HEAT RELEASE RATE CALORIMETER

By

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Starting with the Thompson/Cousins construction materials calorimeter work of 1959, several groups in this country have devised calorimeters to measure the thermochemical response of materials exposed to fire. Among these groups are: Ohio State, NBS, SRI and Forest Products Lab. The experiment essentially involves exposing a slab-specimen of the test material to a prescribed external radiant flux and continuously monitoring the events at the specimen, the enthalpy flux of the product exhaust stream and the smoke content of this stream. The results are then employed, essentially as they come out of the release rate apparatus, in developing mathematical fire models. The contention of the present research brief is that the recorded data can be employed to deduce certain important intrinsic properties of the test materials and that it is these intrinsic properties which are permissible for use in modeling rather than the extrinsic properties directly given by the raw data. A detailed advocation of this argument is presented by this author in the attached paper.

In the following, we point out some requirements in the experiment which promise to enhance the utility of release rate calorimetry.

(a) The specimen boundary conditions have to be specified umambiguously, especially at the back-face. This would also involve a clear statement, in all experiments, of the specimen thickness and its laminate description. Measurement of two or more thermocouple outputs at two different depths beneath the exposed surface will yield the conductivity, specific heat and diffusivity from the preignition stage of the experiment.

(b) Ignition source, its presence or absence as well as its location and strength have to be fully prescribed. Ignition characteristics of the boundary layer flow adjacent to the heated specimen can be deduced only if the flow in the calorimeter is properly defined. A material could be characterized for ignition by such criteria as critical ignition temperature for piloted and or spontaneous ignition, critical pyrolysate mass flux, critical thermal exposure dosage, etc.

(c) The flame spread rate obviously depends upon where the flame is initiated on the specimen. Provided the nature of ignition and the imposed flow are clearly stipulated, one can deduce from the raw data several relevant thermochemical properties in addition to explaining the drastically different time-dependencies of the release rates.

(d) Statement of the thickness-related description of the sample and of the boundary conditions also enable one to deduce the resistance of a specimen to fire penetration.

(e) Not done currently but possible is the deduction of the heat of burning of a sample from the integrated heat release and the measured specimen mass loss. The heat of burning, in contrast to heat of combustion, indicates the degree of completeness of combustion in the boundary layer. This factor is an urgently needed quantity in any reasonable modeling of efforts.

Capability to test the size-dependency of the degree of completeness of combustion is not available now.

(f) Based on energy balance arguments, the heat release rate data can be employed to rate materials for their sensitivity in response to external heat fluxes. A material at low external heating may be 'safe' compared to another material but the situation may be just the reverse at other heating rates.

Also based on energy balance, one can draw the limiting thermal indices for rating materials.

(g) With only minor alterations in the optical attenuation measurement in the release rate apparatus, the nature of the particulates composing smoke can be found. Even more importantly the results of release rate apparatus smoke measurements can be related to the NBS smoke chamber results.

(h) With proper scaling analysis of the reactive boundary layer, the rates measured on small samples in the release rate apparatus can be extended to realistically large panels of cabin interior finish and furnishings. Such an adoption is not available now.

The attached paper describes the rationale underlying these eight points recommended for a research project at the University of Notre Dame. Drs. A. M. Kanury and J. R. Lloyd will carry out the study with the assistance of one graduate student. Dr. K. T. Yang will coordinate the research with other on-going activities. Considerable progress can be accomplished within one year with a budget of the order of $60,000. A detailed Statement of Work formulated with the advise of the FAA technical personnel will formalize a more precise cost of the project. The data of Tustin (Boeing) and others will form the basis of the proposed study.