostat 2, shown here, from Kennedy Space Center. Manufacturers now have an option for testing high-performance insulation materials in relevant conditions on-site at their production or lab facilities.

The Cryostat may also prove beneficial in evaluating the materials used to insulate pharmaceuticals when they are being shipped for the medical industry. "We're looking at all of these industries," says Kohler. "Any industry that needs to keep things cold can benefit from the device."

For insulation manufacturers, the commercialization of the technology will allow on-site tests at production or lab facilities. It will also enable the evaluation of thermal performance over a range of pressures and temperatures—something that has not been previously attainable. "Researchers can quickly test 10 different insulation materials and get the results to see what insulation is better. Manufacturers can use it for quality control. If they make hundreds of insulation products, they might want to test every tenth one for quality or consistency," says Fesmire.

The most important benefit, according to Fesmire, is that the technology can test high performance insulation in relevant conditions and provide the real-world engineering data that are needed for aerospace, energy industries, and building construction. "If it's a really good insulation, then commercial instruments start having a hard time. If it's a high performance thing, you need something like this," he says. And that is why Fesmire is leading the development, in accordance with ASTM International, of a comprehensive new ASTM standard for testing high-performance, low-temperature insulation materials and systems.

With a valuable NASA spinoff technology in hand, QinetiQ NA's Kohler supports Fesmire's idea wholeheartedly. "We saw the opportunity to not only license the technology and sell it, but we also saw an opportunity for NASA, which is looking to take these cryostats into the world and establish a new standard for testing." ❖