



Heat release rate measurements of thin samples in the OSU apparatus and the cone calorimeter

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Abstract

The Ohio State University (OSU) apparatus and the cone calorimeter are two devices commonly used to measure the heat release rate (HRR) of materials and products in forced flaming combustion. Each operates on a different principle but is calibrated in the same way. However, HRR results from these two test methods do not agree in most cases. For the present study, the OSU was modified to measure oxygen consumption and sensible enthalpy (temperature rise) of the apparatus in addition to the usual sensible enthalpy of the exhaust gases during the test. After calibration, total sensible heat (exhaust gases + apparatus) and oxygen consumption methods gave similar results for thin samples in the OSU. However, OSU results for thin samples did not agree with results from the cone calorimeter (ASTM 1354/ISO 1556) unless the HRR history in the cone calorimeter was corrected for smearing that results from dilution of the combustion gases with air in the sample chamber, exhaust duct, and scrubbers and the response time of the oxygen analyzer.

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Nomenclature

q	Heat release rate (W)
$q_{f,l}$	heat losses from the flame (W)
m	mass flow rate (kg/s)
ρ	density (kg/m ³)
c	heat capacity (J/kg K)
T	temperature (K)
T^∞	steady-state temperature (K)
v	volumetric flow rate (m ³ /s)
V	volume (m ³)
E	heat of combustion of oxygen with typical organic materials, 13.1 MJ/kg O ₂
ϕ	fraction of the heat of combustion lost to surroundings (dimensionless)
OSU	Ohio State University rate of heat release apparatus
ASTM	American Society for Testing and Materials
ISO	International Standards Organization
h	average convective heat transfer coefficient (W/m ² K)
K_c	empirical calibration factor for OSU (W/K)
K_a	empirical calibration factor for OSU (J/K)
K_e	empirical calibration factor for OSU (W/K)
Y_{O_2}	oxygen mass fraction (dimensionless)
τ	response time of instrument to 63% of full-scale deflection
HRR	heat release rate in flaming combustion (W/m ²)

Subscripts

a	OSU apparatus
air	Air
e	Exhaust gases
c	Convection

1. Background

Many approaches have been used to measure the rate at which heat is released during the burning of materials and products [1,2]. The devices used to measure the heat release rate (HRR) are fire calorimeters and they operate on a variety of principles including sensible enthalpy (temperature rise) of the gas stream or enclosure, with or without a substitution/compensation burner, and analysis of the combustion gases for excess carbon dioxide or depleted oxygen [1,2]. The Ohio State University (OSU) rate of heat release apparatus [1–4] is one these devices. In the standard method [3,4], the OSU apparatus estimates the HRR of a material from the sensible enthalpy (temperature) rise of the air flowing past a 15 cm × 15 cm burning

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