A New Smoke Concentration Meter

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All fires produce smoke, and that smoke can be beneficial (as in triggering a smoke detector) or harmful (as in impeding escape). Therefore, it is critical that one knows how much smoke a burning object produces and where that smoke is moving relative to people or fire sensors. A new smoke meter is designed to measure the smoke production on a mass basis by an optical method rather than requiring tedious filter collection and weighing of the smoke produced.

The key to this new instrument is the discovery that the specific extinction coefficient, σ_s, is nearly universal for overventilated flaming combustion with a value of 8.7 m^2/g $\pm$ 1.1 m^2/g with only a modest dependence on fire size, fuel, and flame condition. This finding enables the measurement of the mass concentration of smoke, m_s, from the transmission of light through the smoke via the following formula:

$$m_s = \frac{ln(I_0 / I)}{\sigma_s L}$$

where L is the path length through the smoke and I_0 and I refer to the incident and transmitted light intensity for a monochromatic light source. This finding will obviate the more cumbersome mass extraction methods and offer the potential for both time- and space-resolved determinations.

The key design features of the new smoke meter will be presented. The detailed design, which is almost entirely based on commercially available components, is available from a NIST Report. An extensive series of tests involving propane fires at 50 kW, 200 kW, and 450 kW and heptane and toluene pool fires at about 250 kW were carried out to assess the uncertainty in the measurement method. The results of the uncertainty assessment will be discussed along with the range of application of the new smoke meter. A specific example will be presented illustrating how the mass concentration of smoke, the rate of smoke production, and the yield of smoke are determined using the new instrument.

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