National Aeronautics and
Space Administration

Making Sure That Propellant Is Available in Space

game changing development

To travel on a regular basis beyond low Earth orbit, future spacecraft will depend on propellants stored in space for weeks or months at a time. However, even in space, energy radiated from the Sun and the Earth can cause extremely cold, or "cryogenic," propellants—such as liquid hydrogen or liquid oxygen—to "boil-off" (change state from liquid to gas). Storage tanks would need to periodically relieve the pressure buildup and vent some of the gas, so less propellant would be available for missions.

To minimize this energy transfer, the propellant storage tanks used in space must be insulated with the best insulation known to man. This superinsulation, known as Multi-Layer Insulation (MLI), acts as a radiation barrier and is specifically designed to work in the vacuum of space. If applied to your coffee mug, this insulation would keep your coffee warm for several months.

Traditional MLI "blankets" for propellant tanks in space would be composed of 60 or more layers of thin, highly reflective sheets (similar to the silver-colored material used for party balloons and potato chip bags) separated by an insulating netting. A new type of MLI—Integrated Multi-Layer Insulation (IMLI)—uses rigid, low-conductivity polymer spacers instead of netting to keep the radiation barriers separated. In addition to making the material stiff enough to support itself and advanced thermal shields, the spacers reduce the amount of heat leak to the tank. Quest Thermal Group, partnering with Ball Aerospace, developed the technology through NASA's Small Business Innovation Research (SBIR) program.

To find out if IMLI can meet NASA's needs for future cryogenic storage

IMLI coupons mounted in NASA's Kennedy Space Center's calorimeters (which are used to measure thermal conductivity). Left: Penetration tests. Right: Thermal tests.

systems, the Game Changing Development program is funding the Self Supporting Multi-Layer Insulation Project, which is being managed by NASA's Glenn Research Center. The project began in March of 2012 and will continue through July of 2013 to mature the technology so that it will be ready for a demonstration in space.

Recent Tests

Recent testing evaluated "coupons" of IMLI (smaller sections of a layered blanket). Coupons of traditional MLI had already been tested at the same facilities and under the same conditions.

- NASA's Kennedy Space Center measured thermal performance from 80 to –321 °F as well as the reduction in insulation effectiveness when hardware like plumbing, support structures, or wiring penetrated through the IMLI.
- Florida State University is measuring the thermal performance of IMLI coupons from –300 to –424 °F.
- NASA's Marshall Space Flight Center determined whether the extreme vibration and noise levels experienced on a launch vehicle would damage the IMLI.

Promising Test Results

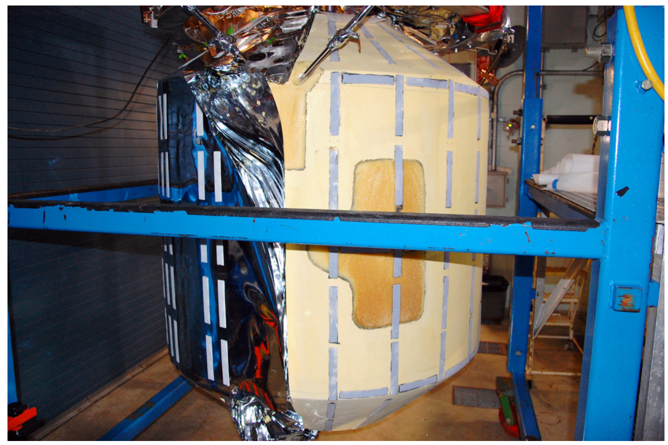
IMLI coupons have been outperforming traditional MLI. IMLI has better thermal performance—with some insulating properties improved by up to 37 percent (and analysis indicates that this could grow to 73 percent for a full system). IMLI reduces system uncertainty in thermal performance and lowers fabrication and installation costs. In addition, it has a more durable structure and was not damaged by the high acoustic noise levels associated with launching on a rocket.

IMLI coupons in NASA Marshall's Acoustic Test Chamber.
Top: Flat panel coupon.
Bottom: Curved panel coupon.

2013 Tests

In 2013, the project will conduct two tests with IMLI blankets applied to storage tanks: a thermal test and an acoustic test. The tests will have already been completed with traditional MLI.

NASA Glenn will conduct the thermal test in its Small, Multi-Purpose Research Facility (SMiRF), which simulates the vacuum and temperature extremes of space. The researchers will test IMLI that is supporting a Broad Area Cooling shield actively cooled by a cryocooler to see if IMLI can be used for the long-duration storage of liquid hydrogen with reduced boil-off.



Test tank in buildup for IMLI test in SMiRF. IMLI on the left; spray-on foam insulation on the right.

NASA Marshall will conduct the acoustic test, subjecting an IMLI blanket and shield identical to those used in the SMiRF tests to the vibrations and noise levels experienced during launch on a rocket.

Use of this new insulation system supports NASA's goal to achieve zero boil-off, which would help enable long-duration missions as NASA develops new capabilities for human space exploration.

On Earth, this superinsulation may one day be used in homes and factories—reducing energy usage and furthering NASA's mission to drive advances in science that benefit everyone.

The Game Changing Development (GCD) program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit
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