# Advanced Refrigerator/Freezer Technology Development Project

The Advanced Refrigerator/Freezer (R/F) Technology Development Project was initiated in 1994, on the basis of recommendations of a team of NASA Scientists and engineers, who assessed the need for advanced technology to support future life and biomedical sciences space flight missions. The project, which was cofunded by NASA's Office of Aerospace Technology and Life and Biomedical Sciences & Applications Division, has two phases. In the Phase I Advanced R/F Technology Assessment, candidate technologies were identified and ranked, on the basis of a combination of their effect on system performance and their risk of developmental success. In Phase II Technology Development, the advanced technologies with the highest combined ranking, which could be accomplished within the budgetary constraints, were pursued. The effort has been mainly by contract, with a modest in-house effort at the NASA Lewis Research Center. Oceaneering Space Systems (OSS) of Houston, Texas, was selected as the prime contractor for both contract phases.

*Six-sided vacuum panel insulated box.*

The Phase I report (ref. 1) identified nine candidate advanced technologies for development. Resource availability forced a limiting of the Phase II technology development contract effort to only the highest priority technology, rigid polymer vacuum panel multi-layer insulation (MLI). Typical 3-1/2-in.-thick fiberglass insulation has an insulation value of R-11/in. or R-3.14/in. The best commercially available vacuum panel insulation has an insulation value of about R-35/in. and has an expected 10-yr life with insulation value of at least R-20/in. Vacuum panel insulation tests by OSS indicated center of panel insulation values of more than R-100/in. Unfortunately, severe design compromises, made to expedite construction of the panels, yielded high conduction heat flow at the panel edges. As a result, the measured overall insulation value for a six-sided box (see the preceding photograph), constructed of these panels, was about R-11.5/in. Although this was well below the intended goal, it agreed reasonably well with the R-13.89/in. computer model prediction. OSS is confident that overall insulation values of R-60/in. to R-80/in. are achievable with optimal panel edge design. The long-term performance of these panels remains to be demonstrated. The OSS contract has been completed, and the final report has been delivered to Lewis for NASA review and editing. It should be published in early 1999.

The Stirling Orbiter Refrigerator Freezer (SOR/F), which flew as a space flight experiment on the STS-60 shuttle mission, was acquired from the NASA Johnson Space Center to serve as a test bed for in-house, advanced refrigerator/freezer technology testing at Lewis. The current effort is aimed at improving the SOR/F performance and making it more versatile. Key objectives are to (1) reduce the electrical power consumption and heat rejection, (2) reduce the rate of temperature rise with the power turned off, (3) reduce the levels of noise and vibration, and (4) extend the operating temperature range down to -80 °C. The original SOR/F operated at temperatures from 4 to -26 °C.

*Stirling Orbiter Refrigerator Freezer.*

So that these objectives can be realized, the original double Stirling cycle cooler, built by Sunpower, Inc. of Athens, Ohio, is being replaced with two improved, higher efficiency coolers (see the photograph on the left) built by Global Cooling Manufacturing Company, under license from Sunpower. Lewis, with the aid of technology furnished by the NASA Goddard Space Flight Center, is developing controls to drive the Stirling coolers to maintain operating temperature and to minimize vibration. The new coolers use liquid cooling, which allows lower heat rejection temperature and improved cooler efficiency in comparison to the original air-cooled Sunpower coolers. Liquid cooling also eliminates the noise of a cooling fan.

*Left: Improved Stirling cooler. Right: Low-temperature diode heat pipes.*

The original SOR/F used heat pipes to transport heat from the storage volume to the

Stirling cooler. The acetone fluid in these heat pipes limits the lower operating temperature to about -40 °C. During 1998, new heat pipes (see the photograph on the right) with propylene working fluid were designed, fabricated, and tested by Thermacore, Inc., of Lancaster, Pennsylvania, and delivered to Lewis. The new heat pipes can operate at temperatures to -100 °C. Also, they are designed to operate as thermal diodes, allowing heat to flow easily from the storage space to the cooler, but they restrict heat flow in the reverse direction, when the cooler is not operating.

# Reference


1. Gaseor, T.; Hunter, R.; and Hamill, D.: Advanced Refrigerator/Freezer Technology Development Technology Assessment. NASA CR-198484, 1996.



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**Programs/Projects:** Life and biomedical sciences spaceflight missions