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Energy Materials
Testing Laboratory

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University of Hawaii
Institute for Astronomy
2680 Woodlawn Drive
Honolulu, HI 96822

Attn: Dr. Alan Tokunaga

Ref: P.O. # P722193
FMI/EMTL W/A # 4499

Dear Dr. Tokunaga:

This is our final report on the referenced order. The objective was the measurement of emittance on a coated sample over the temperature range from 77 K to 300 K.

SAMPLE DESCRIPTION

One rectangular specimen was received for testing, machined to the nominal dimensions 2" long by 0.5" wide by 0.13" inch thick. The specimen was coated with a smooth reflective mirror finish which appeared gold in color.

BACKGROUND

Emittance is defined as the ratio of the rate of total radiant emission from a body as a consequence of its temperature only, to the corresponding rate of total emission from an ideal blackbody radiator at the same temperature. **Emissivity** is the lower limiting case for emittance when the surfaces of the substance are free from contamination, ideally smooth and optically polished.

In engineering heat transfer calculations, emittance or emissivity are important values in determining the total radiant power emitted from a non-blackbody according to the relation;

$$W = \epsilon A \sigma (T^4 - T_o^4)$$

where;

W = radiant power
ϵ = emittance
A = surface area of the emitting body
σ = Stefan-Bolztmann constant
T = absolute temperature of the body
T_o= absolute temperature of the surroundings

Usually, the **emittance** is of greater interest and is measured on a sample whose surface matches the final application condition of the material. For this sample however, the coating surface conditions closely matched those defined by **emissivity**.

When the emittance is taken in all radial directions above the emitting surface and summed over all wavelengths, the term **hemispherical total emittance** is used.

EXPERIMENTAL PROCEDURE

Total hemispherical emittance measurements were performed by the calorimetric method in general accordance with test procedure ASTM C-835, at six temperature points over the temperature range from 77 K to 300 K (room temperature).

With this method, the test sample is electrically self-heated within a liquid nitrogen (LN_2) cooled vacuum chamber to some steady-state temperature above ambient. In vacuum, energy losses are by radiation only. If the chamber walls are prepared to an emittance value of unity, the emittance of the sample, ϵ, can be calculated from;

$$\epsilon = \frac{IV}{\sigma A_1 (T^4 - T_w^4)}$$

where;

IV	=	electrical power generated in the specimen
σ	=	Stefan-Boltzmann constant
A_1	=	area of the radiating surface
T	=	specimen temperature
T_w	=	cooled chamber wall temperature

This procedure is repeated at other specimen temperatures to establish a relationship between emittance and temperature over the range of interest.

The specimen was prepared with current electrodes on opposite ends, a pair of voltage leads across the center, and a thermocouple at the center surface. The sample was then suspended in the center of the vacuum chamber, and a second thermocouple attached to the inner wall of the chamber.

The chamber was evacuated and a continuous flow of LN_2 established to bring the wall temperature down to a constant temperature near 77 K. A constant electric current was then applied to the specimen to bring the sample to a temperature above the chamber wall temperature. At thermal equilibrium conditions, thermocouple temperatures, along with voltage and current values were recorded.

The procedure was repeated at five additional temperatures to define the emittance temperature curve. Data reduction for the emittance calculations included corrections for lead loss from electrodes and thermocouples attached to the specimen.

Measurement Results

Hemispherical total emittance measurement results for the single sample tested are shown in Table 1 and Figure 1. Values increased slightly with increasing temperature. The estimated error for this measurement is ±7%.

Again, based on the mirror surface condition of the coating, the values are the equivalently hemispherical total emissivity for the coating.

This concludes all measurements under the referenced order. Thank you for the opportunity to have worked with the University of Hawaii/IFA . Please contact me if you have any questions.

Sincerely,

ENERGY MATERIALS TESTING LABORATORY

Stephen A. Michaud
Manager, Thermophysics Lab

TABLE 1

HEMISPHERICAL TOTAL EMITTANCE

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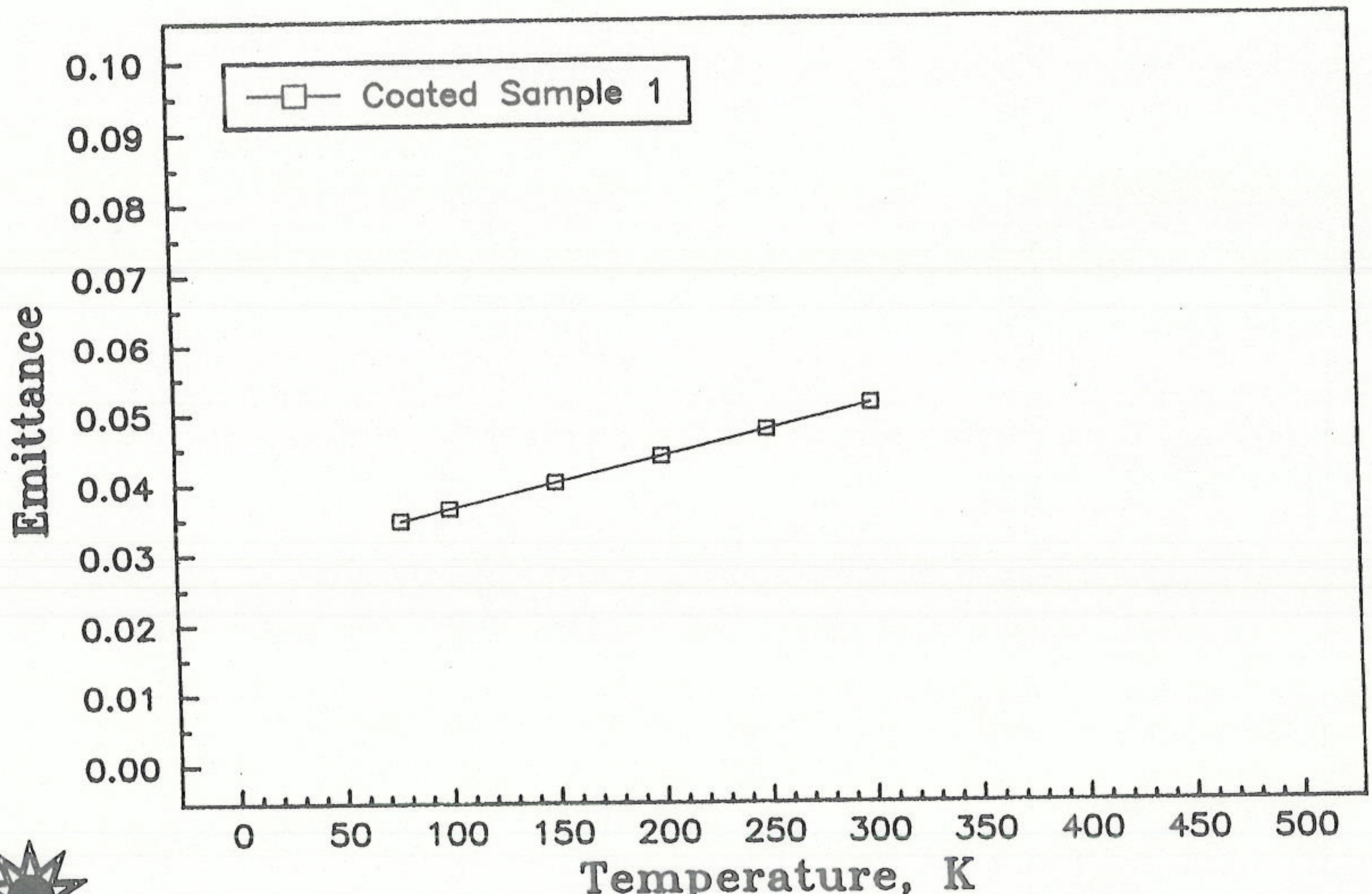
Coated Sample #1

Temperature		Hemispherical Total Emittance
K	°C	ϵ_{HT}
77	-196	0.0348
100	-173	0.0365
150	-123	0.0402
200	-73	0.0438
250	-23	0.0475
300	+27	0.0511

Specimen Details

Length, in:	2.0015
Width, in:	0.5010
Thickness, in:	0.1275
Mass, g:	5.4985
Density, g/cm^3:	2.6245

HEMISPHERICAL TOTAL EMITTANCE
University of Hawaii
Insitute for Astronomy



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