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NASA TECH BRIEF

Marshall Space Flight Center

Method of Determining Thermal Conductivity in Multi-Layer Insulation Systems

The problem:

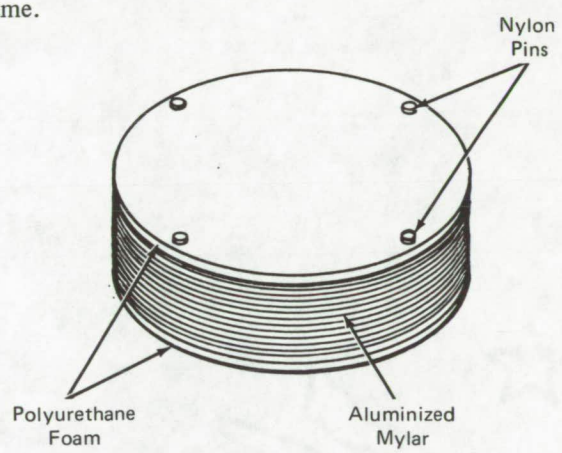
An accurate and repeatable non-destructive method of determining the thermal conductivity of multilayer cryo-insulation material is needed. Methods currently used suffer from lack of reproducible data and difficulties in sample preparation.

The solution:

A method has been devised which prepares the multilayer insulation material for thermal conductivity measurements. Nylon pins of fixed length are used to fasten the layers together. A fixed pin length allows a variable number of layers to be analyzed. The total thickness and pressure of the layer sample can then be measured, using an Instron tester. By determining the plate-to-plate distance of the material, the compressive load can be estimated. This value is needed when the sample is being tested in the calorimeter.

How it's done:

Samples of the insulation material (shields) are stacked so that the aluminized side touches the mylar side of the adjoining shields. Polyurethane spacers are placed on the top and bottom forming a sandwich and pinned as illustrated. A slight compression results from the pins, but it is negligible. The sample is weighed and placed in an Instron tester fitted with parallel plates, 30.5 cm (12 in.) in diameter, which are adjusted to just visibly touch the sides of the sample. The sample thickness and pressure applied are then measured. The sample is then removed from the Instron tester and placed in a calorimeter; a bell jar is placed over the shielded calorimeter; the warm plate of the calorimeter is raised to give a plate to plate distance of 1.72 cm (0.434 in.), and the calorimeter is evacuated for 24 hours. At this time a cryogen is introduced into the test setup at the outer guard, the inner guard, and the measuring vessel. The sample is allowed to equilibrate for 12 hours, and then data acquisition is begun. The data taken are volume of boil-off gas, barometric pressure, gas temperature, chamber pressure, and differential pressure between extremities. The volume of boil-off is plotted as a function of time. The slope of this line is equal to the equilibrium boil-off per unit of time.



The thermal conductivity is calculated according to the following equation:

$$k = \frac{29.9\ mt}{12\ \Delta T} \quad \text{where}$$

29.9 = heat flux in $\frac{BTU}{ft^2}$ per cubic ft. of nitrogen

for 6-1/4 in diameter measuring vessel

m = equilibrium boil-off in $\frac{ft^3}{hr}$

t = sample thickness in inches

ΔT = temperature difference in hot and cold boundaries in degrees Fahrenheit

(continued overleaf)

12 = conversion of sample thickness from inches to feet

This gives k in units of $\frac{\text{BTU}}{\text{hr. ft. }^{\circ}\text{F}} = 1490 \frac{\text{calories}}{\text{hr. m }^{\circ}\text{C}}$

At the end of the test the sample is returned to room temperature and examined for any defect.

Notes:

Requests for further information may be directed to:
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Patent status:

No patent action is contemplated by NASA.

Source: K. G. Scrogham of
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