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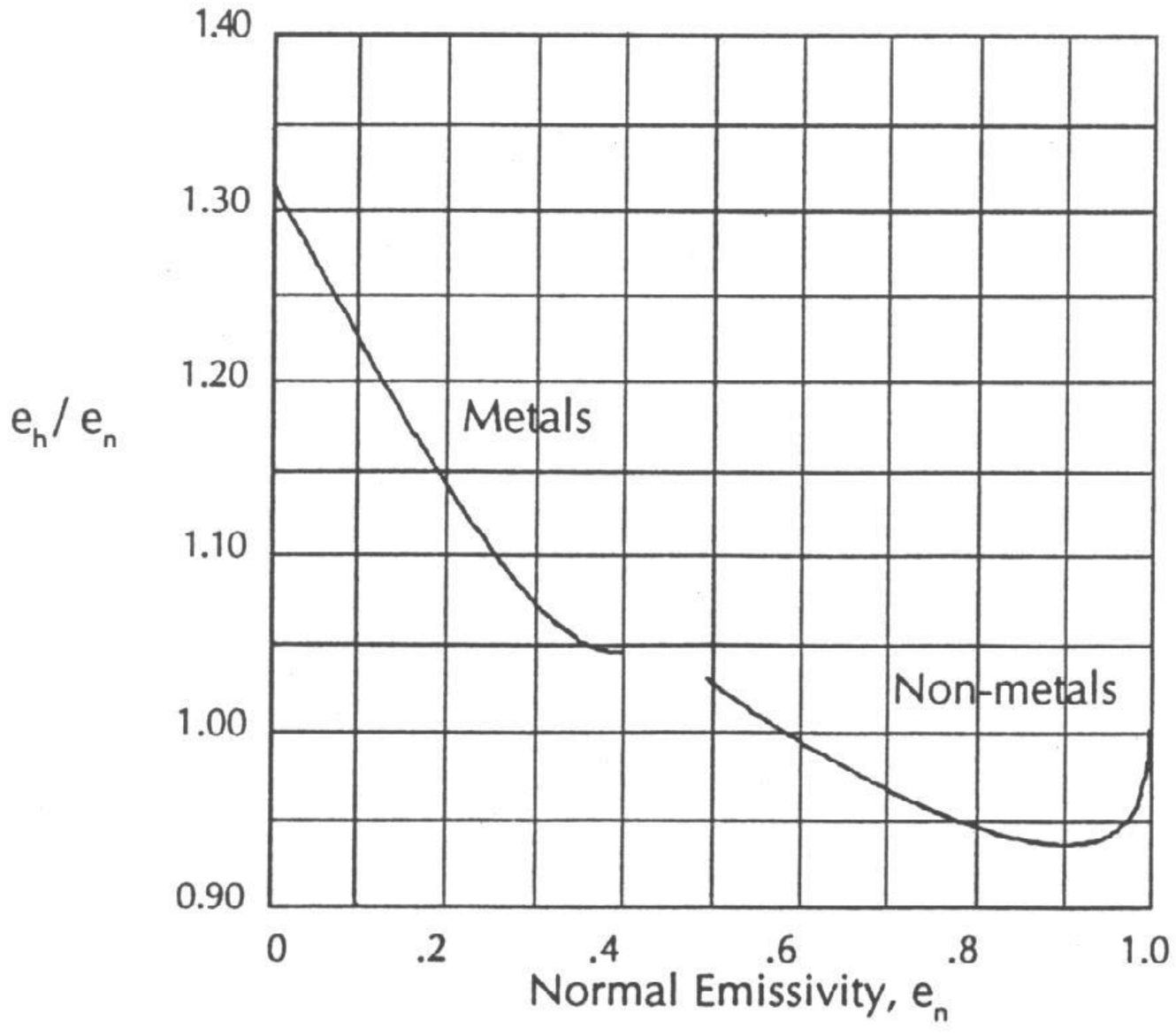
**D&S Technical Note 92-1**


## EMISSOMETER MODEL AE - Hemispherical vs Normal Emittance

The D&S Model AE Emissometer is designed to measure hemispherical emittance. However, because of the geometry of the detector element and the non-diffuse properties of the sensing surfaces, the detector is more sensitive at angles near normal to the surface. Therefore the detector response is proportional to a weighted average over all directions and will be somewhere between the normal and hemispherical values.

The emittance values of the calibration standards however, are hemispherical values (within the limits of accuracy of the measurements made to establish our own emittance standards, see TN78-2). Therefore, even though the AE detector response is more sensitive in the normal direction, the fact that it is calibrated to standards for which hemispherical values have been specified, biases the results toward the hemispherical value of the measured sample. Similarly, if the instrument were calibrated using the normal emittance values of the standards, the resulting measurements would be closer to normal emittance values. This is only true because most common materials and coatings exhibit a very similar relationship between their normal and hemispherical emittance values. That is, the ratio of hemispherical to normal emittance for a material is primarily a function of the emittance of the surface. Experimental results show that this relationship matches approximately the behavior that would be predicted of metallic and non-metallic surfaces by electromagnetic theory. This simple relationship is often used to convert measured normal emittance values to hemispherical values. The relationship is shown graphically in the figure below.



An example will illustrate how the AE Emissometer would perform presuming that the samples to be measured and the standards follow the relationship shown above for the ratio of hemispherical to normal emittance. It is also assumed for the purpose of this example that the Emissometer responds linearly to the average of the hemispherical and normal emittance of a surface.

| Normal Emittance | Hemispherical Response | AE detector |
|---|---|---|
| 0.02 | 0.026 | 0.023 |
| *0.05 | 0.064 | 0.057 |
| 0.10 | 0.123 | 0.112 |
| 0.15 | 0.177 | 0.164 |
| 0.20 | 0.228 | 0.214 |
| 0.40 | 0.42 | 0.41 |
| 0.60 | 0.594 | 0.597 |
| 0.70 | 0.679 | 0.690 |
| 0.80 | 0.756 | 0.778 |
| 0.90 | 0.837 | 0.869 |
| *0.95 | 0.893 | 0.921 |
| 0.98 | 0.941 | 0.960 |

*These two materials are chosen as the high and low calibration standards.

Once again, for this example it is assumed that the detector responds to a straight average of the normal and hemispherical emittance. A hypothetical table of actual versus indicated emittance can be generated by creating a straight line relationship between the assumed response of the detector and the emittance value of the standard, either hemispherical or normal. This is analogous to calibrating the instrument. For example to "calibrate" the instrument to normal emittance, even though the detector output (i.e. voltage) is proportional to 0.057 and 0.921 for the low and high emittance standards selected, the offset and gain are adjusted so that these materials read 0.05 and 0.95. This hypothetical calibration results in the two tables below for indicated versus actual emittance values. These tables should not be used to correct measured emittance values but rather indicate the magnitude of errors that might be expected.

**Emissometer Calibrated to Normal Emittance**

| Actual Normal Emittance | Indicated Normal Emittance | Actual Hemispherical Emittance |
|---|---|---|
| 0.02 | 0.015 | 0.026 |
| *0.05 | 0.05 | 0.064 |
| 0.10 | 0.107 | 0.123 |
| 0.15 | 0.161 | 0.177 |
| 0.20 | 0.214 | 0.228 |
| 0.40 | 0.418 | 0.42 |
| 0.60 | 0.613 | 0.594 |

| | | |
|---|---|---|
| 0.70 | 0.709 | 0.679 |
| 0.80 | 0.801 | 0.756 |
| 0.90 | 0.896 | 0.837 |
| *0.95 | 0.95 | 0.893 |
| 0.98 | 0.995 | 0.941 |

**Emissometer Calibrated to Hemispherical Emittance**

| Actual Normal Emittance | Indicated Hemisphereical Emittance | Actual Hemispherical Emittance |
|---|---|---|
| 0.02 | 0.031 | 0.026 |
| *0.05 | 0.064 | 0.064 |
| 0.10 | 0.117 | 0.123 |
| 0.15 | 0.166 | 0.177 |
| 0.20 | 0.215 | 0.228 |
| 0.40 | 0.403 | 0.42 |
| 0.60 | 0.582 | 0.594 |
| 0.70 | 0.671 | 0.679 |
| 0.80 | 0.756 | 0.756 |
| 0.90 | 0.843 | 0.837 |
| *0.95 | 0.893 | 0.893 |
| 0.98 | 0.931 | 0.941 |