HOLOMETRIX, INC.

Report on

THE APPARENT THERMAL CONDUCTIVITY AND THERMAL RESISTANCE OF A SPECIMEN OF A CELLULAR INSULATION MATERIAL

Prepared for:

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A specimen of a cellular insulation material was submitted for the analysis of apparent thermal conductivity and thermal resistance of 2C (35F). The specimen was identified as Air-Krete Insulation and a sample approximately dimensioned 290mm (11.5 inches) square by 50.1mm (2.01 inches) thick was supplied. This sample had a test density of 82.2 Kg m^{-3} (5.13 lbs ft^{-3}).

Experimental Procedure for Testing by ASTM C518-85 (Rapid-k)

Each specimen was evaluated in accordance with ASTM C518-85, "Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus" utilizing a Holometrix Model Rapid-k heat flow meter instrument. A schematic diagram of the test facility is shown in Figure 1. The specimen was installed horizontally between 300 mm (12 inch) square aluminum surface plates treated to have a total hemispherical emittance of 0.82 at 24C (75F). The surface plates were smoothly finished to conform to a true plane within a 0.25 percent. Above the upper (hot) and below the lower (cold) surface plates, heaters, heat sinks and insulation were installed. The two heat sink assemblies were connected to a refrigeration system capable of maintaining -30C (-20F) at the heat sink. Temperature control of the surface plates was accomplished by operating the refrigeration system continuously and reheating with the electrical resistance heaters. The temperatures of the surface plates were controlled and monitored by temperature sensors mounted near the heaters and in the surface plates.

Between the bottom of the test specimen and the bottom surface plate, a heat flux transducer was installed. The instrument heat flux transducer utilized has a sensing area 100 mm (4 inches) square located in the center of its 300 mm (12 inch) square overall area.

Temperature measurements were performed by utilizing Type T Copper/Constantan thermocouples calibrated to the special limits of error specified in ASTM E230-83, "Temperature-Electromotive Force (EMF) Tables for Standardized

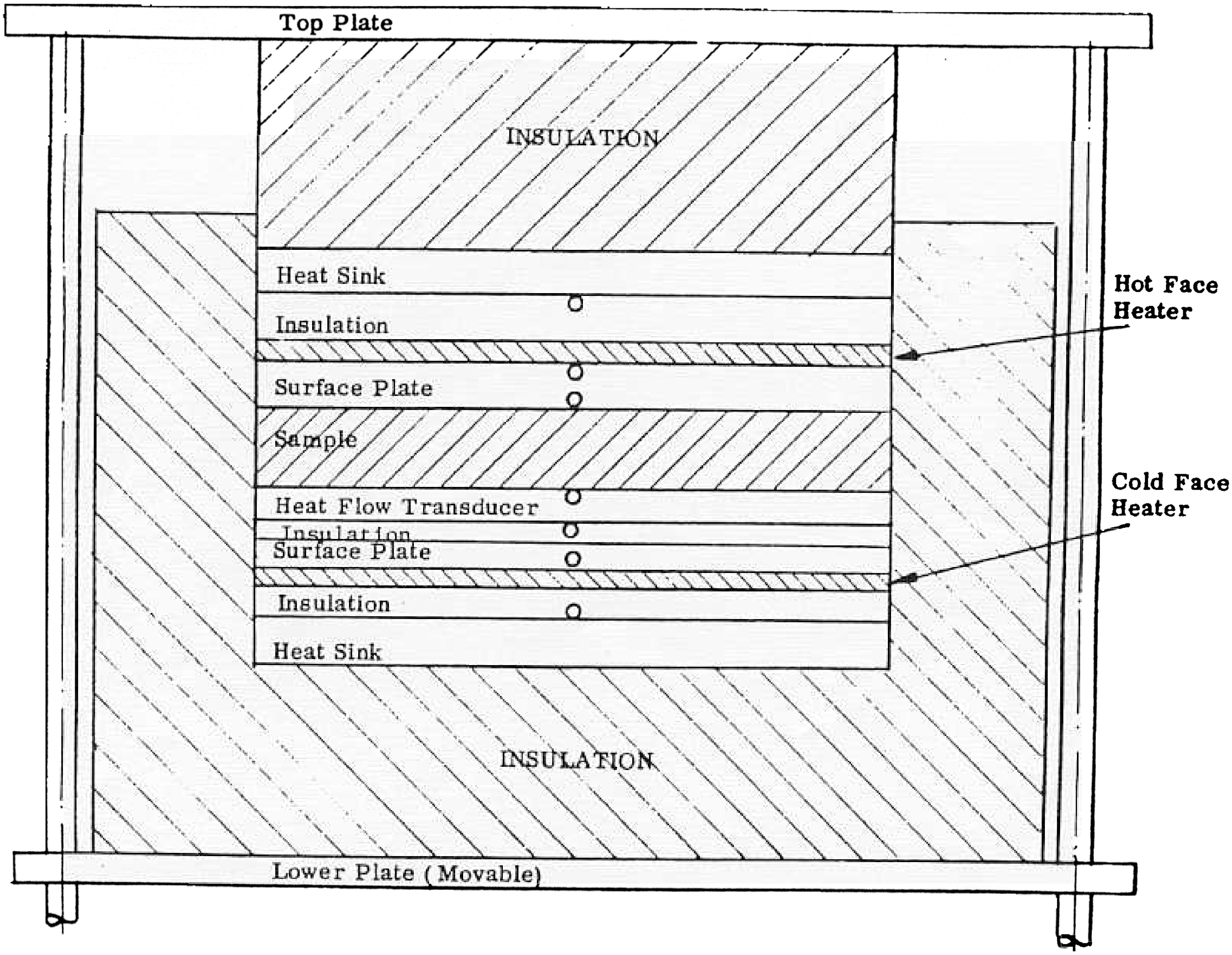

Figure 1

SCHEMATIC OF HEAT FLOW METER
THERMAL CONDUCTIVITY INSTRUMENT

Thermocouples." All thermocouple sensors were fabricated with No. 30 AWG wire. Single temperature sensors were used for measuring the hot and cold surface plate temperatures in the center of the sensing area of the instrument heat flux transducer. All temperature sensors were individually connected to a digital millivolt meter having a resolution of ±1 microvolt.

The bottom surface plate assembly could be adjusted to accommodate surface plate separations from 0 to 100 mm (0 to 4 inches). The opening between the surface plates was measured by using a linear motion potentiometer. The periphery of the test stack was lined with 50 mm (2 inches) of an extruded polystyrene foam insulation having a thermal resistance of about 1.8 m^2K/W (10 hr ft^2 F/Btu) at 24C (75F).

In operation, the plate separation was adjusted to accommodate the test thickness of the specimen being evaluated. Typically the thickness of the specimen was measured prior to its insertion into the instrument and the plates were closed such that the thickness readout corresponded to the average test specimen thickness. The temperature of the top and bottom surface plates were adjusted such that the mean temperature and temperature difference test requirements were satisfied. If no temperature difference requirements were given, 28C (50F) was used.

At equilibrium, established after ensuring that during five consecutive observations at intervals of approximately 1200 seconds the test specimen apparent thermal conductivity changed less than 1 percent and not monotonically, the temperatures of both hot and cold faces were evaluated from the sensors embedded in the plates, and the heat flux through the specimen was derived from the heat flux transducer output.

The test specimen apparent thermal conductivity was calculated from

$$K = \frac{(S_I)\ (HFTOP)_I\ dX}{dT}$$

and the thermal resistance was calculated from

$$R = dx/K,$$

where

K	=	test specimen apparent thermal conductivity;
S_I	=	instrument heat flux transducer sensitivity;
$HFTOP_I$	=	instrument heat flux transducer output;
dX	=	test specimen thickness; and
dT	=	temperature difference across test specimen ; and
R	=	thermal resistance

The instrumentation was calibrated using the National Bureau of Standards' Standard Reference Material 1450b. The calibration specimen is a high density fibrous glass material, 1.0 inches thick, having a thermal resistance of approximately 4.2 hr ft^2 F/Btu. The instrumentation was calibrated before and after every change in the surface plate temperatures.

results are summarized in the following tables.

TABLE 1

THE APPARENT THERMAL CONDUCTIVITY AND THERMAL RESISTANCE OF A SPECIMEN OF A CELLULAR INSULATION MATERIAL

Specimen	Test Thickness		Test Density		Mean Temperature		Apparent Thermal Conductivity		Thermal Resistance
	mm	inches	Kg/m^3	lbs/ft^3	C	F	W/m K	Btu-in/hr ft^2 F	hr ft^2 F/Btu
Air-Krete	50.1	1.97	82.2	5.13	2	35	0.0378	0.262	7.53