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D&S Technical Note 78-2

EMISSOMETER MODEL AE - Accuracy and Calibration of Standards

Accuracy of the Emissometer depends primarily on the linearity of the output voltage with emittance, and the accuracy of the standards used in making the measurements. Small errors are introduced by the facts that the black and gold detecting surfaces are not perfectly diffuse and gray, and that the sample is measured at room temperature.

The emittance of the standards and the linearity of the Emissometer were established by comparison with emittance measurements that were made as follows. The measurements were made in a hard vacuum to eliminate both conduction and convection heat transfer. A thermopile type heat flux meter was mounted in the center of a water cooled 4 inch x 4 inch plate to measure the radiation emitted by the sample. Both the plate and the thermopile detector were coated with Nextel Black paint. The test sample (4"x4") was clamped to a steam heated plate and positioned about 0.1" from the detector and the water cooled plate. In this configuration, the radiation detector received essentially the same flux as would be transferred between infinite parallel flat plates.

Sample emittance was calculated using the relationship for infinite parallel plates assuming diffuse gray surfaces.

V = k(S)(Ts**4 - Td**4)/(1/Es + 1/Ed - 1) (1)

Where:

V = detector voltage output
k = detector constant (volts/(Btu/hr-ft**2))
S = Stefan - Boltzmann constant
T = absolute temperature
s = denotes sample
d = denotes detector
E = emittance
**4 = fourth power

If the detector coating is diffuse and gray, this relationship is a good approximation for test samples that are not diffuse and gray, since most of the emitted radiation is absorbed the first time it strikes the high emittance detector coating.

This system was calibrated against a black body. The detector was removed from the cooled plate and mounted in the vacuum chamber with the detector surface in the opening of a heated hemispherical black body. The emittance of the black body was calculated to be greater than 0.997.

The output voltage of the detector is,

V = k(Ed)S(Tb**4 - Td**4) (2)

Where:

d = denotes the detector
b = denotes the black body

Following this test, a sample coated with the Nextel Black paint was tested as described above, so that the emittance of the sample and detector are the same. From equation (1),

V2 = k(s)(Ts**4 -Td**4)/(2/Ed -1) (3)

With data from these two tests, equations (2) and (3) can be solved for the detector constant, k, and the detector emittance, Ed, which are needed to determine the emittance of a test sample.

Linearity of the Emissometer was checked with samples ranging from 0.03 to 0.93, using an aluminum sample (E = 0.04) and a Nextel Black (E = 0.93) as high and low standards. Agreement was better than +/- 0.01 emissivity units.