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CONTENTS

ABSTRACT

Building and Fire Research Publications, 1995 contains references to the publications prepared by the members of the Building and Fire Research (BFRL) staff, by other National Institute of Standards and Technology (NIST) personnel for BFRL, or by external laboratories under contract or grant from the BFRL during the calendar year 1995.

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1. LITERATURE CITATIONS ARRANGED BY FIRST AUTHOR

A

Alvord, D. M.

Alvord, D. M.
CFAST Output Comparison Method and Its Use in Comparing Different CFAST Versions.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5705; 51 p. August 1995.
Available from National Technical Information Service
PB96-109541

computer models; computer programs; comparison; differences; fire models; fire research; tests

A multiple step method was developed to compare the output of CFAST simulations, produced either by the same version of CFAST, or by different versions of the model. Scenarios to be compared are run with CFAST before the method is used, producing files containing a history of the model results. The first step of the comparison method produces a text file of important output variables from each of these history files, corresponding to significant fire phenomena occurring during the course of each fire simulation. The next step of the method is used to compare two such text files, and store their differences. Finally, the last step summarizes the difference information found in one or more files from the previous step. The comparison method can be used to find differences between CFAST runs, and to track changes in the CFAST model and detect if they perform as anticipated. It has been used to compare three CFAST versions through use of a documented set of test files. This set will change as improvements are made to the model. The method can be used to find the effects whenever any substantial changes are made to CFAST, and is a useful tool for any user of the model. This report describes the comparison method in sufficient detail to serve as a user's guide, provides examples of the method's use, and discusses ways in which it could be improved and generalized.

Andrus, R. D.

Andrus, R. D.; Chung, R. M.
Ground Improvement Techniques for Liquefaction Remediation Near Existing Lifelines.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5714; 87 p. October 1995.
Available from National Technical Information Service
PB96-128111

lifelines; building technology; compaction grouting; cost estimate; drain pile; earthquakes; ground improvement; jet grouting; liquefaction remediation; permanent ground deformation; permeation grouting; soil liquefaction; soil mixing

This report reviews five low vibration ground improvement techniques suitable for remedial work near existing structures. The five techniques are: compaction grouting, permeation grouting, jet grouting, in situ soil mixing, and drain pile. The factors which can influence the effectiveness of each technique are identified. Cost estimates are given for each technique, except the drain pile technique which is not yet available in the United States. Nineteen case studies of liquefaction remediation and remedial work near existing lifelines are reviewed. Advantages and constraints of the five techniques are compared. A

combination of techniques may provide the most cost-effective ground improvement solution for preventing damage to existing lifelines resulting from liquefaction-induced horizontal ground displacement, subsidence, and uplift.

Axley, J. W.

Axley, J. W.
New Mass Transport Elements and Components for the NIST IAQ Model.
Yale Univ., New Haven, CT
NIST-GCR-95-676; 33 p. July 1995.
Available from National Technical Information Service
PB95-255899

contaminant dispersal; filtration; indoor air quality; mass transport; modeling; ventilation

This report presents new mass transport elements for the next generation of the NIST IAQ Model that may be used to model [a] homogeneous (bulk-air) chemistry within well-mixed chamber, [b] aerosol mass transport within well-mixed chambers and fractional particle filtration in building filtration devices, and [c] heterogeneous (surface-related) physical processes and chemical transformations including those governing the behavior of gas-phase air cleaning devices. In an effort to maintain rigor, generality, and flexibility, each transport process is formulated in terms of the elemental mass transport steps that together govern the overall process. In this way, the more complex processes may be represented as component equations that are assembled from fundamental element equations. The element/component assembly method, upon which the NIST IAQ Model is based, provides a general and modular approach to the formulation of systems of equation governing the mass and air transport in buildings to effect indoor air quality analysis. In this approach, the solution of the system equations is a computationally distinct task that may be achieved using a variety of numerical methods. The third chapter of this report discusses numerical and computational strategies for the solution of the system equations that are compatible with both the existing and proposed new mass transport elements and presents candidate strategies that appear to be most promising. Finally the fourth chapter of this report considers user interface strategies to implement the proposed new mass transport elements and components.

B

Babrauskas, V.

Babrauskas, V.
Specimen Heat Fluxes for Bench-Scale Heat Release Rate Testing.
National Institute of Standards and Technology, Gaithersburg, MD
Fire and Materials, Vol. 19, No. 6, 243-252, 1995.

fire safety; fire science; cone calorimeters; heat release rate; heat flux; radiant heating; corner tests; room fires; upholstered furniture; wall fires

When a specimen is tested for its heat release rate (HRR) behavior using a bench-scale test such as ISO 5660 or equivalent, one very important test condition is not pre-standardized and must be set: the heat flux to be imposed on the specimen by the heater. The heat flux cannot be legitimately standardized, since the value appropriately to be used will differ according to purpose or application. The present paper sets forth the considerations which should govern the correct choice of heat flux. A discussion is given of minimum ignitability level; statistical variability at low heat fluxes; the ranges of heat fluxes associated with small actual ignition sources; the heat fluxes associated with fires away from the ignition source, all the way up to fully-involved room fires; the applicaton of the product; and the needs associated with mathematical modeling of room fires.

Correlational approaches are also illustrated and contrasted to physics-based ones. Finally, the empirical nature of the present situation is emphasized. Judged from first principles, it would appear that successful prediction of room fire results from bench-scale test data would require both the testing at a large number of different heat fluxes and the use of algorithms to permit time-dependent interpolation. Such algorithms have been proposed; however, some very successful predictions are noted with much simpler techniques.

Babushok, V.

Babushok, V.; Burgess, D. F. R.; Linteris, G. T.; Tsang, W.; Miziolek, A.
Modeling of Hydrogen Fluoride Formation From Flame Suppressants During Combustion.
National Institute of Standards and Technology, Gaithersburg, MD
Army Research Laboratory, Aberdeen Proving Ground, MD
Halon Options Technical Working Conference. Proceedings. May 9-11, 1995, Albuquerque, NM, 1-11 pp, 1995.

combustion; hydrogen fluorides; halons; halon 1301; flame velocity; computer simulation

We have completed an initial computational study related to acid gas formation for two of the leading near-term Halon substitutes, FE-13 (CF3H) and HFC-125 (C2F5H), and compared these results with Halon 1301 (CF3Br). Our goal is to determine whether we can identify conditions under which HF production can be minimized for the same inhibiting power, a result that could have significant practical implications. Our approach is based on investigating possible differences in the kinetics of HF formation under different agent loading scenarios using premixed flame codes with CH4/air as the combusting system. We consider the situation where suppressants are mixed with inert compounds such as N2 and CO2 and deduce the commensurate decreased in hydrogen fluoride yields to obtain the same degrees of suppressant capability. This work clearly illustrates the great potential of computational simulations as a tool for identifying specific agent configurations for maximized performance. Other areas of possible future application of simulations are indicated.

Baum, H. R.

Baum, H. R.; Cassel, K. W.; McGrattan, K. B.; Rehm, R. G.
Gravity-Current Transport in Building Fires.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 27-32 pp, 1995.

fire research; building fires; gravity currents; heat transfer; Navier-Stokes equations; numerical simulation; smoke transport; transients

Gravity currents generated by smoke movement in corridors are studied by numerically integrating the two dimensional Navier Stokes equations. High resolution solutions to these equations in the Boussinesq limit are compared with salt water experiments to demonstrate the validity of the model. Then the effects of heat transfer are included and its consequences for smoke and hot gas transport in corridors is assessed. Sample numerical results are presented to illustrate these phenomena.

Bentz, D. P.

Bentz, D. P.
Three-Dimensional Cement Hydration and Microstructure Program. I. Hydration Rate, Heat of Hydration, and Chemical Shrinkage.
National Institute of Standards and Technology, Gaithersburg, MD

NISTIR 5756; 54 p. November 1995.
Available from National Technical Information Service

building technology; cement hydration; chemical shrinkage; compressive strength; computer models; heat of hydration; microstructure; non-evaporable water; simulation

A computer program that implements a three-dimensional model for the microstructural development occuring during the hydration of portland cement has been developed. The model includes reactions for the four major cement phases: tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite, and the gypsum which is added to avoid flash setting. The basis for the computer model is a set of cellular automata-like rules for dissolution, diffusion, and reaction. The model operates on three-dimensional images of multi-phase cement particles generated to match specific characteristics of two-dimensional images of real cements. To calibrate the kinetics of the model, experimental studies have been conducted at room temperature on two cements issued by the Cement and Concrete Reference Laboratory at NIST. Measurements of non-evaporable water content, heat of hydration, and chemical shrinkage over periods of up to 90 days have been performed for comparison with model predictions. The measurement of chemical shrinkage is particularly critical, as it allows an estimation of the density of the calcium silicate hydrate gel formed during the hydration to be made. The dispersion models of Knudsen have been applied in fitting both the model and experimental data. For the two cements investigated, it appears that a single function can be used to convert between model cycles and experimental time for the three water-to-cement ratios investigated in this study. This suggests that accurately capturing the particle size distribution, phase fractions, and phase distributions of a given cement allows for an accurate estimation of its hydration characteristics. Finally, the calibrated kinetic models for the two cements have been used to successfully predict 7 and 28-day compressive strengths of ASTM C109 50 mm mortar cubes from 3-day compressive strength data, illustrating one engineering application for such a three-dimensional cement hydration and microstructure model.

Bentz, D. P.; Garboczi, E. J.; Jennings, H. M.; Quenard, D. A.
Multi-Scale Digital-Image-Based Modelling of Cement-Based Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Northwestern Uinv., Evanston, IL
Centre Scientifique et Technique du Batiment, Saint-Martin d'Heres, France
Materials Research Society. Microstructure of Cement-Based Systems/Bonding and Interfaces in Cementitious Materials Symposia. Materials Research Society Symposium Proceedings Volume 370. November 28-December 1, 1994, Boston, MA, Materials Research Society, Pittsburgh, PA, Diamond, S.; Mindess, S.; Glasser, F. P.; Roberts, L. W., Editors, 33-41 pp, 1995.

building technology; cements; computer models

Computer modelling of the properties and performance of cement-based materials is complicated by the large range of relevant size scales. Processes occurring in the nanometer sized pores ultimately affect the performance of these materials at the structural level of meters and larger. One approach to alleviating this complication is the development of a suite of models, consisting of individual digital-image-based structural models for the calcium silicate hydrate gel at the nanometer level, the hydrated cement paste at the micrometer level, and a mortar or concrete at the millimeter level. Computations performed at one level provide input properties to be used in simulations of performance at the next higher level. This methodology is demonstrated for the property of ionic diffusivity in saturated concrete. The more complicated problem of drying shrinkage is also addressed.

Bentz, D. P.; Hwang, J. T. G.; Hagwood, C.; Garboczi, E. J.; Snyder, K. A.; Buenfeld, N.; Scrivener, K. L.
Interfacial Zone Percolation in Concrete: Effects of Interfacial Zone Thickness and Aggregate Shape.

National Institute of Standards and Technology, Gaithersburg, MD
Cornell University, Ithaca, NY
Imperial College of Science and Technology, London, England
Materials Research Society. Microstructure of Cement-Based Systems/Bonding and Interfaces in Cemetitious Materials. Materials Research Society Symposium Proceedings Volume 370. November 28-December 1, 1994, Boston, MA, Materials Research Society, Pittsburgh, PA, Diamond, S.; Mindess, S.; Glasser, F. P.; Roberts, L. W., Editors, 437-442 pp, 1995.

building technology; concretes; thickness

Previously, a hard core/soft shell computer model was developed to simulate the overlap and percolation of the interfacial transition zones surrounding each aggregate in a mortar or concrete. The aggregate particles were modelled as spheres with a size distribution representative of a real mortar or concrete specimen. Here, the model has been extended to investigate the effects of aggregate shape on interfacial transition zone percolation, by modelling the aggregates as hard ellipsoids, which gives a dynamic range of shapes from plates to spheres, to fibers. For high performance concretes, the interfacial transition zone thickness will generally be reduced, which will also affect their percolation properties. This paper presents results from a study of the effects of interfacial transition zone thickness and aggregate shape on these percolation characteristics.

Bentz, D. P.; Martys, N. S.; Stutzman, P. E.; Levenson, M. S.; Garboczi, E. J.; Dunsmuir, J.; Schwartz, L. M.
X-Ray Microtomography of an ASTM C109 Mortar Exposed to Sulfate Attack.
National Institute of Standards and Technology, Gaithersburg, MD
Exxon Research and Engineering Co., Annandale, NJ
Schlumberger-Doll Research, Ridgefield, CT
Materials Research Society. Microstructure of Cement-Based Systems/Bonding and Interfaces in Cementitious Materials. Materials Research Society Symposium Proceedings Volume 370. November 28-December 1, 1994, Boston, MA., Materials Research Society, Pittsburgh, PA, Diamond, S.; Mindess, S.; Glasser, F. P.; Roberts, L. W., Editors, 77-82 pp, 1995.

building technology; microtomography; mortar; x-ray

X-ray microtomography can be used to generate three-dimensional 5123 images of random materials at a resolution of a few micrometers per voxel. This technique has been used to obtain an image of an ASTM C109 mortar sample that had been exposed to a sodium sulfate solution. The three-dimensional image clearly shows sand grains, cement paste, air voids, cracks, and needle-like crystals growing in the air voids. Volume fractions of sand and cement paste determined from the image agree well with the known quantitites. Implications for the study of microstructure and proposed uses of X-ray microtomography on cement-based composites are discussed.

Bentz, D. P.; Quenard, D. A.; Baroghel-Bounty, V.; Garboczi, E. J.; Jennings, H. M.
Modelling Drying Shrinkage of Cement Paste and Mortar. Part 1. Structural Models From Nanometres to Millimetres.
National Institute of Standards and Technology, Gaithersburg, MD
Centre Scientifique et Technique du Batiment, Saint-Martin d'Heres, France
Laboratoire Central des Ponts et Chaussees, Paris, France
Northwestern Univ., Evanston, IL
Materials and Structures, Vol. 28, 450-458, 1995.

calcium silicate hydrate; cements; drying; modeling; multi-scale; shrinkage; sorption isotherms

The nanostructure of calcium silicate hydrate (C-S-H) gel contributes to many physical properties of concrete, including the important engineering properties of creep and shrinkage. A set of structural models for this gel and computational techniques for their validation have been developed. The basic nanostructure of C-S-H is conceived as a self-similar agglomeration of spherical particles at two levels (diameters of 5 nm and 40nm). Computational techniques are presented for simulating transmission electron microscopy images and computing sorption characteristics of the model nanostructures. Agreement with available experimental data is reasonable. The development of these nanostructural models is a first step in a multi-scale approach to computing the drying shrinkage of model cement-based materials. Such an approach will provide a better understanding of the relationships between microstructure and the shrinkage behavior of these systems.

Bentz, D. P.; Schlangen, E.; Garboczi, E. J.
Computer Simulation of Interfacial Zone Microstructure and Its Effect on the Properties of Cement-Based Composites.
National Institute of Standards and Technology, Gaithersburg, MD
Delft University of Technology, The Netherlands
American Ceramic Society. Materials Science of Concrete. Volume 6. 1995, Westerville, OH, Skalny, J. P.; Mindell, S., Editors, 155-199 pp, 1995.

aggregates; building technology; cements; computer models; concretes; conductivity; crack propagation; crack bridging; elastic modulus; fracture; interfacial zone; percolation

Much recent research on the materials science of concrete has focused on the characteristics of the interfacial zone between cement paste and aggregate and its effects on mechanical and other properties. This chapter reviews recent computer modelling work on these topics, including the formation mechanisms of interfacial zone microstructure, the effects of cement paste and aggregate physical properties on this microstructure, the percolation of individual interfacial zones as a function of aggregate size distribution and content, and the mechanical and transport properties of cement paste-aggregate composites. Model results are compared with experimental results from the available literature.

Bentz, D. P.; Stutzman, P. E.
SEM Analysis and Computer Modelling of Hydration of Portland Cement Particles.
National Institute of Standards and Technology, Gaithersburg, MD
American Society for Testing and Materials (ASTM). Petrography of Cementitious Materials. Proceedings. ASTM STP 1215. 1995, Am. Soc. for Testing and Matl., Philadelphia, PA, DeHayes, S. M.; Stark, D., Editors, 60-73 pp, 1995.

building technology; cement particles; characterization; hydration; image processing; interfacial zone; microstructure; phase analysis; scanning electron microscopy; simulation; x-ray images

Characterization of cement particles is complicated due to their wide size range, complex shapes, and multi-phase nature. Accurate characterization should allow for better prediction of cement performance and more realistic modelling of cement microstructural development. This paper presents a technique, based on scanning electron microscopy and digital image processing, for obtaining two-dimensional digital images of actual portland cement particles in which all major phases are identified. By combining backscattered electron and x-ray images, an image segmented into the major cement phases may be created. These images can be analyzed to determine any number of quantitative measures such as phase fractions or phase perimeters. The technique has also been successfully utilized in obtaining realistic starting images for input into a two-dimensional cement microstructure model which simulates the hydration process.

Berry, R. J.

Berry, R. J.; Burgess, D. R. F., Jr.; Nyden, M. R.; Zachariah, M. R.

Halon Thermochemistry: Ab Initio Calculations of the Enthalpies of Formation of Fluoromethanes.

Wright Laboratory, Wright-Patterson AFB, OH

National Institute of Standards and Technology, Gaithersburg, MD

University of North Texas, Denton, TX

Journal of Physical Chemistry, Vol. 99, No. 47, 17145-17150, 1995.

halons; thermochemistry; enthalpy

Atomic equivalent (AEQ), BAC-MP4, G2(MP2), G2, CBS-4, BCS-Q, and CBS-QCI/APNO molecular orbital calculations were used to calculate enthalpies of formation in the series of fluoromethanes, CHxF4-x, x = 0-4. While the computed BAC-MP4 and CBS-4 were in close agreement with experiment, errors in enthalpies from the other five methods were relatively high. In particular, enthalpies of formation calculated with the G2(MP2) and G2 procedures exhibited systematic deviations from experiment which were linearly dependent upon the number of C-F bonds in the molecule. Application of isodesmic reaction calculaitons yielded values of G2(MP2), G2, CBS-Q, and CBS-QCI/APNO that were in remarkably close agreement with experiment. This technique had no significant effect on the quality of results from the AEQ, BAC-MP4, and CBS-4 methods.

Bieniawski, A. S.

Bieniawski, A. S.; Todd, D. R.

How-To Suggestions for Implementing Executive Order 12941 on Seismic Safety of Existing Federal Buildings: A Handbook.

National Institute of Standards and Technology, Gaithersburg, MD

NISTIR 5770; ICSSC TR-17; 201 p. November 1995.

Available from National Technical Information Service

PB96-131552

building technology; databases; cost estimates; evaluation; inventory; mitigation; prioritization; seismic evaluation; seismic rehabilitation; seismic safety

This Handbook supplements ICCSSC RP5, ICSSC Guidance on Implementing Executive Order 12941 on Seismic Safety of Existing Federally Owned or Leased Buildings. RP5 describes the approach recommended by the Interagency Committee on Seismic Safety in Construction (ICSSC) to fulfill the inventorying and cost estimating requirements of Executive Order 12941, Seismic Safety of Federally Owned or Leased Buildings. This Handbook describes detailed methodologies for developing inventories, screening for exempt buildings, identifying buildings for evaluation, and developing cost estimate information. These methodologies are not mandatory requirements of the ICSSC recommended program but provide guidance for agencies which do not have agency-specific programs in place and would like a model to follow. The Handbook also outlines the specific fields to be entered into each agency's electronic database for owned buildings as well as the specific items which should be discussed in the supporting documentation. Each agency is required to follow the format outlined in these sections when submitting their information in order to ensure that data received from all agencies is compatible and machine-readable.

Bryner, N. P.

Bryner, N. P.; Johnsson, E. L.; Pitts, W. M.
Scaling Compartment Fires - Reduced- and Full-Scale Enclosure Burns.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 9-14 pp, 1995.

fire research; compartment fires; scale models; acute toxicity; fuel/air ratio; carbon monoxide; combustion products; fire chemistry; flashover; room fires

An extensive series of over 140 natural gas fires in a 2/5ths-scale model of a standard room has been previously reported. This work extends the earlier reduced-scale enclosure (RSE) study to a full-scale enclosure (FSE) and focuses on comparing the gas concentrations and temperatures of the upper layers and the ventilation behaviors of the two compartments. Both studies are part of a larger research effort which is designed to develop a better understanding and a predictive capability for the generation of carbon monoxide, the major toxicant in fires. The findings will be incorporated into realistic fire models and used in the development of strategies for reducing the number of deaths attributed to carbon monoxide.

Bukowski, R. W.

Bukowski, R. W.
Fire Codes for Global Practice.
National Institute of Standards and Technology, Gaithersburg, MD
Progressive Architecture (P/A), 117-119, June 1995.

fire codes; code equivalency

Architecture in a world economy, with multinational clients and a global range of building materials and systems, demands fire codes based on performance. The International Council for Building Research is now working on methods to verify compliance under performance-based fire codes. Performance codes will have several advantages: code objectives clearly stated and understood by all parties, and analytical methods, data, and assumptions formalized in a single code of practice.

Bukowski, R. W.
Guide for Developing Emergency Evacuation Plans for Employees With Disabilities. U.S. Fire Administration Booklet.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Administration Booklet; 29 p. 1995.

evacuation; handicapped; emergencies

People with disabilities are increasingly moving into the mainstream of society, contributing to the diversity which has been this country's strength. It is only right that they be provided with the same level of safety as the rest of society, as referenced in the Americans with Disabilities Act (ADA). Equipment and procedures exist that can provide such safety for any person with a disability that is not so severe that it would preclude the ability to work. The key points regarding finding the best solution for your building arc, first, to remember that every person with a disability has unique abilities and limitations, and accommodations should be tailored to their needs. Second, it is crucial that the person be included in the decision on which equipment and procedures will work for tham to provide them with the confidence that they will be protected.

Bukowski, R. W.
How to Evaluate Alternative Designs Based on Fire Modeling.
National Institute of Standards and Technology, Gaithersburg, MD

NFPA Journal, Vol. 89, No. 2, 68-70,72-74, March/April 1995.

fire models; codes; evacuation; alternative design

These days, fire models are being widely used to help code officials determine whether alternative design analyses - such as those sometimes used in unique buildings or large projects - provide protection equivalent to that prescribed by existing building codes. However, many code officials faced with the application of a new engineering method in a high-profile project are uncomfortable if there is no independent verification that such analyses have been done properly.

Bukowski, R. W.
International Activities for Developing Performance-Based Fire Codes.
National Institute of Standards and Technology, Gaithersburg, MD
Building Research Institute. Fire Safety Design of Buildings and Fire Safety Engineering. Mini-Symposium. June 12, 1995, Tsukuba, Japan, IV/1-3 pp, 1995.

fire safety; safety engineering; building design; fire codes; acceptance criteria; alternative design; code equivalency; fire models; performance evaluation; regulations; safety factors

The purpose of this paper is to review the status of current activities associated with the development of performance-based fire codes in various countries across the globe, as well as the coordinated activities of international standardization and pre-standardization research in this field. Every attempt was made to include the latest developments but some activities in individual countries that do not participate in international conferences or standards activities may have been overlooked.

Bukowski, R. W.
Modeling a Backdraft Incident: The 62 Watts Street (New York) Fire.
National Institute of Standards and Technology, Gaithersburg, MD
Institution of Fire Engineers; University of Sunderland; Fire Research Station; Tyne and Wear Metropolitan Fire Brigade. Fire Safety by Design. Conference Proceedings. Volume 2. Case Studies and Workshop Reports. July 10-12, 1995, UK, 77-82 pp, 1995.

fire safety; safety engineering; backdraft; fire fatalities; fire fighters; fire models; apartments; smoke; heat release rate; oxygen concentration; temperature; computer models; casualties; smoke; ventilation; building fires

On March 28, 1994, the New York City Fire Department responded to a report of smoke and sparks issuing from a chimney at a three-story apartment building in Manhattan. The officer in charge ordered three person hose teams to make entry into the first and second floor apartments while the truck company ventilated the stairway from the roof. When the door to the first floor apartment was forced open, a large flame issued from the apartment and up the stairway, engulfing the three fire fighters at the second-floor landing. The flame persisted for at least 6 1/2 minutes, resulting in their deaths. The FDNY requested the assistance of the National Institute of Standards and Technology (NIST) to model the incident in the hope of understanding the factors which produced a backdraft condition of such a duration. The CFAST model was able to reproduce the observed conditions and supported a theory of the accumulation of significant quantities of unburned fuel from a vitiated fire in an apartment which had been insulated and sealed fore energy efficiency.

Bukowski, R. W.
Modeling a Backdraft: The Fire at 62 Watts Street.
National Institute of Standards and Technology, Gaithersburg, MD
NFPA Journal, Vol. 89, No. 6, 85-89, November/December 1995.

backdraft; fire fatalities; fire fighters; fire models; apartments; smoke; heat release rate; oxygen concentration; temperature; computer models; casualties; safety; ventilation; building fires

On March 28, 1994, the New York City Fire Department responded to a report of smoke and sparks issuing from a chimney of a three-story apartment building in Manhattan. The officer in charge ordered three-person hose teams to enter the first- and second-floor apartments while the truck company ventilated the stairway from the roof. When the door to the first-floor apartment was forced open, a large flame shot out of the apartment and up the stairway, engulfing three fire fighters on the second-floor landing. The flame lasted for at least 6 1/2 minutes, killing the three men. In the hope of understanding the factors that produced a backdraft of such duration, the fire department asked the National Institute of Standards and Technology (NIST) to model the incident.

Bukowski, R. W.
On the Central Role of Fire Calorimetry in Modern Fire Hazard Assessment.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology. Fire Calorimetry. Proceedings. July 27-28, 1995, Gaithersburg, MD, Hirschler, M. M.; Lyon, R. E., Editors, p. 81, 1995.

calorimetry; fire hazards; hazard assessment; heat release rate; fire safety; systems engineering

Over the past two decades, fire science has evolved to the point that predictive models provide a practical means to evaluate the performance of safety systems over the range of applications regulated under law. Such evaluations take the form of fire hazard or fire risk assessments where the end points are loss of life, injury, or property damage. Numerous successful applications of these techniques to the reconstruction of accidental fires as well as quantitative validation studies have contributed to a general acceptance of these techniques. This presentation will review the role of RHR in fire hazard assessment and provide some examples of the application of RHR measurements in the reconstruction of fire incidents and in the performance evaluation of fire safety systems designs for regulatory approval.

Bukowski, R. W.
Predicting the Fire Performance of Buildings: Establishing Appropriate Calculation Methods for Regulatory Applications.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Limited. ASIAFLAM '95. International Conference on Fire Science and Engineering, 1st. Proceedings. March 15-16, 1995, Kowloon, Hong Kong, 9-18 pp, 1995.

fire science; fire protection engineering; fire models; evacuation; fire codes; performance evaluation; regulations; safety factors; acceptance criteria; alternative design; code equivalency

A recently organized effort in the International Council for Building Research, Working Commission 14 (CIB W14), on Engineering Evaluation of Building Fire Safety is examining the various quantitative methods being developed to underpin performance-based codes or for determining equivalency with the implied performance of existing prescriptive codes. These methods share many common features and all recognize the range of fire models and calculational methods that the fire safety engineering profession have begun to embrace as their technical foundation. The broad range of assumptions inherent in the available methods as well as the data required to utilize them raises some interesting questions about their appropriateness in applications to code-regulated situations. Many fire-related computations have inherent uncertainty because of lack of understanding of the physics. Thus, one can ask, where a code defines a minimum level of performance, how far must the fire safety engineer go to minimize uncertainty in a calculation intended to verify compliance? The variability of fire means that there are no unique answers against which to define accuracy; and fire experiments involve measurement uncertainties as well as approximations used to reduce the data which often have similar form to the calculations we wish to verify. These methods all focus on managing fire risk, and their successful application depends on assessing the acceptable level of risk implied by the current codes. Some argue that the lack of a public outcry over fire losses is not a tacit acceptance of those losses by society. Thus, how can acceptable levels of risk be determined when regulatory authorities and legislators are uncomfortable with the notion that there is no zero risk so some fatalities are inevitable? This paper explores these questions

from the perspective of the fire scientist, the practicing engineer, and the regulatory offical. The fire scientist needs to be explicit about the impact of assumptions on the applicability of the results. The engineer needs to utilize methods and assumptions which are justified by the application and to assess the sensitivity and uncertainty implications. The regulatory officials are insisting on appropriate and properly documented methods. These is a need for models and calculations incorporated into codes of practice, handbooks, or the codes themselves to be reviewed, verified, documented, and approved for use in specific manners and by qualified persons. There are international efforts to define levels of risk acceptable to society in specific occupancies. Until these points are addressed, the transition to performance-based codes cannot be made with confidence.

Bukowski, R. W.; Budnick, E. K.
Guide for the Implementation of PL 102-522 for Fire Alarm and Automatic Sprinkler Installations.
National Institute of Standards and Technology, Gaithersburg, MD
Hughes Associates, Inc., Baltimore, MD
HUD-1571-PDR; 94 p. September 1995.
Available from Department of Housing and Urban Development,
Washington, DC

fire alarm systems; sprinklers; sprinkler systems; installations; housing; residential buildings; smoke detectors; life safety code; multifamily housing; fire protection; NFPA 74

The 1992 Fire Administration Authorization Act (PL 102-522) included three provisions that directly affect HUD-assisted housing: (1) newly constructed, four-story or higher multifamily buildings must be protected with an automatic sprinkler system and hard-wired smoke detectors; (2) rebuilt, four-story or higher multifamily buildings must be brought into compliance with Chapter 19 of National Fire Protection Association 101, the "Life Safety Code;" and (3) other dwelling units must be protected by hard-wired or battery-operated smoke detectors installed in compliance with NFPA 74, "Standard for the Installation, Maintenance, and Use of Household Fire Warning Equipment." The National Institute of Standards and Technology (NIST) has developed this Guide for the Implementation of PL 102-522 for Fire Alarm and Automatic Sprinkler Installations to assist HUD field offices in the efficient implementation of the provisions in the Act. The guide provides information on installation of smoke detectors and automatic sprinkler systems. It does not address the rebuilt multifamily properties that must be brought into compliance with the "Life Safety Code."

Bukowski, R. W.; Juillet, E.
Emergency Procedures for Employees With Disabilities in Office Occupancies.
National Institute of Standards and Technology, Gaithersburg, MD
National Task Force on Life Safety and People with Disabilities, Luray, VA
Available from U. S. Fire Administration, Emmitsburg, MD
FA 154; 28 p. June 1995.

emergency plans; handicapped; office buildings; planning; fire detection; people movement

People with disabilites are increasingly moving into the mainstream of society, contributing to the diversity which has been this country's strength. It is only right that they be provided with the same level of safety asthe rese of society, as referenced in the Americans With Disabilities Act (ADA). Equipment and procedures exist that can provide such safety for any person with a disability that is not so severe that it would preclude the ability to work. The key points regarding finding the best solution for your building are, first, to remember that every person with a disability has unique abilities and limitations, and accommodations should be tailored to their needs. Second, it is crucial that the person be included in the decision on which equipment and procedures will work for them to provide them with the confidence that they will be protected.

Bullard, J. W.

Bullard, J. W.; Garboczi, E. J.; Carter, W. C.; Fuller, E. R., Jr.
Numerical Methods for Computing Interfacial Mean Curvature.
National Institute of Standards and Technology, Gaithersburg, MD
Computational Materials Science, Vol. 4, 103-116, 1995.

building technology; computer models; interfaces; mean curvature; sintering; equations

A procedure is described for computing the mean curvature along condensed phase interfaces in two or three dimensions, without knowledge of the spatial derivatives of the interface. For any point P on the interface, the method consists of computing the portion of volume enclosed by a small template sphere, centered on P, that lies on one side of the interface. That portion of the template volume is shown to be linear in the mean curvature of the surface, relative to the phase lying on the opposite side of the interface, to within terms that can usually be made negligible. An analogous procedure is described in two dimensions. Application of the procedure to compute the mean curvature along a digitized surface is demonstrated. A burning algorithm can be included to improve computational accuracy for interfaces having sharp curvature fluctuations. A minor extension of the method allows computation of the orientation of an interfacial element relative to a fixed reference frame.

Burch, D. M.

Burch, D. M.
Analysis of Moisture Accumulation in Roof Cavities of Manufactured Housing.
National Institute of Standards and Technology, Gaithersburg, MD
American Society for Testing and Materials. Airflow Performance of Building Envelopes, Components, and Systems. ASTM STP 1255. ASTM, Philadelphia, PA, Modera, M. P.; Persily, A. K., Editors, 156-177 pp, 1995.

roofs; housing; attic ventilation; HUD Manufactured Home Construction; safety standards; mobile homes; moisture control guidelines; moisture in attics; manufactured housing

A detailed computer analysis is conducted to investigate whether moisture problems occur in the roof cavity of manufactured homes constructed in compliance with the current Department of Housing and Urban Development (HUD) Standards for manufactured housing. The current HUD Standards require a ceiling vapor retarder, but do not require outdoor ventilation of the roof cavity. In cold climates, the analysis revealed that moisture accumulates at lower roof surface and poses a risk of material degradation. The analysis found the following combination of passive measures to be effective in preventing detrimental winter moisture accumulation at lower surface of the roof: 1) providing a ceiling vapor retarder, 2) sealing penetrations and openings in the ceiling construction, and 3) providing natural ventilation of the roof cavity. In addition, the performance of a roof cavity exposed to a hot and humid climate is investigated. The analysis revealed that outdoor ventilation of the roof cavity causes the monthly mean relative humidity at the upper surface of the vapor retarder to exceed 80%. This condition is conducive to mold and mildew growth.

Burch, D. M.; Desjarlais, A. O.
Water-Vapor Measurements of Low-Slope Roofing Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Oak Ridge National Lab., TN
NISTIR 5681; 32 p. July 1995.
Available from National Technical Information Service
PB95-251617

moisture; moisture transfer; sorption isotherm; water vapor permeability; water vapor transfer; moisture property

New measurement methods recently developed at the National Institute of Standards and Technology were used to measure the sorption isotherm and permeability of several low-slope roofing materials at a mean temperature of 24 deg C (75 deg F). The materials included: fiberboard, perlite board, exterior-grade plywood, polyisocyanurate board insulation with glass-matt facers, and glass-fiber board insulation with a facer. For the sorption isotherm measurements, the materials were placed in various ambient relative humidities ranging from a dry to a saturated state. The equilibrium moisture content plotted versus ambient relative humidity at 24 deg C (75 deg F) gave the sorption isotherm. Separate sorption isotherms were obtained for specimens initially dry (adsorption isotherm) and specimens initially saturated (desorption isotherm). For the permeability measurements, a series of cup measurements was performed, and the permeability was plotted as a function of the mean relative humidity across the specimen. The measurements revealed that the moisture properties of building materials are often significantly dependent on average relative humidity. Standard measurement methods currently in use in the United States do not adequately account for the effect of relative humidity on moisture properties.

Burch, D. M.; Saunders, C. A.
Computer Analysis of Wall Constructions in the Moisture Control Handbook.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5627; 70 p. May 1995.
Available from National Technical Information Service

building technology; walls; construction; moisture; computer models; material degradation; Moisture Control Handbook; moisture transfer model; mold and mildew growth; vapor retarders; vinyl wallpaper; wall construction

A computer model, called MOIST, is used to investigate the moisture performance of recommended wall constructions given in the Moisture Control Handbook (1991). These wall constructions are intended to minimize moisture accumulation, thereby preventing material degradation, mold and mildew growth, and loss in thermal performance. For the heating climate (northern United States) and mixed climate (central United States), all the wall constructions in the Moisture Control Handbook were found to perform satisfactorily. That is, when the surface relative humidities of the construction layers were plotted versus time of year, the peak relative humidities were always found to be within acceptable limits that preclude material degradation and mold and mildew growth. For the cooling climate (south-eastern United States), one of the walls had risk of mold and mildew growth behind an interior vapor retarder. During the summer, moisture from the outdoor environment diffused inwardly into this construction. Upon reaching the interior vapor retarder, moisture was significantly retarded and accumulated, thereby causing the surface relative humidity to rise above the critical 80% level for mold and mildew growth. An interesting finding was that moisture accumulated during the winter at exterior layers having low permeability, thereby giving rise to relative humidities above a critical level (80%). However, this moisture accumulation occurred at relatively low outdoor temperatures, which would slow mold and mildew growth. For a cooling climate, a permeable wall (i.e., without vapor retarding layers and low-permeability materials) was found to perform satisfactorily. During both winter and summer periods, moisture passed through the construction and did not significantly accumulate within construction layers.

Burch, D. M.; Saunders, C. A.; TenWolde, A.
Manufactured Housing Walls That Provide Satisfactory Moisture Performance in All Climates.
National Institute of Standards and Technology, Gaithersburg, MD
Forest Products Lab., Madison, WI
NISTIR 5558; 33 p. January 1995.
Available from National Technical Information Service
PB95-178885

housing; moisture analysis; moisture control guidelines; mobile homes; manufactured housing; moisture in walls; moisture problems; moisture transfer

We used the MOIST Computer Model to conduct a detailed analysis of the moisture performance of one wall typical of current construction practice in manufactured housing, and two new alternative wall designs with potential for better moisture performance in a wider variety of climates. The analysis showed that the current-practice wall with an interior vapor retarder performed acceptably in a cold climate (Madison, WI), but poorly in a hot and humid climate (Miami, FL). The alternative wall designs both exhibited satisfactory moisture performance in the cold climate and the hot and humid climate, even with moderately severe indoor conditions. The alternative wall designs also performed satisfactorily in a mixed climate (Little Rock, AR). These alternative wall designs should be of interest to the manufactured housing industry, who distributes houses to all climatic regions of the United States.

Burch, D. M.; TenWolde, A.
Manufactured Housing Walls That Provide Satisfactory Moisture Performance in All Climates.
National Institute of Standards and Technology, Gaithersburg, MD
Forest Products Laboratory, Madison, WI
International Building Performance Simulation Association.
Building Simulation '95. Building Simulation Conference, 4th Proceedings. August 14-16, 1995, Madison, WI, Intl. Building Performance Simulation Assoc., Mitchell, J. W.; Beckman, W. A., Editors, 22-33 pp, 1995.

building technology; manufactured housing; moisture performance; walls

We used the MOIST Computer Model to conduct a detailed analysis of the moisture performance of one wall typical of current construction practice in manufactured housing, and two new alternative wall designs with potential for better mositure performance in a wider variety of climates. The analysis showed that the current-practice wall with an interior vapor retarder performed acceptably in a cold climate (Madison, WI), but poorly in a hot and humid climate (Miami, FL). The alternative wall designs both exhibited satisfactory moisture performance in the cold climate and the hot and humid climate, even with moderately severe indoor conditions. The alternative wall designs also performed satisfactorily in a mixed climate (Little Rock, AR). These alternative wall designs should be of interest to the manufactured housing industry, who distributes houses to all climatic regions of the United States.

Burch, D. M.; Zarr, R. R.; Fanney, A. H.
Experimental Verification of a Moisture and Heat Transfer Model in Hygroscopic Regime.
National Institute of Standards and Technology, Gaithersburg, MD
Thermal Performance of the Exterior Envelopes of Building VI Conference. Proceedings. December 4-8, 1995, Clearwater Beach, FL, 273-282 pp, 1995.

moisture; heat transfer; building; building envelopes; MOIST; moisture transfer; calibrated hot box; manufactured housing; moisture analysis

The National Institute of Standards and Technology (NIST) has developed a personal computer model, called MOIST, for predicting the transient moisture and heat transfer within building envelopes. This paper summarizes selected results from a comprehensive laboratory experiment conducted to verify the accuracy of the computer model in the hygroscopic regime. This paper discusses three different multilayer wall specimens installed in a calibrated hot box. The exterior surface of the wall specimens were first exposed to both steady and time-dependent winter conditions, while their interior surfaces were maintained at 21DG (70DGF and 50% relative humidity. These boundary conditions caused moisture from the interior environment to permeate into the wall specimens and accumulate in their exterior construction materials. Subsequently, the exterior air temperature was elevated to 32DGC (90DGF), and the exterior construction materials lost moisture to the interior environment. The moisture content within the exterior construction materials and the heat transfer rate at the inside surface of the wall specimens were measured and compared to computer predictions. The moisture and heat transfer properties for the construction materials comprising the wall specimens were independently measured and used as input to the computer model. The agreement between predicted and measured moisture contents was within 1.1% moisture content. Predicted and measured heat transfer rates also were in close agreement. Accumulated moisture was observed to have little effect on heat transfer because moisture did not accumulate above the hygroscopic limit (i.e., the so-called fiber saturation point) and capillary water did not exist within the pore space of the materials. The insulation remained relatively dry, and the boundary conditions did not give

rise to a latent heat effect (i.e., water was not induced to evaporate from one part of the construction and condense in another part).

Butler, K. M.

Butler, K. M.; Baum, H. R.; Kashiwagi, T.
Heat Transfer in an Intumescent Material Using a Three-Dimensional Lagrangian Model.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 261-266 pp, 1995.

fire research; bubbles; intumescence; mathematical models; numerical analysis; thermoplastics; heat transfer

The addition of heat transfer calculations to a three-dimensional, time-dependent numerical model of intumescent materials is described. Intumescent materials protect an underlying substrate from fire through endothermic chemical reactions producing bubbles and through the reduced thermal conductivity of the final porous char. These mechanisms are demonstrated for a single bubble and multiple bubbles. Both flow and temperature fields within the intumescent melt are determined by summing fields due to the individual bubbles.

C

Carino, N. J.

Carino, N. J.; Clifton, J. R.
Prediction of Cracking in Reinforced Concrete Structures.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5634; 53 p. April 1995.
Available from National Technical Information Service
PB95-220448

building technology; concretes; cracking (fracturing); creep; reinforced concretes; restrained shrinkage

The useful life of a buried concrete, containment structure for low level nuclear waste may be controlled by the loss of its load-bearing capacity or an increase in permeability. The latter factor is controlled by the general degradation of the concrete and by the presence of discrete cracks resulting from externally applied loads or from restraint to normal volume changes. To be able to predict the effects of cracks on permeability, it is necessary to understand the causes and mechanisms of discrete crack formation in reinforced concrete structures. The objective of this report is to provide an overview of the design and behavior of reinforced concrete members and to discuss the factors affecting the formation of cracks in hardened concrete. The underlying philosophy of modern reinforced concrete design is presented, and it is shown that it allows for the formation of cracks of controlled widths under service loads. Models for predicting the width of flexural cracks are reviewed. Factors affecting drying shrinkage cracks and approximate methods for considering them are discussed. An example is provided to illustrate how to determine whether drying shrinkage cracks will develop under specific conditions. This is followed by a discussion of techniques to predict the number and widths of drying shrinkage cracks. Finally, there is a discussion of the interaction between flexural and drying shrinkage cracking. The report is directed to the general audience who is unfamiliar with the structural aspects of reinforced concrete.

Cheok, G. S.

Cheok, G. S.
Workshop on the Seismic Rehabilitation of Lightly Reinforced Concrete Frames. Proceedings. June 12-13, 1995. Gaithersburg, Maryland.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5741; 176 p. November 1995.
Available from National Technical Information Service
National Institute of Standards and Technology and the U.S. Corps of Engineers. Workshop on the Seismic Rehabilitation of Lightly Reinforced Concrete Frames. Proceedings. June 12-13, 1995, Gaithersburg, MD, Cheok, G. S., Editor, 1995.

reinforced concretes; composite; concretes; damping system; frames; lightly reinforced; rehabilitation; retrofit; steels; workshop

This report contains the proceedings from a workshop "Seismic Rehabilitation of Lightly Reinforced Concrete (LRC) Frames" sponsored by the National Institute of Standards and Technology and the U.S. Corps of Engineers, Construction Engineering Research Laboratory. The 1-1/2 day workshop was held on June 12-13, 1995 in Gaithersburg, Maryland. A total of 24 researchers, design engineers, and representatives from various federal agencies were invited to attend the workshop. The objectives of the workshop were to determine the state-of-the-art in the rehabilitation of LRC frames, to determine any gaps in the knowledge base that are preventing the development of guidelines or the widespread use of the rehabilitation methods, and the methods to fill these gaps. Six papers were presented at the workshop. The participants were divided into three working groups - concrete/masonry, steel, composites and damping systems. The participants discussed and recommended areas of needed research for rehabilitation methods in the three areas.

Choi, M. Y.

Choi, M. Y.; Mulholland, G. W.; Hamins, A.; Kashiwagi, T.
Comparisons of the Soot Volume Fraction Using Gravimetric and Light Extinction Techniques.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 102, No. 1/2, 161-169, July 1995.

soot; light extinction; experiments; temperature; premixed flames

Simultaneous optical and gravimetric measurements were performed in the postflame region of an acetylene/air premixed flame where the temperature of the soot/gas mixture was reduced to 500 K through nitrogen dilution. By combining gravimetric measurements of the collected soot with soot density measurements using helium pycnometry, an accurate value of the soot volume fraction was obtained. The temperature and soot concentration profiles were measured to compare the line of sight light extinction measurement with the point sampling gravimetric measurements. The soot volume fraction obtained by light extinction measurements overestimated the actual soot volume fraction by about a factor of two. By calibrating the optical measurements with the gravimetric soot volume fractions, a dimensionless extinction coefficient, Ke, of 8.6 was measured. This value is conjectured to be applicable for soot generated for a variety of fuels and to be valid for extinction wavelengths in the visible to the near-infrared. It was also found that the mass specific light extinction coefficient was found to be 8.0 m2/g which is consistent with measurements reported in the literature for a variety of fuels.

Chung, R. M.

Chung, R. M.; Jason, N. H.; Mohraz, B.; Mowrer, F. W.; Walton, W. D.
Post-Earthquake Fire and Lifelines Workshop; Long Beach, California, January 30-31, 1995. Proceedings.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 889; August 1995.

Available from Government Printing Office
SN003-003-03362-6
Available from National Technical Information Service
PB96-117916

building design; earthquakes; electric power; fire departments; fire research; fire spread; fire technology; lifelines; liquid fuels; natural gas; seismic design; sprinkler systems; telecommunications; transportation; water services; telecommunications

A post-earthquake fire and lifeline workshop sponsored by the Building and Fire Research Laboratory, National Institute of Standards and Technology, was held January 30-31, 1995, in Long Beach, California. The objective of the workshop was to assess technology development and research needs that will be used in developing recommendations to reduce the number and severity of post-earthquake fires. The workshop participants included leaders in the fire service; fire protection engineering; codes and standards; insurance; transportation; and water, gas, power distribution, and telecommunication utilities with experience in dealing with consequences of earthquakes. The workshop participants developed a list of priority project areas where further research, technology development, or information collection and dissemination would serve as a vital step in reducing the losses from future post-earthquake fires. The research and development needs generated by the participants are separated into two broad categories; ignition and fire spread, and fire control. Under the category of ignition and fire spread are the research needs related to either the direct source of ignition or the first fuel ignited, a well as factors that contribute to fire spread. The category of fire control includes research needs related to systems and personnel whose functions include the control and extinguishment of fires.

Civil Engineering Research Foundation

Civil Engineering Research Foundation
National Construction Sector Goals. Industry Strategies for Implementation.
Civil Engineering Research Foundation, Washington, DC
NIST-GCR-95-680; 42 p. July 1995.
Available from National Technical Information Service
PB95-269817

construction; industries

This report presents initial strategic considerations for a national initiative that is intended to fundamentally impact the quality and productivity associated with construction industry activities in the United States. It specifically provides the "implementation strategy templates" for the residential and public works construction sectors. Similar "templates" for the remaining sectors are expected to be completed during this calendar year; the complete set of sectoral strategies will, in turn, provide an important platform for the industry-led development of an integrated National Plan for the Implementation of Construction Goals, a plan that will fully outline the specific procedures, responsibilities and products that, will, when combined, lead to the realization of the challenging national construction goals that have been postulated and documentated through the work of the Construction and Building (C&B) Subcommittee of the National Science and Technology Council (NSTC) and the construction industry. The Residential Sector implementation strategy (Appendix A) was developed through the leadership of the NAHB Research Center. Members of the development team included representatives of building materials manufacturers, the Building Officials Conference of America (BOCA), the National Conference of States on Building Codes and Standards (NCSBCS), the Civil Engineering Research Foundation (CERF) and the Construction and Building Subcommittee. The Public Works Sector implementation strategy (Appendix B) was developed as a cooperative effort involving the American Public Works Association (APWA), the Rebuild America Coalition, the Infrastructure Technology Institute (ITI) and CERF.

Cladding Research Institute

Cladding Research Institute
Literature Review on Seismic Performance of Building Cladding Systems.
Cladding Research Institute, Emeryville, CA
NIST-GCR-95-681; 179 p. February 1995.
Available from National Technical Information Service
PB96-106901

cladding; literature reviews; concretes

A literature survey on the seismic performance of building cladding systems was conducted. The focus was on heavy cladding panels, with a particular emphasis on precast concrete cladding panels. The references used in this literature survey were identified by using the following resources: (1) computerized library data bases, including the "melvyl" system for the University of California libraries, "eea" (eathrquake engineering abstracts) available through "melvyl," and the "gladis" system for the U.C. Berkeley libraries; and (2) the CD-rom from the Information Service at the National Earthquake Engineering Center (NCEER) at SUNY at Buffalo that contains abstracts for references shelved there and at the EERC Library. The facilities used to retrieve the references of interest included: (1) the U.C. Berkeley libraries, including the Earthquake Engineering Research Center (EERC) Library at the Richmond Field Station, the Engineering Library on the U.C. Berkeley campus; and the Environmental Design Library on the U.C. Berkeley campus; (2) the Information Service at NCEER; (3) the National Technical Information Service (NTIS) at the U.S. Department of Commerce; and (4) the Prestressed/Precast Concrete Institute (PCI) in Chicago, Illinois. At the Environmental Design Library, the following additional resources were found to be helpful: the Avery computer data base for post-1978 references, the Avery printed books for pre 1978 references, the Art Index on CD-rom, and the Construction index book seriels. Some of the key words used in the search included: precast, cladding, reinforced concrete, concrete, facades, skins, siding, etc. The literature survey is organized as follows: Chapter 1 is an introduction that includes definitions, cladding panel configurations, details of architectural precast concrete cladding systems in the U.S.A., New Zealand, Japan, and Canada. Chapter 2 describes the current practice for seismically isolated precast concrete cladding panels and connections, including U.S. codes and their interpretation and foreign codes. Chapter 3 offers information on the structural utilization of precast concrete cladding panels and connections, including an historical overview, levels of contribution in seismic response, architectural implications for structural cladding, conditions for effective structural cladding, and issues of responsibility. Chapter 4 contains abstracts and informational highlights from research on the structural utilization of precast concrete cladding panels and connections, including eleven sets of research projects from the U.S.A., one project from Canada, and one project from Japan. Chapter 5 outlines other cladding materials for heavy panels, including prefabricated panel systems, GFRC panels, new types of reinforcement, a new type of RC sandwich panels, and steel and steel alloy panels.

Cleary, T. G.

Cleary, T. G.; Yang, J. C.; King, M. D.; Boyer, C. I.; Grosshandler, W. L.
Pipe Flow Characteristics of Alternative Agents for Engine Nacelle Fire Protection.
National Institute of Standards and Technology, Gaithersburg, MD
Halon Options Technical Working Conference. Proceedings. May 9-11, 1995, Albuquerque, NM, 1-12 pp, 1995.

fire suppression; flow measurement; halon 1301; pressure drop

As part of the U.S. Air Force, Army, Navy and FAA Halon Replacement Project at NIST, the pipe flow characteristics were investigated for three engine nacelle alternative candidate: HFC-227ea, HFC-125 and CF3I. The flow regime in suppression system piping is characteristically a two-phase, two-component gas/liquid system. An apparatus was built to study the pressure drop and flow time of the alternative agents and of halon 1301 as a reference for different storage conditions and piping configurations. The pressure drops and flow times of the alternative agents and halon 1301 show similar trends suggesting that for actual systems, design approaches similar to those used for halon 1301 systems are possible for the alternatives. High speed movies confirmed the two-phase nature of the flow. A computer model that simulates steady-state and transient discharge of nitrogen-pressurized agent from a storage bottle through piping was developed. The model may prove useful in preliminary design of engine nacelle systems employing an alternative agent.

Clifton, J. R.

Clifton, J. R.; Pommersheim, J. M.; Snyder, K. A.
Long-Term Performance of Engineered Concrete Barriers.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
NISTIR 5690; 19 p. July 1995.
Available from National Technical Information Service

concretes; corrosion; leaching; low level nuclear disposal; modeling; service life; sulfate attack; cracking (fracturing); degradation; deterioration

This paper describes research being carried out at NIST on the long-term performance of concrete for constructing low-level nuclear waste (LLW) disposal facilities. These studies have included identification of likely major degradation and cracking processes, evaluation and development of accelerated degradation test methods, and the analysis and development of mathematical models for service life predictions. The major degradation processes that underground concrete will likely to encounter are sulfate attack, corrosion of reinforcing steel, alkali-aggregate reactions, and leaching by ground water. Major cracking processes in immature concrete, such as plastic shrinkage, plastic settlement, and early thermal expansion/contraction should occur before the vault is covered. Cracks caused by drying shrinkage, thermal and moisture expansion/contraction are less likely to occur once a vault is covered. Load-induced can be avoided by proper design and construction practices. Degradation processes which would likely be active above ground, but not below ground, or to be significantly more severe above ground, include freezing and thawing, drying shrinkage, cracking due to thermal and moisture expansion/contraction of concrete, abrasion by wind driven particulate matter, and impact by wind driven objects. Three major research needs have been identified which are: validation of service life models; development of performance criteria for materials and systems to repair concrete before closure of concrete vaults; and development of an expert system to dissiminate knowledge on concrete durability for constructing concrete vaults.

Cooper, L. Y.

Cooper, L. Y.
Calculating Combined Buoyancy- and Pressure-Driven Flow Through a Shallow, Horizontal, Circular Vent; Application to Problem of Steady Burning in a Ceiling-Vented Enclosure.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 321-326 pp, 1995.

fire research; vents; buoyancy; pressure; ceilings; enclosures; algorithms; equations; energy release rate; ships; wood

A model was developed previously for calculating combined buoyancy- and pressure-driven (i.e., forced) flow through a shallow, circular, horizontal vent where the vent-connected spaces are filled with fluids of different density in an unstable configuration (density of the top fluid is larger than that of the bottom). In this paper the model equations are summarized and then applied to the problem of steady burning in a ceiling-vented enclosure where normal atmospheric conditions characterize the upper space environment. Such fire scenarios are seen to involve a zero-to-relatively-moderate cross-vent pressure difference and bi-directional exchange flow between the enclosure and the upper space. A general solution to the problem is obtained. This relates the rate of energy release of the fire to the area of the vent and to the temperature and oxygen concentration of the upper portion of the enclosure environment. The solution is seen to be consistent with previously-published data involving ceiling-vented fire scenarios.

Cooper, L. Y.
Combined Buoyancy- and Pressure-Driven Flow Through a Shallow, Horizontal Circular Vent.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Heat Transfer, Vol. 117, 659-667, August 1995.

vents; building fires; compartment fires; computer models; fire models; mathematical models; zone models

Combined buoyancy- and pressure-driven (i.e., forced) flow through a horizontal vent is considered where the vent-connected spaces are filled with fluids of different density in an unstable configuration (density of the top is larger than that of the bottom). With zero-to-moderate cross-vent pressure difference the instability leads to a bi-directional exchange flow between the two spaces. For relatively large the flow through the vent is un-idirectional, from the high- to the low-pressure space. An anomaly of a standard vent flow model, which uses Bernoulli's equation with a constant flow coefficient is discussed. Thus, the standard model does not predict expected bi-directional flows at small-to-moderate or non-zero flows at [equation]. Also, when [equation] exceeds the critical value [equation], which defines the onset of uni-directional or "flooding" flow, there is a significant dependence of [equation] on the relative buoyancy of the upper and lower fluids (i.e., [equation] is not constant). Finally, the location of the high-pressure side of the vent, i.e., top or bottom, can be expected to influence vent flow characteristics. Analysis of the relevant boundary value problems and of available experimental data lead to a general mathematical model of the vent flow which removes the anomaly of the standard model and which takes all the above effects into account. The result is a algorithm to calculate flow through shallow, horizontal, circular vents under high-Grashof number conditions.

Cooper, L. Y.
Compartment Fire-Generated Environment and Smoke Filling.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Handbook of Fire Protection Engineering. 2nd Edition. Section 3. Chapter 10, National Fire Protection Assoc., Quincy, MA, DiNenno, P. J.; Beyler, C. L.; Custer, R. L. P.; Walton, W. D., Editor(s), 3/174-196 pp., 1995.

fire protection; fire protection engineering; compartment fires; smoke; fire safety; building design; egress; equations; smoke spread; scenarios; mathematical models; temperature; time; thickness; combustion products; detection time; ignition

The following generic problem must be solved if one is to be able to establish the fire safety of building designs: [*] Given: Initiation of a fire in a compartment or enclosed space, [*] Predict: The environment that developes at likely locations of occupancy, at likely locations of fire/smoke sensor hardware (e.g., detectors and sprinkler links), and in locations of safe refuge and along likely egress paths, [*] Compute: The time of fire/smoke sensor hardware response and the time of onset of conditions untenable to life and/or property. This computation would be carried out from the above predictions, using known response characteristics of people, hardware, and materials. The above is only a simple sketch of the overall problem that is likely to be associated with the interesting details of many real fire scenarios. A long-term challenge of fire science and technology is to solve the above type of problem, even when it is formulated in elaborate detail. Compartment fire modeling is the branch of fire science and technology which develops the necessary tools to address this generic problem. This chapter will describe some of the key phenomena that occur in compartment fires, and it will focus on smoke filling which is one of the simplest quantitative global descriptions of these phenomena. A specific smoke-filling model will be presented, and solutions to its model equations will be discussed along with example applications.

Cooper, L. Y.
Interaction of an Isolated Sprinkler Spray and a Two-Layer Compartment Fire Environment.
National Institute of Standards and Technology, Gaithersburg, MD
International Journal of Heat and Mass Transfer, Vol. 38, No. 4, 679-690, March 1995.

building fires; compartment fires; computer models; fire models; mathematical models; vents; sprinklers; sprinkler response; zone models

A model is developed to simulate the interaction of a sprinkler and a two-layer fire environments under arbitrary conditions of sprinkler evaluation, upper- and lower-layer thickness and temperature. The sprinkler is characterized by water flow rate and four measurable device parameters. The model simulates the effects of the sprinkler spray as it entrains, drives downward, humidifies, and cools gases in the upper and lower layers. It predicts the flow rates of mass, enthalpy, products of combustion, and evaporated water to each of the two layers as a result of sprinkler operation. Results of example calculations are presented.

Coverdale, R. T.

Coverdale, R. T.; Christensen, B. J.; Jennings, H. M.; Mason, T. O.; Bentz, D. P.; Garboczi, E. J.

Interpretation of the Impedance Spectroscopy of Cement Paste Via Computer Modelling. Part 1. Bulk Conductivity and Offset Resistance.

Northwestern Univ., Evanston, IL

National Institute of Standards and Technology, Gaithersburg, MD

Journal of Materials Science, Vol. 30, 712-719, 1995.

building technology; cement paste; computer models; conductivity; hydration; impedance; spectroscopy

Computer simulation of impedance spectroscopy (IS) of hydrating cement paste, using a three-dimensional, four-phase model, is described. Two puzzling features of experimental IS results, the possible offset resistance in the Nyquist plot and the shapr decrease in normalized conductivity within the first 50 h of reaction, have been studied using the computer simulation model. Insight is provided into these features using the ability of the model to compare quantitatively microstructure and properties. It is concluded that the offset resistance is an experimental artefact, and does not directly relate to microstructure. The drop in conductivity during the first 50 h is shown to be a consequence of a gradual shift from parallel-dominated to series-dominated behavior of the electrical conductivity, as microstructural modifications take place during hydration, causing the capillary pore structure to become more tortuous. This tortuousity can also explain the high-frequency impedance behavior in terms of a two-arc response.

Coverdale, R. T.; Jennings, H. M.; Garboczi, E. J.

Improved Model for Simulating Impedance Spectroscopy.

Northwestern Univ., Evanston, IL

National Institute of Standards and Technology, Gaithersburg, MD

Computational Materials Science, Vol. 3, 465-474, 1995.

building technology; impedance spectroscopy

A numerical method for simulating the frequency-dependentimpedance response of multi-phase composite materials has been developed. The algorithm takes as input (1) a digital image of a microstructure, in two or three dimensions, of any specified composite material, and (2) the frequency-dependent electrical properties of the individual phases of the composite. An impedance spectrum of any frequency range can then be computed using a conjugate gradient algorithm operating on a finite difference solution scheme of Laplace's equation. Examples are given of the impedance of analytically solvable microstructures, to validate the algorithm, and of a random system, to test the usefulness of two different effective medium theories.

D

Dai, Z.

Dai, Z.; Faeth, G. M.
Evaluation of Approximate Models of Buoyant Turbulent Flows.
University of Michigan, Ann Arbor
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 141-146 pp, 1995.

fire research; turbulent flow; buoyant flow; evaluation; turbulence

At the present time, it is necessary to use approximate turbulence models in order to analyze the properties of practical fires due to the computational intractability of fully resolved three-dimensional time-dependent numerical simulations of buoyant turbulent flows representative of fire environments. Developing reliable models to treat buoyancy/turbulence interactions, however, has been inhibited due to the models to treat buoyancy/turbulence interactions, however, has been inhibited due to the absence of measurements needed to evaluate both model approximations and predictions. Thus, the main objective of the present investigation was to compete measurements of the mean and turbulent properties of a classical buoyant turbulent flow that is frequently used to evaluate the predictions of turbulence models; namely, the round buoyant turbulent plume in the fully-developed (self-preserving) region far from the source. The new measurements also are used to initiate evaluation of turbulence modeling ideas, considering both classical similarity concepts, and turbulence models of varying complexity.

Dai, Z.; Tseng, L, K.; Koylu, U. O.; Faeth, G. M.
Mixing and Radiation Properties of Buoyant Turbulent Diffusion Flames. September 1, 1993-August 31, 1994.
Michigan Univ., Ann Arbor
NIST-GCR-95-671; GDL/GMF-94-01; 98 p. June 1955.
Available from National Technical Information Services
PB95-242327

diffusion flames; fractal properties; laminar flames; lasers; mixing; soot; soot aggregates; turbulent flames; optical properties

An investigation of the mixing and radiation properties of buoyant turbulent diffusion flames is described. The study was divided into two phases: (1) the structure and mixing properties of buoyant turbulent plumes, which must be understood in order to resolve effects of turbulence/radiation interactions and to benchmark models of buoyant turbulent flows; and (2) the fractal and structure properties of soot aggregates, which must be understood in order to develop nonintrusive methods for measuring soot properties and to estimate the continuous radiation and heterogeneous reaction properties of soot in flame environments.

Dai, Z.; Tseng, L. K.; Faeth, G. M.
Velocity/Mixture Fraction Statistics of Round, Self-Preserving, Buoyant Turbulent Plumes.
Michigan Univ., Ann Arbor
American Society of Mechanical Engineers (ASME). National Heat Transfer Conference, 1995. Proceedings, 30th. Combustion and Fire Research. Heat Transfer in High Heat-Flux Systems. Volume 2. HTD-Vol. 304. August 6-8, 1995, Portland, OR, Peterson, R. B.; Ezekoye, O.A.; Simon, T., Editors, 19-33 pp, 1995.

heat transfer; combustion; fire research; heat flux; buoyant plumes; velocity; equations; statistics; turbulence

An experimental study of the structure of round buoyant turbulent plumes was carried out, limited to conditions in the self-preserving portion of the flow. Plume conditions were simulated using dense gas sources (carbon dioxide and sulfur hexafluoride) in a still and unstratified air environment. Velocity/mixture-fraction statistics, and other higher-order turbulence quantities, were measured using laser velocimetry and laser-induced fluorescence. Similar to earlier observations of these plumes, self-preserving behavior of all properties was observed for the present test range, which involved streamwise distances of 87-151 source diameters and 12-43 Morton length scales from the source. Streamwise turbulent fluxes of mass and momentum exhibited countergradient diffusion near the edge of the flow, although the much more significant radial fluxes of these properties satisfied gradient diffusion in the normal manner. The turbulent Prandt/Schmidt number, the ratio of time scales characterizing velocity and mixture function fluctuations and the coefficient of the radial gradient diffusion approximation for Reynolds stress, all exhibited significant variations across the flow rather than remaining constant as prescribed by simple turbulence models. Fourth moments of velocity and velocity/mixture fraction fluctuations generally satisfied the quasi-Gaussian approximation. Consideration of budgets of turbulence quantities provided information about kinetic energy and scalar variance dissipation rates, and also indicated that the source of large mixture fraction fluctuations near the axis of these flows involves interactions between large streamwise turbulent mass fluxes and the rapid decay of mean mixture fractions in the streamwise direction.

Davis, W. D.

Davis, W. D.; Forney, G. P.; Bukowski, R. W.

Developing Detector Siting Rules From Computational Experiments in Spaces With Complex Geometries.

National Institute of Standards and Technology, Gaithersburg, MD

University of Duisburg. International Conference on Automatic Fire Detection "AUBE '95", 10th. April 4-6, 1995, Duisburg, Germany, Luck, H., Editor, 419-428 pp, 1995.

fire detection; experiments; data analysis; ceilings; beams; computer programs

The National Institute of Standards and Technology (NIST) is conducting a four-year research project wherein a computational fluid dynamics (CFD) computer code is utilized to map temperature, flow velocities, and particle densities in spaces with complex ceiling geometries. Through parametric variation of independent variables for the fire and the space, the number and location of smoke or thermal sensors required to assure response prior to a critical fire size is determined. The first year addressed horizontal ceilings with open beams or joists, and the second year adds sloped ceilings. In addition to the geometric studies, several special studies have been conducted. These include detection of low energy fires (as low as 100 Watts), stratification of fire gases in spaces with a vertical thermocline which exceeds the plume temperature, and obstructions which do not come completely to the ceiling. A unique method of relating the response of detectors to the predicted conditions has been developed which can be utilized with any CFD model or with experimental data. The data analysis is being used to produce siting rules for inclusion directly into existing codes. The paper will review the results of the first two years of the project and present some thoughts on the potential for these techniques to greatly improve the technical basis for the utilization of fire sensors in complex installations.

Davis, W. D.; Notarianni, K. A.; Tapper, P. Z.

Modelling of Smoke Movement and Detector Performance in High Bay Spaces.

National Institute of Standards and Technology, Gaithersburg, MD

National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 307-311 pp, 1995.

fire research; fire detection; smoke movement; fire protection; ceiling height; surveys; data analysis; computer models; smoke

The National Aeronautics and Space Administration, together with the National Institute of Standards and Technology are in the third year of a five year project designed to set guidelines for fire protection in high bay facilities. There is a special need to address fire protection issues for high ceiling height (high bay) spaces. NASA has numerous high bay spaces that are used to perform a variety of functions, many of which are critical to meeting the goals of the NASA strategic plan. Examples of high bay spaces at NASA include those used for clean rooms, shuttle simulators, assembly/storage, vacuum and vibration chambers, vehicle assembly, and/or testing facilities with payloads. These spaces represent some of the most difficult fire protection challenges in that detection of a fire in a large sapce may be delayed due to the distance smoke and products of combustion must travel to reach the detector, the large amount of ambient air for smoke dilution, the high dollar value of these spaces, and the low damage threshold of a clean room. Some of these spaces also involve forced air flow.

Deal, S.

Deal, S.
Technical Reference Guide for FPEtool Version 3.2.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5486-1; 137 p. April 1995.
Available from National Fire Protection Association, Quincy, MA 02269 Telephone: (1) + 617-984-7469
Available from International Conference of Building Officials, Whittier, CA 90601 Telephone: (1) + 213-699-0541
Available from Australian Fire Protection Assoc. Ltd., Victoria, Australia Telephone: (61) + 3 + 320-5577

computer programs; detector response; evacuation models; fire research; fire models; tenability; fire safety engineering; performance evaluation; sprinkler response

FPEtool is a collection of computer simulated procedures providing numerical engineering calculations of fire phenomena to the building designer, code enforcer, fire protection engineer and fire-safety related practitioner. Version 3.2 newly incorporates an estimate of smoke conditions developing within a room receiving steady-state smoke leakage from an adjacent space. Estimates of human viability resulting from exposure to developing conditions within the room are calculated based upon the smoke temperature and toxicity. There is no modeling of human behavior. Also new to this release is the estimation (in the FIRE SIMULATOR procedure) of the reduction in fire heat release rate due to sprinkler suppression. This report supersedes NISTIR 5486.

Dembsey, N. A.

Dembsey, N. A.; Pagni, P. J.; Williamson, R. B.
Compartment Fire Near-Field Entrainment Measurements.
California Univ., Berkeley
Fire Safety Journal, Vol. 24, No. 4, 383-419, 1995.

compartment fires; entrainment; experiments; data analysis; mass flow; flow rate; vents; flame height; fire plumes

A widely accepted consensus on entrainment models for large fires in compartments does not yet exist. To obtain further information on such entrainment rates, 20 full-scale, near-field experiments were conducted. Near-field entrainment occurs when hot layer interface heights are beneath the burner mean flame height so that cold layer entrainment occurs only near the burner surface. A durable compartment, similar to the standard fire test compartment, was designed and used in conjunction with a 0DT61 m x 1DT22 m porous surface propane burner to produce compartment fires with heat release rates from 330 to 980 kW. Entrainment rates of 0DT74-0DT98 kg/s were calculated from temperature measurements made within the compartment and in the doorway. The entrainment rates determined here were correlated with values from the literature. This correlation led to two curve fits which modify Zukoski's far-field offset model and can be used to estimate near-field

entrainment rates. An offset for the near-field model of Thomas was also developed. The fire plume model of Baum and McCaffrey was found to compare favorably with the entrainment rates determined here.

diMarzo, M.

diMarzo, M.
Dropwise Evaporative Cooling.
Maryland Univ., College Park
Universita degli Studi di Bologna. National Heat Transfer Conference, XIII UIT. Proceedings. ATTI 13 Congresso Nazionale Sulla Transmissione Del Calore. Giugno 22-23, 1995, Bologna, Italy, 3-25 pp, 1995.

evaporative cooling; droplets; solid surface; thermal conductivity; solids; sprays

A comprehensive review of the findings that punctuated ten years of research on dropwise evaporative cooling is presented. The first studies consider a single droplet evaporating on a high thermal conductivity solid surface. The solid-liquid coupling is addressed when considering the case of a low thermal conductivity solid. A powerful, non-intrusive, infrared thermographic technique is instrumental in describing the thermal behavior of the solid surface. The applications relevant to fire suppression suggest the input of radiant heat from above the surface instead of heat conducted through the solid. Once the single droplet behavior is fully documented experimentally and accurately modelled, the study of sparse water sprays is undertaken. A superposition model is formulated which well represents the experimental data.

Dols, W. S.

Dols, W. S.; Persily, A. K.
Study of Ventilation Measurement in an Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
American Society for Testing and Materials. Airflow Performance of Building Envelopes, Components, and Systems. ASTM STP 1255. Philadelphia, PA, ASTM, West Conshocken, PA, Modera, M. P.; Persily, A. K., Editors, 23-46 pp, 1995.

office buildings; air flow; building performance; carbon dioxide; commercial buildings; indoor air quality; measurement; tracer gas; ventilation

The National Institute of Standards and Technology has conducted a study of ventilation and ventilation measurement techniques in the Bonneville Power Administration (BPA) Building in Portland, Oregon. The project involved the comparison of outdoor air ventilation measurement techniques for relative accuracies and an examination of changes in building ventilation rates over time. The following measurement techniques were compared: tracer gas decay measurements of whole building air change rates, the determination of air change rates based on peak carbon dioxide (CO2) concentrations, the determination of percent outdoor air intake using tracer gas (sulfur hexafluoride and occupant-generated CO2), and direct airflow rate measurements within the air handling system. In addition, air change rate measurements made with an automated tracer gas decay system approximately three years apart were compared. The major findings of the study are as follows. Airflow rates were measured in the air handling system ductwork using pitot tube, hot-wire anemometer, and vane anemometer traverses, and good agreement was obtained between the different techniques. While accurate determinations of percent outdoor air intake were achieved using tracer gas techniques, the use of CO2 detector tubes yielded unreliable results. Reliable determinations of ventilation rates per person were made based on SF6 decay and direct airflow rate measurements but the use of peak CO2 concentrations led to inaccuracies, i.e., the overprediction of ventilation rates by as much as 100%. The measured values of the whole building air change rates, and their dependence on outdoor air temperature, did not change significantly over a three year period. The minimum air change rates were above the building design value and ASHRAE Standard 62-1981, the standard on which the design was based, but the minimum rates were below the minimum recommendation given in Standard 62-1989. The whole building air change rate under minimum outdoor air intake conditions was determined to be twice the outdoor air intake rate provided by the minimum outdoor air intake fans. The additional air change under minimum outdoor air intake conditions was due primarily to leakage through the main outdoor air intake dampers.

Dols, W. S.; Persily, A. K.; Nabinger, S. J.
Indoor Air Quality Commissioning of a New Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5586; 51 p. January 1995.
Available from National Technical Information Service
PB95-182309
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). IAQ'95: Practical Engineering for IAQ. Proceedings. October 22-24, 1995, Denver, CO, 26-41 pp, 1995.

air quality; commissioning; indoor air quality; office buildings; ventilation; building performance

New buildings can have an increased potential for indoor air quality problems due to new building materials and deficiencies in mechanical ventilation system performance during construction and initial occupancy. In order to decrease the potential for such problems, an indoor air quality commissioning program was developed and implemented by the National Institute of Standards and Technology in a new office building for the United States Nuclear Regulatory Commission. This indoor air quality commissioning effort consisted of three tasks: (1) evaluate the mechanical ventilation system design; (2) develop a set of environmental parameters and associated reference values to be used in evaluating the building indoor air quality; and (3) measure these environmental parameters in this building and compare them with the reference values developed in Task 2. The evaluation of the mechanical ventilation system design was based on the recommendations of the 1987 BOCA mechanical code and ASHRAE Standard 62-1989. The design evaluation showed that the system ventilation rates were consistent with the recommendations of both documents. The environmental parameters identified in Task 2 address ventilation system performance, indoor pollutant levels, and thermal comfort. The reference values for these parameters were based on available standards and guidelines as well as on the results of previous indoor air quality research. In Task 3, these environmental parameters were measured in three phases of building construction: after completion of interior build-out; after the installation of the systems furniture; and roughly one month after occupancy. The measured values were within the project reference values with only a few exceptions, and these exceptions were usually attributed to a correctable circumstance.

Dols, W. S.; Persily, A. K.; Nabinger, S. J.
Indoor Air Quality Commissioning of a New Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
National Conference on Building Commissioning, 3rd. Proceedings. May 1-5, 1995, Milwaukee, WI, 1-8 pp, 1995.

air quality; commissioning; indoor air quality; office buildings; ventilation; building performance

This paper presents a case study in the application of an indoor air quality (IAQ) commissioning program. In order to identify and understand the issues involved in implementing such a program, an IAQ commissioning program was developed and applied to a new office building in Rockville, Maryland. This commissioning program is not presented as a candidate for a standardized protocol for IAQ commissioning. Instead, it is intended to provide experience and insight that will assist in the development of future IAQ commissioning protocols.

Domanski, P. A.

Domanski, P. A.
Theoretical Evaluation of the Vapor Compression Cycle With a Liquid-Line/Suction-Line Heat Exchanger, Economizer, and Ejector.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5606; 37 p. March 1995.

Available from National Technical Information Service
PB95-216917

air conditioning; ejector; liquid-line/suction-line heat exchange; Rankine cycle; refrigeration; vapor compression cycle

The report presents a theoretical analysis of three vapor compression cycles which are derived from the Rankine cycle by incorporating a liquid-line/suction-line heat exchanger, economizer, or ejector. These addendums to the basic cycle reduce throttling losses using different principles, and they require different mechanical hardware of different complexity and cost. The theoretical merits of the three modified cycles were evaluated in relation to the reversed Carnot and Rankine cycle. Thirty-eight fluids were included in the study using the Carnahan-Starling-DeSantisequation of state. In general, the benefit of these addendums increases with the amount of the throttling losses realized by the refrigerant in the Rankine cycle. The liquid-line/suction-lineheat exchange cycle shows the smallest COP improvement. Theoretically, the ejector cycle can reach the highest COP, but this requires a high level of ejector efficiency, which has not been demonstrated to be feasible in practice. If the two-phase ejector efficiency is assigned the value attainable in a typical single-phase ejector, the COP of the ejector cycle is comparable to the COP of the one-stage economizer cycle.

Douglas, J. F.

Douglas, J. F.; Garboczi, E. J.
Intrinsic Viscosity and the Polarizability of Particles Having a Wide Range of Shapes.
National Institute of Standards and Technology, Gaithersburg, MD
Advances in Chemical Physics, Vol. XCI, 85-153, 1995.

viscosity; particles; shapes; composite materials; solid mixtures; equations

The intrinsic viscosity and the electric and magnetic polarizabilities of objects having general shape are required in the calculation of some of the most basic properties of solid-solid composites and fluid-solid mixtures. Specifically, the leading order virial coefficients of diverse properties (viscosity, refractive index, dielectric constant, magnetic permeability, thermal and electrical conductivity, and others) can often be expressed in terms of these functionals of object shape. These virial coefficients also provide basic input into effective medium theories describing higher concentration mixtures. The electric and magnetic polarizability tensors have independentinterest in applications involvingthe scattering of electromagnetic and pressure waves from objects of general shape. We present an argument that the ratio of intrinsic viscosity and electric polarizabilities (the average electric polarizability tensor trace) is an invariant to a good approximation. Many analytical and numerical finite element results for a variety of shapes are presented to support the conjectured relation. Our approximate relation between intrinsic viscosity and electric polarizabilities complements the exact relation between the hydrodynamic virtual mass W and the magnetic polarizability tensors.

E

Emmerich, S. J.

Emmerich, S. J.; Persily, A. K.
Effectiveness of a Heat Recovery Ventilator, an Outdoor Air Intake Damper and an Electrostatic Particulate Filter at Controlling Indoor Air Quality in Residential Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
Implementing the Results of Ventilation Research. AIVC Conference, 16th. Proceedings. September 19-22, 1995, Palm Springs, CA, 263-275 pp, 1995.

residential buildings; effectiveness; heat recovery; dampers; filters; air quality; air pollution

A preliminary study of the potential for using central forced-air heating and cooling system modifications to control indoor air quality (IAQ) in residential buildings was performed. The main objective was to provide insight into the potential of three IAQ control options to mitigate residential IAQ problems, the pollutant sources the controls are most likely to impact, and the potential limitations of the controls. Another important objective was to identify key issues related to the use of multizone models to study residential IAQ and to identify areas for follow-up work. The multizone airflow and pollutant transport program CONTAM93 was used to simulate pollutant concentrations due to a variety of sources in eight houses with typical HVAC systems under different weather conditions. The simulations were repeated after modifying the systems with three IAQ control technologies - an electrostatic particulate filter, a heat recovery ventilator (HRV), and an outdoor air intake damper (OAID) on the forced-air system return. Although the system modifications reduced pollutant concentrations in the houses for some cases, the HRV and OAID increased pollutant concentrations in certain situations involving a combination of weak indoor sources, high outdoor concentrations, and indoor pollutant removal mechanisms. Also, limited system run-time during mild weather was identified as a limitation of IAQ controls that operate in conjunction with forced-air systems. Recommendations for future research include: simulation of other buildings, pollutants, and IAQ control technoligies; model validation; sensitivity analysis; and development of a database of important model inputs.

Emmerich, S. J.; Persily, A. K.
Indoor Air Quality Impacts of Residential HVAC Systems. Phase II.A Report: Baseline and Preliminary Simulations.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5559; 77 p. January 1995.
Available from National Technical Information Service
PB95-178893

air flow modeling; building technology; heating; ventilation; air conditioning; computer simulation; filtration; heat recovery ventilator; indoor air quality; infiltration; residential buildings; ventilation

NIST has completed Phase II.A of a project to study the impact of HVAC systems on residential indoor air quality and to assess the potential for using residential forced-air systems to control indoor pollutant levels. In this effort, NIST is performing whole building airflow and contaminant dispersal computer simulations with the program CONTAM93 to assess the ability of modifications of central forced-air heating and cooling systems to control pollutant sources relevant to the residential environment. This report summarizes the results of Phase II.A of this project, which consisted of three major efforts: baseline simulations of contaminant levels without indoor air quality (IAQ) controls, design of the IAQ control retrofits, and preliminary simulations of contaminant levels with the IAQ control retrofits. In Phase II.B of the study, all of the baseline cases will be modified to incorporate the IAQ control retrofits. The retrofit results will then be compared to the baseline results to evaluate the effectiveness of the retrofits. The pollutant concentrations in a building depend on many factors including the configuration of the building zones, the air leakage of the building envelope and of interior partitions, wind pressure profile on the building envelope, pollutant source strengths and temporal profiles, heating and cooling system airflow rates, furnace filter efficiency, characteristics of reversible pollutant sinks in the building, individual pollutant decay or deposition rates, and ambient weather and pollutant concentratons. This report describes the input data used to model the baseline houses with CONTAM93 and presents the resultsof the baseline simulations in the form of the transient pollutant concentrations for selected simulations and a summary of peak and average concentrations for all baseline simulations. Three indoor air quality control technologies were then selected for incorporation into the baseline house models to determine their effectiveness in controlling the modeled pollutant sources. The technologies include the following: electrostatic particulate filtration, heat recovery ventilation, and an outdoor air intake damper on the forced-air system return. Selected baseline cases were then modified to implement these indoor air quality control retrofits, and preliminary simulations were performed to demonstrate the ability of the program to model the control techniques.

Emmerich, S. J.; Persily, A. K.
Indoor Air Quality Impacts of Residential HVAC Systems. Phase II.B Report: IAQ Control Retrofit Simulations and Analysis.
NISTIR 5712; 89 p. September 1995.
Available from National Technical Information Service
PB96-106877

indoor air quality; heating; ventilation; air conditioning; air change rates; airflow modeling; building technology; computer simulation; filtration; heat recovery ventilation; infiltration; modeling; outdoor air; residential buildings

The National Institute of Standards and Technology (NIST) performed a preliminary study of the potential for using central forced-air heating and cooling system modifications to control indoor air quality (IAQ) in residential buildings. The objective of this effort was to provide insight into the use of state-of-the-art IAQ models to evaluate such modifications, the potential of these modifications to mitigate residential IAQ problems, the pollutant sources they are most likely to impact, and their potential limitations. This study was not intended to determine definitively whether the IAQ control options studied are reliable and cost-effective. This report summarizes the results of Phase II.B of this project, which consisted of three main efforts: computer simulations of contaminant levels with IAQ control retrofits, evaluation of the effectiveness of the IAQ control retrofits, and development of recommendations for future research. In Phase II.A of the project, NIST used the multizone airflow and pollutant transport program CONTAM93 to simulate the pollutant concentrations due to a variety of sources in eight buildings with typical HVAC systems under different weather conditions. In Phase II.B, the simulations were repeated after modifying the HVAC systems with three IAQ control technologies -- an electrostatic particulate filter, a heat recovery ventilator, and an outdoor air intake damper on the forced-air system return. The impact of these IAQ control technologies on indoor pollutant levels was evaluated by comparing average and peak pollutant concentrations for the modified cases to the concentrations determined for the baseline cases. Simulation results indicate that the system modifications reduced pollutant concentrations in the houses for some cases. However, the heat recovery ventilator and outdoor air intake damper increased pollutant concentrations in certain situations involving a combination of weak indoor sources, high outdoor concentrations, and indoor pollutant removal mechanisms. In cases where the IAQ controls reduced pollutant concentrations, they led to larger relative reductions in the tight houses than in the houses with typical levels of airtightness, though the typical houses still had lower post-control concentrations. The controls had the largest impact on concentrations of non-decaying pollutant from a constant source. Limited system run-time under mild weather conditions was identified as a limitation of IAQ controls that operate in conjunction with forced-air systems. Another important objective of the project was to identify issues related to the use of multizone IAQ models and to identify areas for follow-up work. Recommendations for future research include: additional simulations for other buildings, pollutants, and IAQ control technologies; model validation; model sensitivity analysis; and development of a database of model inputs.

Emmerich, S. J.; Persily, A. K.
Multizone Modeling of Three Residential Indoor Air Quality Control Options.
National Institute of Standards and Technology, Gaithersburg, MD
IBPSA. Building Simulation '95. 4th International Conference. Proceedings. 1995, 213-220 pp, 1995.

air quality; zone models; residential buildings; heating; ventilation; air conditioning; methodology; air pollution

The impact of central forced-air heating and cooling system modifications on the levels of selected pollutants in single-family houses was evaluated by simulating pollutant concentrations due to a variety of sources in eight houses with typical HVAC systems. Simulations were performed with a multizone airflow and pollutant transport model and were repeated with the systems modified to include an electrostatic particulate filter, a heat recovery ventilator, and an outdoor air intake damper. The system modifications reduced the pollutant levels in the houses for some cases; however, the results also demonstrated potential limitations in both the simulation method and the performance of the devices.

Emmerich, S. J.; Persily, A. K.; VanBronkhorst, D. A.
Workplan to Analyze the Energy Impacts of Envelope Airtightness in Office Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5758; 31 p. December 1995.
Available from National Technical Information Service
PB96-154463

office buildings; airflow modeling; building energy simulation; building technology; commercial buildings; computer simulation; heating; ventilation; air conditioning; infiltration

U.S. office buildings consume approximately 1.2 EJ (1.1 Quadrillion BTUs or Quads) of energy, 0.72 EJ (0.68 Quads) of which is associated with space heating, cooling, and ventilation. These estimates, and other analyses of energy consumption in office buildings, are based on building energy analysis programs such as DOE-2. These analyses have been helpful in identifying opportunities for energy efficiency, developing building energy efficiency standards and predicting future energy consumption levels. Although these programs contain sophisticated models of heat transfer and HVAC system performance in buildings, they are acknowledged to have shortcomings in accounting for the energy associated with building airflows, particularly infiltration of outdoor air through leaks in the building envelope. These airflows, and their dependence on weather and ventilation system operation, are more complex than the models used in these programs. The simple models of infiltration, ventilation and interzone airflows that are used in these programs do not enable the analysis of the energy consumption associated with building airflow or the impact of options that may reduce this energy consumption, such as increased envelop airtightness or better control of ventilation system airflow rates. This report describes the impact of building airflows on energy consumption in multi-zone buildings and the analysis approaches that can be used to account for the energy associated with these airflows. Plans to link a multi-zone network airflow analysis program with a building energy analysis program are discussed. An initial estimate of the energy associated with infiltration in U.S. office buildings, based on a simplified analysis approach, is presented. This estimate reveals that infiltration in U.S. office buildings accounts for 0.074 EJ (0.07 Quads) of space heating energy use, which is 18% of the total heating energy use, and 0.0025 EJ (0.0024 Quads) for cooling, which is 2% of the total.

Evans, D. D.

Evans, D. D.
Ceiling Jet Flows.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Handbook of Fire Protection Engineering. 2nd Edition. Section 2. Chapter 4, National Fire Protection Assoc., Quincy, MA, DiNenno, P. J.; Beyler, C. L.; Custer, R. L. P.; Walton, W. D., Editors, 2/32-39 pp, 1995.

fire protection; fire protection engineering; ceiling jets; fire growth; high temperature gases

Much of the hardware associated with detection and suppression of fires in commercial, manufacturing, storage, and recently constructed residential buildings is located near the ceiling surfaces. In the event of a fire, hot gases in the fire plume rise directly above the burning fuel and impinge on the ceiling. The ceiling surface causes the flow to turn and move horizontally under the ceiling to other areas of the building remote from the fire position. The response of smoke detectors, heat detectors, and sprinklers installed below the ceiling so as to be submerged in this hot flow of combustion products from a fire provides the basis for the building fire protection. Studies quantifying the flow of hot gases under a ceiling resulting from the impingement of a fire plume have been conducted since the 1950s. Early studies at the Fire Research Station in Great Britain, and more recently at Factory Mutual Research Corporation, the National Institute of Standards and Technology (NIST), and at other research laboratories, have sought to quantify the gas temperatures and velocities in the hottest portion of the flow produced by steady fires beneath smooth, unconfined horizontal ceilings.

Everest, D. A.

Everest, D. A.; Shaddix, C. R.; Smyth, K. C.
Quantitative Two-Photon LIF Imaging of CO in Flickering CH4/Air Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Proceedings. Fall Technical Meeting, 1995. October 16-18, 1995, Worcester, MA, 71-74 pp, 1995.

combustion; carbon monoxide; diffusion flames; flickering flames; fluorescence; methane; polycyclic aromatic hydrocarbons; soot

Most detailed studies of chemical processes in diffusion flames have been carried out under steady flame conditions, which provide an experimentally reproducible environment for making careful profile measurements. In contrast, flickering diffusion flames exhibit a much wider range of time-dependent, vortex-flamesheet interactions, and thus they serve as an important testing ground for assessing the applicability of chemical models derived from steady flames to complex, turbulent flows. Two examples of particular interest are the production and oxidation of soot and CO. Both involve sufficiently slow chemical rates that one might expect to observe a strong sensitivity to the complex flowfields present in time-varying flames.

F

Fahy, R. F.

Fahy, R. F.
EXIT89: An Evacuation Model for High-Rise Buildings - Recent Enhancements and Example Applications.
National Fire Protection Association, Quincy, MA
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 332-337 pp, 1995.

fire research; high rise buildings; evacuation; time lag; handicapped

The origin and basic features of EXIT89 have been described in previous papers. This paper will concentrate on a brief discussion of the framework of the model, a description of recent enhancements made to the model and will present example applications of the model that illustrate some of its features. EXIT89 was designed to model the evacuation of a large building with the capability of tracking each occupant individually. The output of this model, in combination with a fire and smoke movement model using the same building layout, can be used to predict the effects of cumulative exposure to the toxic environment present in a structure fire.

Fahy, R. F.
Study of Occupant Behavior During the World Trade Center Evacuation: Preliminary Report of Results.
National Fire Protection Association, Quincy, MA
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September

10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 197-202 pp, 1995.

fire research; human factors engineering; evacuation; human behavior; smoke movement; fire alarm systems; bombs (ordnance); explosions; people movement

On February 26, 1993, shortly after noon, a bomb exploded in a subterranean garage below the World Trade Center plaza in New York City. The exploions and subsequent fire caused extensive structural damage on several basement levels, interferred with the operation of the fire protection and other emergency systems and resulted in the evacuation of over 100,000 occupants of the complex. The National Fire Protection Association (NFPA) and the National Research Council of Canada (NRC) undertook a research project, funded by the National Institute of Standards and Technology, the General Services Administration, NFPA and NRC, to study the human behavior of building occupants in this incident and to document, to the extent possible, those engineering details such as building design, fire safety features, and smoke spread, that effected behavior. The purpose of this project was to collect and preserve human behavior data. The information gathered will aid in the understanding of what people do in fires and why and how those actions may conform to or differ from the assumptions used in designing and planning for life safety in such a large building. Results will help in work toward the improvement of fire safety in similar occupancies and to enhance the knowledge needed in the development of emergency evacuation models.

Fang, J. B.

Fang, J. B.; Persily, A. K.
Airflow and Radon Transport in Four Large Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 101, No. 1, 1995.

airflow; building technology; contaminant dispersal; indoor air quality; mechanical ventilation; modeling; multi-family residential; multi-zone; office buildings; radon; ventilation

Computer simulations of multizone airflow and contaminant transport were performed in four large buildings using the program CONTAM88. This paper describes the physical characteristics of the buildings and their idealizations as multizone building airflow systems. These buildings include a twelve-story multifamily residential building, a five-story mechanically ventilated office building with an atrium, a seven-story mechanically ventilated office building with an underground parking garage, and a one-story school building. The air change rates and interzonal airflows of these buildings are predicted for a range of wind speeds, indoor-outdoor temperature differences, and percentages of outdoor air intake in the supply air. Simulations of radon transport were also performed in the buildings to investigate the effects of indoor-outdoor temperature difference and wind speed on indoor radon concentrations.

Fang, J. B.; Persily, A. K.
Computer Simulations of Airflow and Radon Transport in Four Large Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5611; 46 p. April 1995.
Available from National Technical Information Service
PB95-220422

airflow; building technology; contaminant dispersal; indoor air quality; mechanical ventilation; modeling; multi-family residential; multi-zone; office buildings; radon; ventilation

Computer simulations of airflow and radon transport in four large buildings were performed using the multi-zone airflow and pollutant transport model CONTAM88. These buildings include a 40 twelve-story multi-family residential building, a five-story mechanically-ventilated office building with an atrium, a seven-story mechanically-ventilated office building with an underground parking garage, and a one-story mechanically-ventilated school building. Interzone airflow rates and radon concentrations are predicted in these buildings as a function of wind speed and direction, indoor-outdoor

temperature difference, and ventilation system operation. Ventilation system factors that are studied include the operation of exhaust fans in the apartment building and variations in the percent outdoor air intake in the office buildings. Simulations in the office buildings are also made with the ventilation systems off and with variations in the balance of the supply and return airflow rates.

Fanney, A. H.

Fanney, A. H.
Field Monitoring of a Variable-Speed Integrated Heat Pump/Water-Heating Appliance.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 101, No. 2, 1-15, 1995.

heat pump; integrated water heating; field study; building technology; coefficient of performance; combined performance factor; HSPF; peak demand; SEER; thermal performance; variable speed; electrical power

A variable-speed integrated heat pump/water heating appliance was monitored for two years while meeting the space-conditioning and water-heating needs of an occupied residence. Experimental results are presented that show the total energy consumed by the residence was significantly reduced compared to previous years in which electric baseboard heat, a wood stove, and window air conditioners were used. During the two space-heating seasons, the variable-speed integrated heat pump/water heating appliance used 60% less energy than would have been consumed by an electric furnace with the same air distrubition system and a storage-type electric water heater. The monthly space-cooling-only coefficients of performance (COP) ranged from 2.50 to 4.03, whereas the monthly space-heating-only coefficients of performance ranged from a low of 0.91 to a high of 3.33. A proposed index to quantify the overall system performance of integrated water-heating/space-conditioning appliances, referred to as the combined performance factor, ranged from 1.55 to 3.50. The majority of larger values occurred during months in which space cooling dominated. The combined performance factor for the entire two-year study was 2.45. A conventional watt hour meter supplied by the local electrical utility and an electronic digital power analyzer were used to measure the energy consumption of the variable-speed heat pump to discern if variable-speed equipment introduces errors in conventional utility metering equipment. Measurements made using the two instruments were in excellent agreement. The monthly energy consumption and peak electrical demands of the residence, integrated heat pump/water-heating appliance, supplemental space heater, and water heater are discussed. The influence of outdoor temperature on electrical power demand is presented.

Fanney, A. H.; Whitter, K. M.; Cohn, T. B.
Second International Green Building Conference and Exposition, 1995.
National Institute of Standards and Technology, Gaithersburg, MD
Green Building Council, Bethesda, MD
NIST SP 888; 160 p. August 1995.
Available from National Technical Information Service
PB95-253605
Available from Government Printing Office
and U.S. Green Building Council (USGBC) and the National Institute of Standards and Technology. Green Building Conference and Exposition, 2nd International. Proceedings. August 13-15, 1995, Big Sky, MO, Fanney, A. H.; Whitter, K. M.; Cohn, T.B., Editors, 1-155 pp, 1995.

building technology; buildings; economic; environmental benefits

This report constitutes the proceedings of the Green Building Conference held in Big Sky, Montana, August 13-15, 1995. The conference was sponsored by the U.S. Green Building Council (USGBC) and the National Institute of Standards and Technology (NIST), co-sponsored by the American Institute of Architects, American Society of Interior Designers, American Society of Landscape Architects, Construction Specifications Institute and Illuminating Engineering Society of North America

and hosted by Montana State University. The conference focused on the design, construction, operation, maintenance, and demolition of buildings in an environmental and cost-efficient manner.

Farias, T. L.

Farias, T. L.; Carvalho, M. G.; Koylu, U. O.; Faeth, G. M.
Computational Evaluation of Approximate Rayleigh-Debye-Gas/Fractal-Aggregate Theory for the Absorption and Scattering Properties of Soot.
Instituto Superior Tecnico, Lisbon, Portugal
Michigan Univ., Ann Arbor
Journal of Heat Transfer, Vol. 117, No. 1, 152-159, February 1995.

soot; scattering coefficient; optical properties; aggregates; refractive index; evaluation; soot aggregates

A computational evaluation of an approximate theory for the optical properties of soot is described, emphasizing the small-angle (Guinier) regime. The approximate theory (denoted RDG-FA theory) is based on the Rayleigh-Debye-Gans scattering approximation while treating soot as mass-fractal aggregates of spherical primary particles that have constant diameters and refractive indices. The approximate theory was evaluated by more exact predictions from the solution of the volume integral equation formulation of the governing equations, using the method of moments, and based on the ICP algorithm of Iskander et al. (1989). Numerical simulations were used to construct statistically significant populations of soot aggregates having appropriate fractal properties and prescribed numbers of primary particles per aggregate. Optical properties considered included absorption, differential scattering, and total scattering cross sections for conditions typical of soot within flame environments at wavelengths in the visible and the infrared. Specific ranges of aggregate properties were as follows: primary particle optical size parameters up to 0.4, numbers of primary particles per aggregate up to 512, mean fractal dimensions of 1.75, mean fractal prefactors of 8.0, and refractive indices typical of soot. Over the range of the evaluation, ICP and RDG-FA predictions generally agreed within numerical uncertainties (ca. 10 percent) within the Guinier regime, complementing similar performance of RDG-FA theory in the power-law regime based on recent experiments. Thus, the use of approximate RDG-FA theory to estimate the optical properties of soot appears to be acceptable - particulary in view of the significant uncertainties about soot optical properties due to current uncertainties about soot refractive indices.

Fenves, S. J.

Fenves, S. J.; Garrett, J. H., Jr.; Kiliccote, H.; Law, K. H.; Reed, K. A.
Computer Representations of Design Standards and Building Codes: U.S. Perspective.
Carnegie-Mellon Univ., Pittsburgh, PA
Stanford Research Inst., Menlo Park, CA
National Institute of Standards and Technology, Gaithersburg, MD
International Journal of Construction Information Technology, Vol. 3, No. 1, 13-34, Summer 1995.

standards; building codes

Standards representation and processing in the United States has had a long and interesting history of development. The work in the past has focussed primarily on representing a standard, evaluating the intrinsic properties of that represented standard, and evaluating designs for conformance to that standard. To date, for a variety of reasons, standards writing organizations and computer-aided design software vendors have not adopted much of the results of this research. The failure of the approach so far in the U.S. can be traced to two distinct areas. One major cluster of causes is methodological: the initial concepts were not backed up by usable, persistent computer tools; and the initial application and model were not representative. The second cluster of causes of failure is professional, and has a lot to do with the dynamics of interaction of individuals and organizations. Future research must address the inadequacies of the current representations and create models that are able to represent all, or almost all, of the different types of provisions in any given standard; investigate and deliver a much richer set of processing functionalities, such as more support for use of design standards in earlier phases of design; support the treatment of multiple,

heterogeneous standards available from distributed sources; and determine what type of support is needed to go from the textual versions of design standards to the formal models that can support sophisticated computation.

Ferraris, C. F.

Ferraris, C. F.
Alkali-Silica Reaction and High Performance Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5742; 24 p. August 1995.
Available from National Technical Information Service
PB96-131587

building technology; alkali-silica reaction; high performance concrete; concretes; standard testing

Damage due to alkali-silica reaction (ASR) in concrete is a phenomenon that was first recognized in the U.S. since 1940 and has since been observed in many countries. Despite numerous studies published, the mechanism is not yet clearly understood. Nevertheless, the three major factors in concrete have been identified, i.e., the alkalies contained in the pore solution, reactive amorphous or poorly crystallized silica present in certain aggregates, and water. In this study, we attempted to address the question: is high-performance concrete (HPC) susceptible to ASR? Researchers have not reached an agreement on this matter because factors other than the three major ones (pore solution alkalinity, aggregate morphology and water presence) play a significant role in the occurrence of ASR; these factors include aggregate gradation, w/c and compressive strength. It was found that air content is the most important variable (other than the three majors factors cited above) that increase expansion of concretes affected by ASR. This study indicates that even HPC should be susceptible to ASR if reactive aggregates are used.

Ferraris, C. F.
Testing of Selected Self-Leveling Compounds for Floors.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5633; 33 p. January 1995.
Available from National Technical Information Service
PB95-220455

building technology; bond to concrete; lightweight concretes; mechanical properties; self-leveling compounds; shrinkage; water interaction

During the past year, a severe odor developed in some floors of a large office building. The odor has been attributed to interactions among a self-leveling compound, carpet adhesive, and the carpet. The owner of the building, the General Services Administration (GSA), wanted to ascertain if the odor could be eliminate by removing the existing self-leveling compound and replacing it with a compound of a different composition. The National Institute of Standards and Technology (NIST) was asked to evaluate the properties of selected self-leveling compounds being considered for use in the building. Lightweight concrete was also to be tested for possible use as a substrate for the self-leveling compounds. This report gives the results obtained on the self-leveling compounds alone or in combination with normal weight concrete or lightweight concrete. It also gives the test results obtained on lightweight concrete alone. An overall ranking of the compounds was not attempted, because the rank would depend on the weight given to each property by the user in each application of the compound. Specifications for some of the properties tested were developed by GSA. It was not the aim of this study to measure or observe any odor generated by the self-leveling compounds alone or in conjunction with the concrete substrate or any other material.

Ford, S. J.

Ford, S. J.; Mason, T. O.; Christensen, B. J.; Coverdale, R. T.; Jennings, H. M.; Garboczi, E. J.
Electrode Configurations and Impedance Spectra of Cement Pastes.
Northwestern Univ., Evanston, IL
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Materials Science, Vol. 30, 1217-1224, 1995.

building technology; electrode configurations

Electrode effects on impedance spectra of cement pastes were investigated by two-, three-, and four point measurements without a potentiostat over the frequency range 0.01 Hz-10 MHz. Electrode immittance effects arising from highly resistive/capacitive contracts cannot be fully corrected by nulling procedures. Two-point measurements are much more susceptible to such effects than three- or four-point measurements. The three- and four-point results on pastes suggest that there is negligible high-frequency "offset" resistance, and that bulk paste arcs are not significantly depressed below the real axis in Nyquist plots. The important impedance-derived equivalent circuit parameters are bulk resistance and capacitance; offset resistance and arc depression angle may not be physically meaningful parameters. Whereas all electrode configurations give reliable values of bulk paste resistance, only the three-point configuration provides the total paste/electrode dual arc spectrum involving a single electrode. Multielectrode (three- or four-point) measurements may be necessary to establish the true bulk paste dielectric constant.

Forney, G. P.

Forney, G. P.; McGrattan, K. B.
Computing the Effect of Sprinkler Sprays on Fire Induced Gas Flow.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 59-64 pp, 1995.

fire research; sprinkler response; gas flow; curtain walls; fire simulation; fluid flow; smoke detection

Over the last twenty years there has been much debate concerning the interaction of sprinklers and draft curtains in large storage facilities. At issue is whether or not the two fire protection systems are mutually beneficial. It has been suggested that in the event of a fire the draft curtains inhibit the spread of hot gases near the ceiling, delaying the activation of sprinklers needed to suppress the fire. There has been a call for large scale tests to quantify this scenario. In support of such test being planned at NIST, an effort underway to numerically simulate the interaction of sprinklers and draft curtains in the presence of a fire in a large enclosure, such as a warehouse. For this project, the intent is not to necessarily simulate in detail the two phase interaction of droplets and air from a single sprinkler, nor to predict the suppression of the fire itself, but rather to study the effect of dozens of sprinklers on a fire-driven flow field in enclosures up to 60 meters on a side and 10 meters high. The sprinkler spray serves to cool the upper layer hot gases by both mechanical mixing with cooler gases below and absorption of heat by the droplets. Approximations to the governing Navier-Stokes equations make calculations with over one million cells possible with run times on the order of 24 hours.

Frey, M.

Frey, M.; Simiu, E.
Noise-Induced Transitions to Chaos.
Bucknell Univ., Lewisburg, PA
National Institute of Standards and Technology, Gaithersburg, MD

Santa Fe Institute. Spatio-Temporal Patterns in Nonequilibrium Complex Systems. NATO Advanced Research Workshop. Proceedings. Volume 21. SFI Studies in the Sciences of Complexity. Addison-Wesley Publishing Co., Cladis, P. E.; Palffy-Muhoray, P., Editors, 529-544 pp, 1995.

noise (sound); chaos

Multistable systems can exhibit irregular (i.e., neither periodic nor quasiperiodic) motion with jumps. Such motion is referred to as basin-hopping or stochastic chaos when induced by noise, and deterministic chaos in the absence of noise. Deterministic and stochastic chaos have hitherto been viewed as distinct and have been analyzed from different, indeed contrasting, points of view.

Frey, M.; Simiu, E.
Phase Space Flux Ratio as a Measure of Relative Stability.
Bucknell Univ., Lewisburg, PA
National Institute of Standards and Technology, Gaithersburg, MD
Computation of Stochastic Mechanics, 2nd International Conference. Proceedings. June 13-15, 1994, Athens, Greece, Balkema, Rotterdam, Spanos, P. D., Editor, 113-120 pp, 1995.

building technology; chaos; phase space flux; relative stability

A new measure of the relative stability of potential wells is proposed based on phase space transport. This measure is described for continuous one-dimensional bistable dynamical systems and contrasted with a measure of relative stability based on the stationary distribution of system state in phase space. The advantages and limitations of the proposed approach to relative stability are discussed and a "blowtorch" theorem is presented.

Frohnsdorff, G. J. C.

Frohnsdorff, G. J. C.; Clifton, J. R.; Garboczi, E. J.; Bentz, D. P.
Virtual Cement and Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
Portland Cement Association (PCA). Emerging Technologies Symposium on Cement in the 21st Century. Proceedings. March 15, 1995, 1995.

cements; concretes; databases; expert systems; integrated knowledge systems; simulation models; standards; sustainable technology; virtual technology; education; training

In the past, progress in cement and concrete science and technology has come mostly by deduction from the results of empirical investigations. As the body of knowledge about cement and concrete grows and becomes computerized, so does the possibility of relying more on induction to solve technological problems. In this speculative paper, it is suggested that we can look forward to the not-far-distant day when the performance of cements in concrete will be able to be predicted from knowledge of measured properties of the cement and other constituents, the mixture proportions, and the expected conditions of mixing, curing, and use. It will then be possible to conceive of a cement that has not yet been made -- a "virtual cement" -- and predict the performance of a "virtual concrete" made with it. The resulting ability to investigate the effects of possible changes in the composition and particle size and shape distribution of a cement quickly and cost-effectively will have broad impacts. It should facilitate product development.

Fuss, S. P.

Fuss, S. P.; Ezekoye, O. A.; Hall, M. J.
Effect of Temperature on the Infrared Radiation Properties of Methane.
University of Texas, Austin
Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 371-376 pp, 1995.

combustion; methane; temperature effects; infrared radiation; ft-ir; spectral absorptivity; gas temperature; absorptivity

In large scale fires, radiation feedback from the flame to the fuel surface can be an important factor determining the rate of fuel volatilization and the rate of flame spread. The radiant flux can be significantly attenuated by core gases that have absorption features in the infrared. Computer simulations that model flame spread require gas absorption data to accurately predict the radiation feedback.

G

Gann, R. G.

Gann, R. G.
Executive Summary.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; 789 p. November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1 and Volume 2, Gann, R. G., Editor, iii-vi pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; halon 1301; halon alternatives

Halon 1301 (CF3Br), one of the chemicals identified as detrimental to stratospheric ozone, had become the choice for suppressing in-flight fires in nearly all types of aircraft. Production of new halon 1301 was stopped on January 1, 1994, and efforts are underway to identify near-term replacements for critical applications, focussing on available or currently emerging chemicals and technologies. In particular, the three military services and the Federal Aviation Administration (FAA) have pooled resources to provide solutions for two applications: engine nacelles and dry (avionics) bays, while realizing that there are other aircraft areas also in need of protection. This project was managed at Wright Patterson Air Force Base (WPAFB), with oversight provided by a Technology Transition Team of four sponsors. The first major objective of the program was to identify the optimal available alternative fluid(s) for use in suppressing fires in aircraft engine nacelles and dry (avionics) bays. In October, 1993, based on extensive laboratory research and real-scale testing at WPAFB, the sponsors decided on a reduced list of candidates for each application; for engine nacelles: C2HF5 (HFC-125), C3HF7 (HFC-227ea), and CF3I; for dry bays: C2HF5, C3F8 (FC-218), and CF3I. Much of the laboratory-scale research leading to that decision has been described in NIST Special Publication 861, "Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays". That report documents the comprehensive experimental program to screen the performance

of possible suppressant chemicals as a means to identify the best candidates for subsequent full-scale aircraft fire extinguishemnt evaluation at Wright Laboratory, and addresses the compatibility of these agents with flight systems, people, and the environment. In particular, apparatus and measurement methods suited to aircraft applications are carefully described, and extensive performance data are provided and analyzed. The reader is referred to that report as a prerequisite and companion to the current document.

Gann, R. G.
Fire Suppression System Performance of Alternative Agents in
Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; 789 p. November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1, Gann, R. G., Editor, 1-782 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; halon 1301; halon alternatives

In a remarkably short period of time, the world has identified, responded to, and ameliorated a new threat to the global climate (WMO, 1995). Following a mechanism first proposed by Rowland and Molina in 1974, chemically stable chlorine-, bromine-, and iodine-containing molecules rise to the stratosphere and are quantitatively photodissociated by ultraviolet radiation. The halogen atoms then catalytically convert ozone (O3) molecules, whose chemistry shields the earth's surface from excess ultraviolet radiation, into oxygen (O2) molecules, which have no such filtration effect. The evidence supporting this hypothesis soon became substantial, and the international political community produced a landmark agreement in 1987, the "Montreal Protocol on Substances That Deplete the Ozone Layer". Subsequent international amendments to this and, domestically, the U.S. Clean Air Act of 1990 have led to restrictions on both production and use of identified ozone-depleting substances (ODSs).

Gann, R. G.
Fire Suppression System Performance of Alternative Agents in
Aircraft Engine and Dry Bay Laboratory Simulations. Volume 2.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 2; 636 p. November 1995.
Available from Government Printing Office
SN003-003-03372-3
Available from National Technical Information Service
PB96-117783
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 2, Gann, R. G., Editor, 1-636 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; halon 1301; halon alternatives; metal fires

Gann, R. G.
Science of Fire Calorimetry.
National Institute of Standards and Technology, Gaithersburg, MD
DOT/FAA/CT-95/46; AAR-423;
National Institute of Standards and Technology. Fire Calorimetry. Proceedings. July 27-28, 1995, Gaithersburg, MD, Hirschler, M. M.; Lyon, R. E., Editors, p. 10 pp, 1995.

calorimetry

There are several reasons for wanting to quantify the "strength" of a fire, including: describing (or prescribing) the acceptable performance of a potentially flammable component, such as a chair, wall material, or clothing item; knowing the magnitude of the threat that needs to be controlled by containment or suppression measures; and calculating the growth rate of fire hazard in order to predict the time available for people to escape. At the core of each of these is numerical presentation of two of the key flammability properties: heat or enthalpy release and its time derivative or rate. This paper reviews the history of fire calorimetric measurements and the successive chemical and physical principles upon which those measurements have been based. Parallels will be drawn to the quantification of other parameters, such as length and time.

Garboczi, E. J.

Garboczi, E. J.
Microstructure and Transport Properties of Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
RILEM. Performance Criteria for Concrete Durability. Proceedings. State of the Art Report prepared by RILEM Technical Committee TC 116-PCD, Performance of Concrete as a Criterion of Its Durability. RILEM Report 12. Chapter 8. 1995, E & FN SPON, London,England, Kropp, J.; Hilsdorf, H. K., Editors, 198-212 pp, 1995.

concretes; transport properties; cements; mortar

Concrete is a composite material whose microstructure is random over a wide range of length scales. At the largest length scale, concrete can be considered to be a mortar-rock composite, where the randomness in the structure is on the order of centimeters, the size of a typical coarse aggregate. Mortar itself can be considered to be a cement paste-sand composite, with random structure on the order of millimeters. Cement paste can also be considered to be a random composite material, made up of unreacted cement, CSH, CH, capillary pores, and other chemical phases. The randomness in the cement paste microstructure is on the order of micrometers. Finally, CSH is itself a complex material, with random structure, as seen by neutron scattering, on the order of nanometers. This range of random structure, from nanometers (CSH) to centimeters (concrete) covers seven orders of magnitude in size! It is a large and difficult task to try to relate microstructure and properties theoretically for concrete. However, there are some simple, basic ideas that do provide a framework for this task, with the main difficulty being carrying these ideas through to specific application. This chapter attempts to outline the general principles that must be considered in trying to understand icrostructure transport property relaitonships in concrete, or indeed any other random porous material. Specific applications to cement paste, mortar, and concrete will be considered. An earlier review, which mentions some of the ideas discussed in this chapter is also a helpful reference for some of the earlier transport property data and their interpretation in terms of pore structure.

Garboczi, E. J.; Bentz, D. P.
Microstructure Property Relationships in Concrete: From Nanometers to Centimeters.
National Institute of Standards and Technology, Gaithersburg, MD
Second (2nd) Canmet/ACI. Advances in Concrete Technology. International Symposium. Supplementary Papers. 1995, Las Vegas, NV, Malhotra, V. M., Editor, 573-585 pp, 1995.

building technology; concretes; computer models; percolation; microstructure; cement paste; mortar; multi-scale; diffusivity; electrical conductivity

Theroetical understanding of how the properties and performance of cement-based materials relate to microstructure is complicated by the large range of relevant size scales. Processes occurring in the nanometer-sized gel pores ultimately affect the performance of these materials at the structural level of meters and larger. One approach to alleviating this complication is the development of a suite of models, consisting of individual digital-image-based structural models for the calcium silicate hydrate gel at the nanometer level, the hydrated cement paste at the micrometer level, and a mortar or concrete at the millimeter to meter level. Computations performed at one level provide input properties to be used in simulations of performance at the next higher level. This methodology is demonstated for the property of ionic diffusivity in saturated concrete. In addition, the ideas of percolation theory are shown to unify microstructure and many physical phenomena at various length scales in concrete.

Garboczi, E. J.; Day, A. R.
Algorithm for Computing the Effective Linear Elastic Properties of Heterogeneous Materials: Three-Dimensional Results for Composites With Equal Phase Poisson Ratios.
National Institute of Standards and Technology, Gaithersburg, MD
Marquette Univ., Milwaukee, WI
Journal of the Mechanics and Physics of Solids, Vol. 43, No. 9, 1349-1362, 1995.
building technology; algorithms; composite materials; digital image; elasticity; finite element; poisson ratio

An algorithm based on finite elements applied to digital images is described for computing the linear elastic properties of heterogeneous materials. As an example of the algorithm, and for their own intrinsic interest, the effective Poisson's ratios of two-phase random isotropic composites are investigated numerically and via effective medium theory, in two and three dimensions. For the specific case where both phases have the same Poisson's ratio ($v1 = v2$), it is found that there exists a critical value v^*, such that when $v1 = v2 > v^*$, the composite Poisson's ratio v always decreases and is bounded below by v^* when the two phases are mixed. If $v1 = v2 < v^*$, the value of v always increases and is bound above by v^* when the two phases are mixed. In d dimensions, the value of v^* is predicted to be $1/(2d-1)$ using effective medium theory and scaling arguments. Numerical results are presented in two and three dimensions that support this picture, which is believed to be largely independent of microstructural details.

Garboczi, E. J.; Schwartz, L. M.; Bentz, D. P.
Modeling the Influence of the Interfacial Zone on the DC Electrical Condustivity of Mortar.
National Institute of Standards and Technology, Gaithersburg, MD
Advanced Cement Based Materials, Vol. 2, 169-181, 1995.
aggregates; building technology; concretes; electrical conductivity; interfacial zone; model; percolation; permeability

The interfacial zone separating cement paste and aggregate in mortar and concrete is believed to influence many of the properties of these composites. The available experimental evidence, obtained on artificial geometries, indicates that the DC electrical conductivity of the interfacial zone, because of its higher porosity, may be considerably larger than that of the bulk cement paste matrix. This paper presents the theoretical framework for quantitatively understanding the influence of the interfacial zone on the overall electrical conductivity of mortar, based on realistic random aggregate geometries. This understanding is also used, via an electrical analogy with Darcy's law, to make predictions about the effect of the interfacial zone on fluid permeability. The results obtained for mortar should also pertain to concrete.

Garboczi, E. J.; Schwartz, L. M.; Bentz, D. P.
Modelling the D.C. Electrical Conductivity of Mortar.
National Institute of Standards and Technology, Gaithersburg, MD
Schlumberger-Doll Research, Ridgefield, CT

Materials Research Society. Microstructure of Cement-Based Systems/Bonding and Interfaces in Cementitious Materials. Materials Research Society Symposium Proceedings Volume 370. November 28-December 1, 1994, Boston, MA, Materials Research Society, Pittsburgh, PA, Diamond, S.; Mindess, S.; Glasser, F. P.; Roberts, L. W., Editors, 429-436 pp, 1995.

building technology; mortar; electrical resistivity

The interfacial zone separating cement paste and aggregate in ortar and concrete is believed to influence many of the properties of these composites. This paper presents a theoretical framework for quantitatively understanding the influence of the interfacial zone on the overall electrical conductivity of mortar, based on realistic random aggregate geometries. These same ideas may also be used to approximately predict the fluid permeability of mortar.

Garboczi, E. J.; Snyder, K. A.; Douglas, J. F.; Thorpe, M. F.
Geometrical Percolation Threshold of Overlapping Ellipsoids.
National Institute of Standards and Technology, Gaithersburg, MD
Michigan State Univ., East Lansing, MI
Physical Review E, Vol. 52, No. 1, 819-828, July 1995.

building technology

A recurrent problem in materials science is the prediction of the percolation threshold of suspensions and composites containing complex-shaped constituents. We consider an idealized material built up from freely overlapping objects randomly placed in a matrix, and numerically compute the geometrical percolation threshold pc where the objects first form a continuous phase. Ellipsoids of revolution, ranging from the extreme oblate limit of platelike particles to the extreme prolate limit of needlelike particles, are used to study the influence of object shape on the value of pc. The reciprocal threshold 1/pc (pc equals the critical volume fraction occupied by the overlapping elliposids) is found to scale linearly with the ratio of the larger ellipsoid dimension to the smaller dimension in both the needle and plate limits. Ratios of the estimates of pc are taken with other important functionals of object shape (surface area, mean radius of curvature, radius of gyration, electrostatic capacity, excluded volume, and intrinsic conductivity) in an attempt to obtain a universal description of pc. Unfortunately, none of the possibilities considered proves to be invariant over the entire shape range, so that pc appears to be a rather unique functional of object shape. It is conjectured, based on the numerical evidence, that 1/pc is minimal for a sphere of all objects having a finite volume.

Gilman, J. W.

Gilman, J. W.; VanderHart, D. L.; Kashiwagi, T.
Thermal Decomposition Chemistry of Poly(vinyl alcohol).
National Institute of Standards and Technology, Gaithersburg, MD
Chapter 11; ACS Symposium Series 599; American Chemical Society. Fire and Polymers II: Materials and Tests for Hazard Prevention. National Meeting, 208th. ACS Symposium Series 599. August 21-26, 1994, Washington, DC, American Chemical Society, Washington, DC, Nelson, G. L., Editor, 161-185 pp, 1995.

fire retardants; flame retardants; thermal decomposition; char formation; additives; flammability; pyrolysis; morphology; residues; gasification; thermogravimetric analysis; polyvinyl acetate; calorimetry

The fundamental condensed phase processes which lead to char formation during the fire-like pyrolysis of poly(vinyl alcohol), PVA, and PVA-containing maleimides were characterized using CPM/AS 13C NMR. In addition to evidence of the well known chain-stripping elimination of H2O and the chain-scission reactions, which occur during the pyrolysis of pure PVA, evidence is presented in support of cyclization and radical reaction pathways responsible for the conversion of unsaturated carbons into aliphatic carbons. Two general mechanisms; one described as a physical encapsulation, and the other a lowering

of the average volatility of certain degradation products, are proposed for the primary modes of action of maleimides on the pyrolysis of PVA.

Gmurczyk, G. W.

Gmurczyk, G. W.; Grosshandler, W. L.
Suppression of High Speed Flames and Quasi-Detonations.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; Section 2; November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1. Section 2., Gann, R. G., Editor, 9-75 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; detonation; effectiveness; deflagration; experiments; combustion; ethane; propane; fuel/air mixtures; halon 1301; halon alternatives

A dry bay is a normally confined space adjacent to a fuel tank in which a combustible mixture and an ignition source could co-exist following penetration by an anti-aircraft projectile. They vary considerably in volume, typically being in the range of 0.2 to 3.0 m3. They are located in the wings and fuselage, and their shape is most often irregular. Aspect ratios up to 10:1 are not uncommon. The bays may or may not be ventilated, and are usually cluttered with electronic, hydraulic and mechanical components. Compared to the events leading to engine nacelle fire suppression, the required timing is two orders-of-magnitude faster for dry bay protection. The previous study using a deflagration/detonation tube was concerned with establishing a comprehensive experimental program to screen the performance of over a dozen agents. The experiments were designed to cover the range of conditions that might occur in a dry bay. Although actual measurements of fuel concentrations in a dry bay during live-fire testing have never been made, one could envision a worst-case situation in which the fuel is vaporized and partially premixed with the air just prior to ignition, producing a rapidly moving turbulent flame. If the suppressing agent were not well mixed and the dry bay geometry were conductive, the turbulent flame could accelerate, generating a shock wave ahead of it and transitioning to a detonation before encountering the agent. Ethene was chosen as the fuel in the previous study because it was known to detonate easier than many other hydrocarbons. This provided the most severe test for all the agents under conditions that were not duplicated in any of the other bench-scale studies. The specific objectives of the current research project are the following: (a) To determine the effectiveness of HFC-125, relative to FC-218, in suppressing high speed turbulent propane/air flames using the detonation/deflagration tube apparatus; (b) To determine the conditions in the detonation/deflagration tube (equivalence ratio, tube geomtery) which lead to excessive pressure build-up during suppression by HFC-125 of propane/air mixtures initially at room temperature and pressure; (c) To determine the effectiveness of CF3I, relative to FC-218, in suppressing high speed turbulent propane/air flames using the detonation/deflagration tube apparatus; (d) To recommend a ranking of the three agents for full-scale dry bay applications based upon the current and previous suppression experiments.

Gmurczyk, G. W.; Grosshandler, W. L.
Suppression of High Speed Turbulent Flames in a Detonation/Deflagration Tube.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5642; 55 p. January 1995.
Available from National Technical Information Service
PB95-231817

turbulent flames; detonation; deflagration; halon 1301; extinguishment;

aircraft fires; combustion

Live-fire, full-scale testing has been conducted at Wright-Patterson Air Force Base to identify an agent to replace CF3Br (halon 1301) for suppressing fires in military aircraft dry bays. The three chemicals being considered (C2HF5, HFC-125, C3F8, FC-218, and CF3I, halon 13001) had been evaluated in a previous laboratory study, in which unique properties of each chemical were identified in small-scale experiments. The CF3I required the least mass to suppress a turbulent spray flame but performed less-well in suppressing a quasi-detonation. FC-218 performed the best in the presence of a quasi-detonation. HFC-125 was recommended previously as a candidate because of its superior dispersion characteristics; however, this chemical produced large over-pressures in the detonation/deflagration tube. The high pressures motivated the current study to determine the initial conditions which would lead to dangerous conditions, and to explore less extreme situations more representative of a realistic threat. The detonation/deflagration tube was lengthened from 7.5 to 10 m, the spiral insert in the test section was removed, and the fuel was switched from ethene to propane to produce uninhibited pressure ratios below 9:1 and turbulent flame speeds between 300 and 600 m/s. The FC-218 provided the most consistent performance in this new series of experiments which examined lean, stoichiometric and rich initial conditions. The CF3I had the greatest positive impact at low concentrations, but exhibited non-monotonic behavior of flame speed and shock pressure ratio at increasing concentrations. Large pressure build ups were not observed during suppression of the propane/air mixtures under the current set of conditions. None of the agents could be ruled out for dry bay applications based upon the results of this study.

Gottuk, D. T.

Gottuk, D. T.; Roby, R. J.; Beyler, C. L.
Role of Temperature on Carbon Monoxide Production in Compartment Fires.
Hughes Associates, Inc., Columbia, MD
Fire Safety Journal, Vol. 24, 315-331, 1995.
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Work-in-Progress Poster Session Presentations. Work-in-Poster Session 4. Paper 17. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 303 pp, 1994.

combustion; compartment fires; temperature; carbon monoxide

Gross, J. L.

Gross, J. L.; Heckert, N. A.; Lechner, J. A.; Simiu, E.
Study of Optimal Extreme Wind Estimation Procedures.
National Institute of Standards and Technology, Gaithersburg MD
Indian Society for Wind Engineering. Sponsored by University of Roorkee, New Delhi. International Association for Wind Engineering. State of the Art in Wind Engineering. Volume 1. Proceedings. International Conference on Wind Engineering, 9th. Davenport Sixtieth Birth Anniversary Volume. January 9-13, 1995, New Delhi, India, Wiley Eastern Limited, New Delhi, India, 69-80 pp, 1995.

wind velocity; building technology; estimation procedures; extreme value theory; extreme value theory; monte carlo simulation; wind engineering

We describe work aimed at improving procedures for the estimation of non-tornadic extreme wind speeds, regardless of their direction, in regions not subjected to hurricanes. Using the Generalized Pareto Distribution (GPD) approach and the Conditional Mean Exceedance (CME) estimation method, we analyze 115 17-year to 52-year sets of largest annual speeds and sets drawn from 48 15-year to 26-year records of maximum daily wind speeds. Based on this analysis we attempt an assessment of the widely held belief that the Gumbel distribution with site-dependent location and scale parameters is a universal model of extreme wind speeds. Some of our results suggest that the reverse Weibull distribution is a more appropriate model. This would result in more reasonable estimates of wind-induced failure probabilities and wind load factors than the corresponding

estimates based on the Gumbel distribution. However, our assessment is so far only tentative owing to uncertainties inherent in our results. Future work based on lower thresholds (larger data samples) and alternative estimation methods is planned.

Gross, J. L.; Simiu, E.; Heckert, N. A.; Lechner, J. A.
Extreme Wind Estimates by the Conditional Mean Exceedance Procedure.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5531; 16 p. April 1995.
Available from National Technical Information Service
PB95-220471

building technology; wind velocity; beams; columns; concretes; connections; cyclic loading; joint; precast; post-tensioning; story drift

We describe work aimed at improving procedures for the estimation of non-tornadic extreme wind speeds, regardless of their direction, in regions not subjected to hurricanes. Using the Generalized Pareto Distribution (GPD) approach and the Conditional Mean Exceedance (CME) estimation method, we analyze 115 17-year to 52-year sets of largest annual speeds and sets drawn from 48 15-year to 26-year records of maximum daily wind speeds. Based on this analysis we attempt an assessment of the widely held belief that the Gumbel distribution with site-dependent location and scale parameters is a universal model of extreme wind speeds. Some of our results suggest that the reverse Weibull distribution is a more appropriate model. This would result in more reasonable estimates of wind-induced failure probabilities and wind load factors than the corresponding estimates based on the Gumbel distribution. However, our assessment is so far only tentative owing to uncertainties inherent in our results. Future work based on lower thresholds (larger data samples) and alternative estimation methods is planned.

Grosshandler, W. L.

Grosshandler, W. L.
In Search of Alternative Fire Suppressants.
National Institute of Standards and Technology, Gaithersburg, MD
Thermal Science and Engineering Symposium in Honor of Chancellor Chang-Lin Tien. November 1995, Berkeley, CA, 275-282 pp, 1995.

halon 1301; extinguishment; aircraft fires; fire protection; fire suppression; thermodynamic properties

The common fire fighting agent halon 1301 (CF3Br) is among a number of halogenated chemicals that are sufficiently deleterious to stratospheric ozone that their continued production and use has been severely curtailed. Halons had been the agents of choice for numerous fire protection applications because of their inherent ability to inhibit flames at low concentrations with no residue while exhibiting a number of additional strongly positive attributes. The elimination of new production of halon has forced the fire suppression systems manufacturers, the transportation and communications industries, and other large users of these products to search for suitable alternatives. If the alternative chemicals are less efficient suppressants, then new, larger agent storage and delivery components need to be designed. To avoid costly mistakes in choosing replacements for aircraft applications, research has been conducted to determine the performance of different agents in extinguishing aircraft-type fires. This paper describes the major elements of the overall program and the rationale of how an alternative to halon 1301 was chosen for aircraft applications.

Grosshandler, W. L.
Proceedings of the 1995 Workshop on Fire Detector Research.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5700; 43 p. June 1995.
Available from National Technical Information Service
PB95-270062

fire detection systems; fire detectors; certification; test fires; smoke detection; gas detectors; halon alternatives

A workshop was convened February 6 and 7, 1995, to identify the needs of users and specifiers of fire detection systems which are not currently being met by the U.S. fire protection industry; to highlight future needs which may result from new developments in the construction, transportation, and manufacturing sectors, or from regulatory changes; to identify generic, technological barriers which may limit the U.S. fire protection industry from fully meeting the users' needs; and to develop a research agenda and recommend priorties to enable U.S. industry to overcome these technological barriers. A series of experts from industry, government, certifying organizations and academia were invited to review the various applications for fire detection systems and to discuss recent developments that could impact the future of the industry. The speakers were divided into focused panels of users and specifiers, systems and components manufacturers, regulators and certifiers, and researchers. Small working groups were convened after the panel discussions to identify critical research issues, concentrating on sensors, signal processing, systems integration and regulations. The ultimate goals of a comprehensive and integrated research program were identified and include a lower ratio of false-positive-to-actual-fire indications, pre-fire warning for protection of high value operations, more fool-proof installation and maintenance methods, component compatibility for system upgrade, a wider range of fires detectable, reliable detection of noxious fire precursors, faster and more precise response of fire detection systems customized to particular processes, earlier warning in connection with halon-alternative suppression systems, situation monitoring following automatic suppression, means to evaluate system trade-offs with the advent of performance-based standards, combination gas sensors for fire/environmental monitoring, and the capability for partial integration of fire detection with other building control functions. Technological barriers which might inhibit attainment of these goals and a research plan to enable the barriers to be breached are discussed.

Grosshandler, W. L.
Review of Measurements and Candidate Signatures for Early Fire Detection.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5555; 36 p. January 1995.
Available from National Technical Information Service
PB95-189452

fire detection; fire detectors; fire gases; fire plumes; fire research; fire tests; smoke detectors; test fires

The physical and chemical transformations associated with a burgeoning fire are discussed and the results of past experimental measurements of these transformations are summarized. Standard test methods for the current generation of fire detectors and recent developments in detection technologies for which existing standards may not be suitable are described. The literature has been reviewed to determine the extent to which fires have been characterized in their early phase (<100 kW). In particular, measurements of CO, CO2, H2O, H2, O2, smoke and temperature have been examined. Ond finds dramatic variations in the measured magnitude and rate of growth of CO concentration in a vareity of standard fires. The variation is also large between repeat runs of the same tests. When scaled by estimated mass consumed of fuel, the different standard fires group a bit more systematically. Additional measurements of species, temperature and velocity just above the flame are suggested to get a more complete footprint of each fire type. Similar measurements of non-fire nuisance sources are required in order to discriminate between a fire and non-threatening situation with a high degree of certainty. The concept of a universal fire emulator/detector evaluator (FE/DE) is introduced. The objective is to have a facility that will eliminate the unavoidable run-to-run variations associated with full-scale tests, and to allow more well controlled environments. Computational fluid dynamics could then be used to insert the fire source into the space being protected to guide detector placement and to predict system performance, as well as to compare alternative systems and new concepts on a level, realistic playing field.

Grosshandler, W. L.
Towards the Development of a Universal Fire Emulator/Detector Evaluator.
National Institute of Standards and Technology, Gaithersburg, MD
University of Duisburg. International Conference on Automatic Fire Detection "AUBE '95", 10th. April 4-6, 1995, Duisburg, Germany, Luck, H., Editor, 368-380 pp, 1995.

fire detection; heat release rate; large scale fire tests; fluid dynamics; standards; fire tests

Past measurements are examined of CO, CO2, H2O, H2, O2, smoke and temperature produced in standard fires of the UL and EN type. Additional measurements just above the heat release zone are suggested to get a more complete footprint of each standard fire, and the concept of a universal fire emulator/detector evaluator (FE/DE) is introduced. The objective of the emulator is to produce more well controlled environments that eliminate the unavoidable run-to-run variations associated with full-scale tests. Numerical fluid dynamic computations are recommended to insert the fire source into the space being protected as a guide for detector placement and to predict system performance under realistic conditions.

Grosshandler, W. L.; Gmurczyk, G. W.
Interaction of HFC-125, FC-218 and CF3I With High Speed Combustion Waves.
National Institute of Standards and Technology, Gaithersburg, MD
Science Applications International Corp., Gaithersburg, MD
Alliance for Responsible Atmospheric Policy; U.S. Environmental Protection Agency; Environment Canada; United Nations Environment Programme; U.S. Department of Agriculture. Stratospheric Ozone Protection for the 90's. 1995 International CFC and Halon Alternatives Conference and Exhibition. Proceedings. October 21-23, 1995, Washington, DC, 635-643 pp, 1995.

combustion waves; halon alternatives; fire suppression; detonation; aircraft fires; military aircraft

Live-fire, full-scale testing has been conducted at Wright-Patterson Air Force Base to identify an agent to replace CF3Br (halon 1301) for suppressing fires in military aircraft dry bays. The three chemicals being considered (HFC-125, FC-218 and CF3I) had been evaluated in a previous laboratory study, in which unique properties of each chemical were identified in small-scale experiments. The CF3I required the least mass to suppress a turbulent spray flame but performed less well in suppressing a quasi-detonation. FC-218 performed the best in the presence of a quasi-detonation. HFC-125 was recommended previously as a candidate because of its superior dispersion characteristics; however, this chemical produced large over-pressures in the deflagration/detonation tube. The high pressures motivated the current study to determine the initial conditions which would lead to dangerous situations, and to explore a less extreme regime more representative of a realistic threat. The deflagration/detonation tube was lengthened from 7.5 to 10 m, the spiral insert in the test section was removed, and the fuel was switched from ethene to propane to produce uninhibited pressure ratios below 9:1 and turbulent flame speeds between 300 and 600 m/s. Based upon over a hundred experiments with the modified facilty, it was possible to reconfirm the conclusion that FC-218 provides the most consistent performance over the widest range of fuel/air mixtures and tube geometries. The CF3I has the greatest positive impact at low partial pressure fractions, but exhibits non-monotonic behavior of flame speed and shock pressure ratio at increasing concentrations. The dangerously high over-pressures previously exhibited by HFC-125 were not observed during suppression under more moderate (and realistic) combustion conditions. Considering these results alone, all three agents remain viable candidates for dry-bay applications.

Grosshandler, W. L.; Presser, C.; Gmurczyk, G. W.
Effectiveness of Halon Alternatives in Suppressing Dynamic Combustion Processes.
National Institute of Standards and Technology, Gaithersburg, MD
Science Applications Interactional Corp., Gaithersburg, MD

American Chemical Society. Halon Replacements - Technology and Science. National Meeting, 208th. Proceedings. ACS Symposium Series 611. Chapter 18. August 21-25, 1994, Washington, DC, American Chemical Society, Washington, DC, Miziolek, A. W.; Tsang, W., Editors, 204-224 pp, 1995.

halon 1301; fire suppression; detonation; aircraft fires; halon alternatives; combustion

C3F8 is shown to require the least storage volume among twelve fluorocarbons for suppressing a quasi-detonation. CF3I performs the best of the gaseous suppressants evaluated in a spray burner. Two experimental facilities are described as part of an effort to identify suitable replacements for CF3Br in aircraft applications. A turbulent spray burner simulates the hazard associated with a ruptured fuel line in an engine nacelle or dry bay. A deflagration/detonation tube evaluates the ability of a gaseous agent to attenuate the pressure build-up and Mach number of a quasi-detonation.

Grosshandler, W. L.; Presser, C.; Lowe, D. L.; Rinkinen, W. J.
Assessing Halon Alternatives for Aircraft Engine Nacelle Fire Suppression.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Heat Transfer, Vol. 117, 489-494, May 1995.

halons; halon alternatives; halon 1301; aircraft engines; nacelle fires; fire suppression; methodology; nitrogen; jet engines; thermodynamic properties

A coaxial turbulent spray burner was built to evaluate the relative effectiveness of different chemicals for suppressing fires in a jet engine nacelle. The fire suppressant of current choice, halon 1301 (CF3Br), must be replaced because of its detrimental effect on the ozone layer. The alternatives being considered lack the chemical activity of CF3Br, so that the ability of the agents to mix into the flame convectively and to absorb heat is critical to their success. An agent delivery system was designed to inject the desired amount of material into the air upstream of a fuel nozzle and to control the agent injection rate through variation of the storage pressure and the duration of time that a solenoid valve remains open. The influence of air velocity, fuel flow, and injection period on the amount of nitrogen required to extinguish a jet fuel spray flame is discussed. The effectiveness of eleven different fluorocarbons, hydrofluorocarbons, and hydrochlorofluorocarbons is compared to that of halon 1301. The alternatives required 1.7 to 2.3 times the amount (on a mass basis) of CF3Br to extinguish the spray flame, with HCFC-22 being the most efficient and FC-31-10 the least.

H

Halamickova, P.

Halamickova, P.; Detwiler, R. J.; Bentz, D. P.; Garboczi, E. J.
Water Permeability and Chloride Ion Diffusion in Portland Cement Mortars: Relationship to Sand Content and Critical Pore Diameter.
University of Toronto, Ontario, Canada
National Institute of Standards and Technology, Gaithersburg, MD
Cement and Concrete Research, Vol. 25, No. 4, 790-802, 1995.

cements; chloride ion; diffusion; interfacial zone; mercury intrusion porosimetry; mortar; percolation; permeability; transport

The pore structure of hydrated cement in mortar and concrete is quite different from that of neat cement paste. The porous transition zones formed at the aggregate-paste interfaces affect the pore size distribution. The effect of the sand content on the development of pore structure, the permeability to water and the diffusivity of chloride ions was studied on portland cement mortars. Mortars of two water-to-cement ratios and three sand volume fractions were cast together with pastes and tested at degrees of hydration ranging from 45 to 70%. An electrically-accelerated concentration cell test was used to determine the

coefficient of chloride ion diffusion while a high pressure permeability cell was employed to assess liquid permeability. The coefficient of chloride ion diffusion varied linearly with the critical pore radius as determined by mercury intrusion porosimetry while permeability was found to follow a power-law relationship vs. this critical radius. The data set provides an opportunity to directly examine the application of the Katz-Thompson relationship to cement-based materials.

Hamins, A.

Hamins, A.
Aspects of Flame Suppression.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5766; November 1995.
Available from National Technical Information Service
PB96-131479
National Institute of Standards and Technology. Solid Propellant Gas Generators: Proceedings of the 1995 Workshop. June 28-29, 1995, Gaithersburg, MD, 123-146 pp, 1995.

fire suppression; nacelle fires; solid propellants; flame stability; pool fires; baffles

Give guidance on the performance of fire suppression systems in engine nacelles.

Hamins, A.; Borthwick, P.; Presser, C.
Suppression of Ignition Over a Heated Metal Surface.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 77-81 pp, 1995.

fire research; halogenated compounds; ignition; ignition suppression; ignition temperature

The objective of this work is to investigate the effectiveness of various agents in suppressing flame ignition. Experiments were conducted to determine the amount of agent needed to suppress the ignition of a gaseious propane flow over a heated metal disk. The disk was 14 mm in diameter and was a wound ribbon composed primarily of nickel. The metal surface was heated by a regulated power supply which provided up to 200 W. An optical pyrometer was used to measure the surface temperature of the heated disk. With power applied to the metal disk, a fairly uniform temperature (+30 deg C) was measured in an annular section of the disk. A coflowing mixture of air and gaseious fire suppressant flowed through a 78 mm tube about the fuel flow. With the fuel and oxidizer flowing, flame ignition occurred in a repeatable fashion by increasing the power through the metal disk. Various amounts of agent were added to the air flow and the temperature of the heated metal disk was measured at flame ignition using an optical pyrometer. The effectiveness of N2, HFC-125, HFC-227 and CF3I were compared in suppressing the ignition event.

Hamins, A.; Cleary, T. G.
Suppression Criteria in Engine Nacelle Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Alliance for Responsible Atmospheric Policy; U.S. Environmental Protection Agency; Environment Canada; United Nations Environment Programme; U.S. Department of Agriculture. Stratospheric Ozone Protection for the 90's. 1995 International CFC and Halon Alternatives Conference and Exhibition. Proceedings. October 21-23, 1995, Washington, DC, 664-673 pp, 1995.

nacelle fires; fire suppression; aircraft safety; blowout velocity; flame extinguishment; flammability limits; halogenated compounds; ignition; pool fires; sprays

A series of experimental measurements were conducted and simple models were developed in an effort to provide an improved understanding of the influence of various parameters on the processes controlling flame stability in engine nacelle applications. The model was constructed to predict the quantity of agent required to suppress a generic engine nacelle fire. The model was based on suppression experiments from a bench-scale turbulent jet spray burner and a pool burner, and on agent fluid mixing calculations. The experiments indicate that fire hazard is dependent on a large number of parameters including the air velocity, nacelle temperature, fuel type, and system pressure in the nacelle. The geometry of the fire configuration is critical in defining the ease of fire suppression. The model illustrates the importance of injection duration, air flow, nacelle free volume, fluid mixing, and fire scenario on the minimum agent suppression requirements.

Hamins, A.; Cleary, T. G.; Borthwick, P.; Gorchkov, N.; McGrattan, K. B.; Forney, G. P.; Grosshandler, W. L.; Presser, C.; Melton, L.
Suppression of Engine Nacelle Fires.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 2; Section 9; November 1995.
Available from Government Printing Office
SN003-003-03372-3
Available from National Technical Information Service
PB96-117783
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 2, Gann, R. G., Editor, 1-199 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; halon 1301; halon alternatives; aircraft safety; blowout velocity; flame extinguishment; flammability limits; halogenated compounds; ignition; pool fires; sprays; wind tunnels

A series of experimental measurements were conducted and simple models were developed in an effort to provide an improved understanding of the influence of various parameters on the processes controlling flame stability in engine nacelle applications. The knowledge gained is compiled into usable tools which may assist suppression system designers determine the mass and rate of agent injection required for engine nacelle fire suppression. The Section is broken into several subsections. In Section 9.2, a description of the range of parameters which characterize engine nacelles is provided. The historical development of current halon 1301 fire protection systems is described. In Section 9.3, the results of four distinct experiments are discussed. First, the suppression effectiveness of candidate replacement agents (CF3I, C2HF5, and C3HF7) are tested on a turbulent jet spray flame. Second, suppression of a baffle stabilized pool fire is described. Third, measurements on the impact of the replacement agents on the ignition temperature of fuel/air/agent mixtures is discussed. Finally, measurements determining the flammability limits of propane/air/C2HF5 mixtures are discussed. The importance of agent entrainment into the recirculation/combustion zone of obstacle stabilized flames is emphasized. In Section 9.4, computational modeling of gaseous agent injection into a mock engine nacelle is described. The calculations are compared to measurements conducted in a wind tunnel. In Section 9.5, a simple algebraic model is developed which gives guidance on agent concentration requirements for flame suppression in generic nacelle configurations. Key findings and recommendations are compiled in Section 9.6. References are listed in Section 9.8.

Harris, R. H., Jr.

Harris, R. H., Jr.
Agent Stability Under Storage.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; Section 7; November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1. Section 7, Gann, R. G., Editor, 249-406 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; storage stability; ft-ir; copper; degradation; halon 1301; halon alternatives

Significant losses in fire suppression effectiveness and increases in toxicity are possible if a fire extinguishing agent degrades during multi-year storage. Halon 1301 is known to be stable in metal containers for many years, and any trace degradation products do not affect its fire suppression effectiveness. For candidate replacement agents, comparable data are needed, reflecting the storage conditions of elevated temperature and pressure. The storage environment fosters conditions which may have an adverse effect on the stability of halon replacements. Stored chemicals may engage in oxidation-reduction reactions, hydrolysis, and other corrosive interactions with metal cylinders. They are also subject to unimolecular decomposition and attack by reactive impurities in the agent. Water and oxygen, for example, will sorb to surfaces of cylinders and transfer lines and can never be completely excluded. These sources of instability, along with the possibility of catalytic interactions with the cylinder walls, can promote the evolution of undersirable products and a concomitant loss of fire suppression effectiveness. Toxicity and corrosiveness are particularly important concerns with respect to halogenated compounds, due to the tendency to librate hydrogen halide in the process of degradation. This report gives the details of the test procedure and a comparison of agent absorbance band areas from low concentration spectra. Also, presented are a comparison of absorbance bands in high density spectra for impurities present in the agents or produced as a result of degradation. These data provide a quantification of any degradation of the agents during long-term storage.

Hopkins, D., Jr.

Hopkins, D., Jr.
Predicting the Ignition Time and Burning Rate of Thermoplastics in the Cone Calorimeter. January 1995-June 1995.
Maryland Univ., College Park
NIST-GCR-95-677; 191 p. September 1995.
Available from National Technical Information Service
PB96-154794

cone calorimeters; heat flux; nylon 6 (trademark); polyethylenes; polypropylene; thermoplastics; wood

Ignition and burning rate data are developed for Nylon 6/6, Polyethylene, and Polypropylene in a Cone Calorimeter heating assembly. The objective is to examine a testing protocol that leads to the prediction of ignition and burning rate for thermoplastics from Cone data. The flame heat flux is not measured, but is inferred from Cone data. The constancy of the flame heat flux for thermoplastics in the Cone calorimeter is due to the geometry of the flame. The burning rate model is shown to yield good accuracy in comparison to measured transient values. Ignition and burning rate data are developed for Redwood and Red Oak in a Cone Calorimeter heating assembly. Measurements of the flame plus external heat flux are presented. The data is intended to be used for future work to develop a testing protocol and burning rate model for charring materials.

J

Jason, N. H.

Jason, N. H.
Information Resources for the Fire Community.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 469-474 pp, 1995.

fire research; information retrieval; fire protection engineering; databases

As information technology expands, information has become more readily available but the sources of this information have become more diverse. Within the field of fire research and engineering, it has become more challenging to find critical information because traditional sources of information have been augmented by a variety of electronic sources. While looking for specific information used to be a question of brute force, i.e., check the library card catalog, with the explosion in computer communication, information retrieval has become an art form. Where does one look for information? While there are no "best" resources, the fire scientist or engineer must develop a familiarity with a wide range of old and new methods for acquiring information as well as staying abreast of latest developments. Success in the new world order of information science will go to the well informed user. An overview of print and electronic resources are described in this paper that can provide a starting point for any information request.

Jason, N. H.
NIST Building and Fire Research Laboratory Publications, 1994.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-7; 130 p. May 1995.
Available from Government Printing Office
SN003-003-03335-9
Available from National Technical Information Service
PB95-226684

fire research; building technology; fire extinguishing agents; refrigerants; earthquakes; fire detection; fire models; building construction; cements; robotics; oil spills; urban fires

Building and Fire Research Publications, 1994 contains references to the publications prepared by the members of the Building and Fire Research Laboratory (BFRL) staff, by other National Institute of Standards and Technology (NIST) personnel for BFRL, or by external laboratories under contract or grant from the BFRL during the calendar year 1994. NIST Report series are available for purchase from either the Government Printing Office (GPO) or the National Technical Information Service (NTIS). GPO documents, e.g., the NIST Technical Note series, are obtained by writing directly to the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325. They also may be contacted by telephone; the Order Desk telephone number is 202/783-3238. NTIS documents, e.g., the NISTIR series, are obtained by writing directly to the National Technical Information Service, Springfield, VA 22161. They also may be contacted by telephone; the Order Desk telephone number is 800/553-6847or (703)487-4650.

Johnsson, E. L.

Johnsson, E. L.
Study of Technology for Detecting Pre-Ignition Conditions of Cooking-Related Fires Associated With Electric and Gas Ranges and Cooktops. Phase 1 Report.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5729; 115 p. October 1995.
Available from National Technical Information Service
PB96-128095

stoves; appliances; fire detection; fire prevention; ignition prevention; kitchen fires; residential buildings; sensors; smoke detectors; smoke measurement

A significant portion of residential fires stem from kitchen cooking fires. Existing fire data indicate that cooking fires primarily are unattended and most often involve oil or grease. The purpose of this investigation was to ascertain the existence of one or more common features or characteristics of the pre-ignition environment that could be used as input to a sensor in a pre-fire detection device. The ultimate goal of this continuing study is to evaluate the feasibility of incorporating such a device into the range that would react to a pre-fire condition and reduce the occurrence of unwanted kitchen fires. The focus of the study was unattended foods placed in pans on burners set to high heat. Experiments were conducted with three different foods and with gas and electric ranges to investigate the pre-ignition enviornment of actual range-top cooking fires. Numerous temperatures in the near surroundings as well as local plume velocity and laser-attenuation measurements were recorded. A Fourier transform infrared spectrometer was used to observe significant species production above the food. Results of these experiments are presented and evaluated. The second part of this study was a literature and patent search of technologies with the capability to act as either the sensor in a pre-fire detection device or as the automatic control that would respond to a detector warning signal by shutting off the gas or electricity supply. A broad range of potential detection technologies was reviewed because the pre-fire signatures had not yet been identified. A bibliography and comments on the applicability of different technologies are included. The conclusions pertaining to the experiments are based on measurements and observations of combinations of specific ranges, pans, foods, and ventilation so extrapolation to other conditions should be performed with caution. The major conclusions of this research are as follows: (1) Strong indicators of impending ignition were temperatures, smoke particulates, and hydrocarbon gases. (2) Promising detection technologies include: tin oxide (SnO2) sensors for hydrocarbon detection, narrow band infrared absorption for hydrocarbon detection, scattering or attenuation types of photoelectric devices for smoke particle detection, thermocouples for thermometry of the burner, pan, range surface (top and below), or range hood. (3) Logical processing of signals from two or more of the detection technologies could be an important means by which false alarms of pre-ignition conditions are elimianted. (4) Control technologies exist that are applicable to the safe shutdown and restart of gas and electric ranges upon detection of approaching ignition.

K

Kaetzel, L. J.

Kaetzel, L. J.; Clifton, J. R.
Expert/Knowledge Based Systems for Materials in the Construction Industry: State-of-the-Art Report.
National Institute of Standards and Technology, Gaithersburg, MD
RILEM Journal of Materials and Structures, Vol. 28, No. 177, 160-174, 1995.

construction; expert systems; building design; industries; knowledge based system; planning; management; repair; rehabilitation; construction industry

Artificial intelligence, a branch of computer sciences, comprises machine vision, natural language, robotics, and expert systems. Many agree that the expert systems area has advanced furtherst and achieved the most success in applying artificial intelligence methods to real-world problems. Two examples of operational systems in use today are Windloader, an advisory system

designed to assist in determining wind loads on structures, and Highway Concrete (HWYCON), designed to assist in the diagnosis of selection of materials for, and repair and rehabilitation of highway concrete structures. Successes in using expert systems technology to develop practical applications for the construction industry are relatively few, compared with advances in computer aided design, real-time control, and data analysis.

Kaetzel, L. J.; McKnight, M. E.
Enhancing Coatings Diagnostics, Selection, and Use Through Computer Based Knowledge Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Steel Structures Painting Council (SSPC). Balancing Economics and Compliance for Maintaining Protective Coatings. SSPC 95 Protective Coatings Blazing New Trails. SSPC 95-09. Proceedings. November 9-16, 1995, Dallas, TX, 287-295 pp, 1995.

coatings; computers; decision making; industries; computer programs; standards

Today, virtually every organization is increasing its emphasis on coatings knowledge. This could result in improved decision-making, competitiveness, and access to world-wide knowledge bases. For wide-scale use, standards and new procedures must be developed for the representation, exchange and use of coatings knowledge. This paper discusses the need for standard formats for knowledge, new technologies, and methods that will have an impact on knowledge based system development. A view of how SSPC can play an important role in this process, a description of some existing applications, and a proposed architecture for a global system is presented.

Kaetzel, L. J.; Struble, L. S.
Highway Concrete (HWYCON) Expert System in the Classroom.
National Institute of Standards and Technology, Gaithersburg, MD
Illinois Univ., Urbana-Champaign
University of Cincinnati. Teaching the Materials Science, Engineering, and Field Aspects of Concrete. 3rd Annual Undergraduate Faculty Enhancement Symposium. Proceedings. July 9-12, 1995, Cincinnati, OH, 7-14 pp, 1995.

highways; concretes; expert systems; material science; teaching tools

Expert Systems have proven to be useful tools to aid the decision-making process for the construction industry. HWYCON, a computer-based decision-support system was developed as part of the Strategic Highway Research Program's "Optimization of Highway Concrete Technology". The system was developed at the National Institute of Standards and Technology and is now being used by highway departments throughout the United States. Included in the HWYCON knowledge base is high-level expert knowledge, visual information (digitized photographs and drawings), and reference information for concrete pavements and structures. HWYCON was designed to address three materials-related activities: 1) distress identification and diagnosis; 2) selection of materials for construction and reconstruction; and 3) guidance on the use of materials and procedures for several repair methods. HWYCON has been used in the classroom in an upper-class/graduate course on durability of construction materials. The students used the HWYCON system to become familiar with materials selection issues. A homework assignment could easily be developed using HWYCON.

Kashiwagi, T.

Kashiwagi, T.
Use of Calorimetry for Fire Materials Research.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology. Fire Calorimetry. Proceedings. July 27-28, 1995, Gaithersburg, MD, Hirschler, M. M.; Lyon, R. E., Editors, 48-49 pp, 1995.

calorimetry; flammability; heat release rate; calorimeters; heat of combustion

Research to improve the fire performance of materials requires tools to measure the flammability properties and validated fire growth models to predict fire behavior of the materials in specific fire scenarios using the measured properties as inputs to the models. One of the key flammability properties is heat release rate during free-burning or radiatively-assisted burning. Since the available amount of a new experimental material is generally quite limited, a small scale calorimeter, using a small amount of a sample, is used in fire research. The current available, small scale calorimeters such as the Cone Calorimeter are capable of measuring not only time-dependent heat release rate but also many other flammability properties. Using such a device, this presentation will describe unique trends of heat release rate, specific heat of combustion, and others flammability properties of polymeric materials as they vary with the nature of the materials.

Kedzierski, M. A.

Kedzierski, M. A.
Calorimetric and Visual Measurements of R123 Pool Boiling on Four Enhanced Surfaces.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5732; 59 p. November 1995.
Available from National Technical Information Service
PB96-128129

building technology; electric resistance heating; enhanced heat transfer; fluid heating; GEWA-K(TM); GEWA-T(TM); high-flux(TM); porous surface; T-fin; trapezoidal-fin; R123; pool boiling; Turbo-BII(TM)

Pool boiling of R123 on four commercial enhanced surfaces was investigated both calorimetrically and visually. The four surfaces were: (1) Turbo-BII(TM) (2) High-Flux(TM) (3) GEWA-K(TM), and (4) GEWA-T(TM). The surfaces were either machined or soldered onto a flat thick oxygen-free high-conductivity copper plate. This permitted 20 sheathed thermocouples to be embedded in the copper for accurate heat transfer measurements. The difference between electric resistance and fluid heating was investigated. The fluid heating condition results in heat fluxes that are as much as 32% greater than those obtained by electric resistance heating. Hysterisis effects near the onset of nucleate boiling were also investigated. The boiling was visually recorded with 16 mm high speed film. Mechanistic descriptions of the boiling activity are given for each surface.

Kedzierski, M. A.
Effect of Inclination on the Performance of a Compact Brazed Plate Condenser and Evaporator.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5767; 31 p. November 1995.
Available from National Technical Information Service
PB96-136973

building technology; brazed plate; compact heat exchanger; evaporator; condenser; gravity

This study experimentally quantified the performance change associated with tilting a compact brazed plate heat exchanger from the intended vertical position. Both clockwise and counterclockwise rotations within a plane perpendicular to the fittings were examined. A SWEP B15x36 was tested as an R-22 evaporator and condenser under fixed refrigerant state conditions suitable to high-efficiency water source heat pumps. This study showed that a substantial performance penalty occurred when the evaporator was rotated past 30 deg from the vertical. The evaporator capacity in the horizontal position was 62 to 74% of the vertical value. For a rotation angle of 30 deg, the degraded performance was within 5% of the vertical value. Rotation direction and entering refrigerant state had little effect on the performance of the evaporator for rotation angles less than 60 deg. Only when the evaporator was rotated to the horizontal position did rotation direction and refrigerant state have much effect. At the horizontal position, a subcooled-entering refrigerant and a counterclockwise rotation both tended to lessen the evaporator capacity degradation. Rotation of the condenser to the horizontal position improved the overall heat transfer coefficient by approximately 25%. Rotation direction had a negligible effect on the performance of the condenser.

Kiliccote, H.

Kiliccote, H.; Garrett, J. H., Jr.; Choi, B.; Reed, K. A.
Distributed Architecture for Standards Processing.
Carnegie-Mellon Univ., Pittsburgh, PA
National Institute of Standards and Technology, Gaithersburg, MD
Computing in Civil and Building Engineering, 6th International Conference. Proceedings. July 12-15, 1995, Berlin, Germany, 1995.

architecture; standards

An approach to providing computer-aided support for using design standards in design systems is presented. The standards processing system we developed is composed of five major components that interact with each other using the Internet: standards processing servers which evaluate a given design to check whether it satisfies the requirements of a specified design standard; the standards processor broker which is used by the designer to identify applicable design standards; the evaluation module which manages the evaluation of a design with respect to applicable design standards; the data server which acts as a front-end between the database of the design system and the standards processing servers; and standards processing clients which display the results of evaluation to the designer and support access to the standards processor broker and standards processing servers. By separating the design system from the standards processing activiites, multiple standards can be dealth with by the design system and the design system is insulated from changes in standards.

Kim, M. S.

Kim, M. S.; Didion, D. A.
Simulation of Isothermal and Adiabatic Leak Processes of Zeotropic Refrigerant Mixtures.
Seoul National Univ., Korea
National Institute of Standards and Technology, Gaithersburg, MD
HVAC&R Research, Vol. 1, No. 1, 3-20, January 1995.

refrigerants; isothermal leak process; adiabatic leak process; heat pump; air conditioners; simulation

Nonflammable zeotropic mixtures of flammable and nonflammable rerigerants are possible alternative refrigerants for use in domestic heat pumps and air conditioners. Refrigerant leakage from such a system is of paramount concern since it is possible that a mixture composition will shift to a flammable range. This paper presents simulations of leak processes of zeotropic refrigerant mixtures. Idealized cases of isothermal and adiabatic leak processes are considered in this study as representations of slow and fast leaks, respectively. Results of simulations are presented for a selected composition of binary and ternary refrigerant mixtures: R-32/134a and R-32/125/134a. Mass fraction changes of the mixtures are presented with respect to the percentage leak of the original charge. In the isothermal leak process, the fraction of the more volatile refrigerant in both vapor and liquid phases decreases for either a vapor or a liquid leak. The mass fraction changes at a low initial temperature are greater than those at a high initial temperature. During the adiabatic leak process, the vapor mass fraction of the more volatile component increases, while the liquid mass fraction of that component decreases for both vapor and liquid leak processes.

Kim, M. S.; Didion, D. A.
Simulation of Leak/Recharge Processes of Refrigerant Mixtures.
Seoul National Univ., Korea
National Institute of Standards and Technology, Gaithersburg, MD
HVAC&R Research, Vol. 1, No. 3, 242-254, July 1995.

refrigerants; leak process; mass fraction; recharge; refrigerant mixtures; zeotrope; flammable refrigerant

As alternatives to ozone-depleting refrigerants, zeotropic and near-azeotropic mixtures of nonflammable and flammable hydrofluorocarbon(HFC) refrigerants are being evaluated for use in most refrigeration/air conditioning machines that do not have flooded evaporators. Refrigerant leakage from these systems is very important because a mixture composition may shift

to a flammable range. After a recharging process, the mixture composition changes, as does the performance of the system. A model simulating isothermal and adiabatic leaks was presented by the authors in the first issue of this journal. This paper presents an isothermal or adiabatic leak simulation with a recharge process which is capable of simulating up to five cycles. Case studies of an isothermal leak of vapor and liquid phases, with a liquid or vapor recharge process were conducted for binary and ternary refrigerant mixtures at the specified overall composition of R-32/134a(30/70% by mass) and R-32/125/134a (23/25/52% by mass). Mass fraction changes in both vapor and liquid phases are presented. A theoretical machinery system performance change after each recharge was evaluated using another NIST simulation model. Changes in capacity and COP are presented.

Klote, J. H.

Klote, J. H.
Design of Smoke Control Systems for Elevator Fire Evacuation Including Wind Effects.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers (ASME). Elevators, Fire and Accessibility, 2nd Symposium. Proceedings. April 19-21, 1995, Am. Soc. of Mechanical Engineers, New York, NY, 59-77 pp, 1995.

elevators (lifts); smoke control; evacuation; wind effects; fire safety; mobility; handicapped; pressure differential; pressure effects; pressurization; temperature

There is a rising concern for the safety of people from fire who cannot travel building emergency exit routes in the same manner or as quickly as expected of able people. One proposed solution for providing safety for persons with mobility limitations is the concept of an emergency elevator evacuation system (EEES). This paper presents information about the design of smoke control systems to prevent smoke infiltration into an EEES. Pressure differences produced when windows break both with and without wind can be significant, and the design of a smoke control system for an EEES needs to address these pressure differences. The paper identifies that wind data specifically for the design of smoke control systems is needed. The pressure fluctuations due to opening and closing building doors during fire situations can also be significant, and the design of a smoke control system for an elevator system needs to address these pressure fluctuations. An example analysis incorporating the pressure effects of broken windows, wind, and open doors illustrates the feasibility of designing smoke control systems for EEESs.

Klote, J. H.
Overview of Smoke Control Research.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions: Symposia, Vol. 101, No. 1, 979-990, 1995.

smoke control; air flow; fire research; fire tests; pressurization; stairwells

In commemoration of the ASHRAE Centennial, this paper is a brief overview of research relating to smoke control. This paper describes many significant smoke control research and related efforts from 1972 to the present. These projects are discussed in this paper with the intent of providing information about smoke control systems and the underlying principles behind them. A secondary goal of the paper is to develop an appreciation of the effort required to advance the technology of these systems. The two main categories of smoke management systems used in buildings are pressurization systems and exhaust systems for atria (and other large spaces). In general, this paper addresses the pressurization systems and related efforts.

Klote, J. H.
Smoke Control.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Handbook of Fire Protection Engineering. 2nd Edition. Section 4. Chapter 12, National Fire Protection Assoc., Quincy, MA, DiNenno, P. J.; Beyler, C. L.; Custer, R. L. P.; Walton, W. D., Editors, 4/230-245 p., 1995.

fire protection; fire protection engineering; smoke control; smoke movement; heating; ventilation; air conditioning; stairwells; elevators (lifts); acceptability; stack effect; buoyancy; expansion; wind effects; air flow; pressurization; piston effect; elevator shafts

In building fire situations, smoke often flows to locations remote from the fire, threatening life and damaging property. Stairwells and elevators frequently become smoke-logged, thereby blocking and/or an inhibiting evacuation. Today smoke is recognized as the major killer in fire situations. In the late 1960s, the idea of using pressurization to prevent smoke infiltration of stairwells started to attract attention. This was followed by the idea of the "pressure sandwich," i.e., venting or exhausting the fire floor and pressurizing the surrounding floors. Frequently, the building's ventilation system is used for this purpose. The term "smoke control" was coined as a name for such systems that use pressurization produced by mechanical fans to limit smoke movement in fire situations. Research in the field of smoke control has been conducted in Australia, Canada, England, France, Japan, the United States, and West Germany. This research has consisted of field tests, full-scale fire tests, and computer simulations. Many buildings have been built with smoke control systems and numerous others have been retrofitted for smoke control. In this chapter the term smoke is defined in accordance with the Americal Society for Testing and Materials (ASTM) and the National Fire Protection Association (NFPA) definitions which state that smoke consists of the airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis of combustion.

Klote, J. H.; Levin, B. M.; Groner, N. E.
Emergency Elevator Evacuation Systems.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers (ASME). Elevators, Fire and Accessibility, 2nd Symposium. Proceedings. April 19-21, 1995, Am. Soc. of Mechanical Engineers, New York, NY, 131-150 pp, 1995.

elevators (lifts); evacuation; emergencies; fire protection; machinery; reliability; compartmentation; dilution; pressurization; water; overheating; electrical power

Throughoutmost of the world, warning signs next to elevators indicate that they should not be used in fire situations. However, the idea of using elevators to speed up fire evacuation and to evacuate people with disabilities has gained considerable attention in recent years. The concept of an emergency elevator evacuation system (EEES) is developed. An EEES includes the elevator equipment, hoistway (elevator shaft), machine room, elevator lobby, as well as, protection from heat, flame, smoke, water, overheating of elevator machine room equipment, and loss of electrical power. While the primary objective of an EEES is fire evacuation of building occupants, these systems are also applicable for fire service mobilization before fire fighting and for non-fire emergency evacuation (due to bomb threats for example). In areas of high seismic activity, attention must be paid to earthquake design. Further, the development of an EEES needs to take into account human behavior so that building occupants will be willing and capable of operating the system in an emergency. The issues of communications, elevator control and out-of-service elevators are addressed. It is concluded that design of an EEES for a small number of people is feasible. An EEES for small numbers of people is much simpler than one for the large numbers of people in a general evacuation. Based on what is learned from an EEES for a small number of people, an application for many people could follow.

Knauss, D. M.

Knauss, D. M.; McGrath, J. E.; Kashiwagi, T.
Copolycarbonates and Poly(arylates) Derived From Hydrolytically Stable Phosphine Oxide Comonomers.
Virginia Polytechnic Institute and State Univ., Blacksburg
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society. Fire and Polymers II: Materials and Tests for Hazard Prevention. National Meeting, 208th. ACS Symposium Series 599. August 21-26, 1994, Washington, DC, American Chemical Society, Washington, DC, Nelson, G. L., Editor, 41-55 pp, 1995.

fire retardants; flame retardants; phosphine oxides; phosphorus compounds; copolymers; monomers

Hydrolytically stable bis(4-hydroxyphenyl)phenyl phosphine oxide was synthesized and utilized to produce high molecular weight polycarbonate and aromatic polyester copolymers. The glass transition temperature increased from about 150 deg C for the control bisphenol-A polycarbonate system to 186 deg C for the 50 wt. percent copolymer. The char yield via dynamic TGA in air increased from 0% for the control to 30% at 700 deg C for the 50% copolymer. The homopolymer had a Tg of 202 deg C, but only low molecular weight was achieved. In contrast, tough, transparent, high Tg polyarylates were prepared with terephthaloyl chloride that had a high char yield in air. Transparency and toughness were maintained in the copolymers, and the char yield in air increased significantly with phosphorus concentration. The materials are being characterized as improved fire resistant transparent systems and initial cone calorimetry studies do show that the heat release rate is significantly decreased. The residual carbon monoxide concentration does increase, which is consistent with the incomplete combustion.

Koylu, U. O.

Koylu, U. O.; Faeth, G. M.
Spectral Extinction Coefficients of Soot Aggregates From Turbulent Diffusion Flames.
Yale Univ., New Haven, CT
University of Michigan, Ann Arbor
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Proceedings. Fall Technical Meeting, 1995. October 16-18, 1995, Worcester, MA, 211-214 pp, 1995.

combustion; soot; aggregates; turbulent flames; diffusion flames; extinction; luminous flames; soot aggregates

Accurate knowledge of the spectral variation of the refractive indices of soot is necessary in order to estimate continuum radiation from luminous flames and to develop in-situ optical techniques for measuring soot properties. However, there are fairly large variations among the soot refractive indices reported in the literature, implying uncertainties about which values should be used in a particular application, see example, Tien and Lee, Chang and Charalampopoulos, and references cited therein for a complete discussion. Moreover, results regarding the effects of fuel type (H/C ratio) on soot refractive indices are also contradictory. Early work of Dalzell and Sarofim, and Lee and Tien suggested that soot refractive indices were relatively insensitive to fuel type. On the other hand, later work of Habib and Vervisch, and Charalampopouloset al indicated significant effects of fuel type on soot refractive indices. However, Sivathanu et al recently reported that their measurements were most consistent with the values reported by Dalzell and Sarofim, while finding only a weak dependence of fuel type on soot refractive indices. In view of these observations, the main objective of the present study was to evaluate the capabilities of the soot refractive indices reported in the literature to treat the spectral extinction properties of soot aggregates, and to investigate the effect of fuel type on refractive indices.

Koylu, U. O.; Gaeth, G. M.; Farias, T. L.; Carvalho, M. G.
Fractal and Projected Structure Properties of Soot Aggregates.
University of Michigan, Ann Arbor
Instituto Superior Tecnico, Lisbon, Portugal
Combustion and Flame, Vol. 100, No. 4, 621-633, March 1995.

soot; aggregates; fractal properties; fractals; fractal properties; simulation; turbulent flames; laminar flames; equations; soot aggregates

The structure of soot aggregates was investigated, emphasizing the fractal properties as well as the relationships between the properties of actual and projected soot images. This information was developed by considering numerically simulated soot aggregates based on cluster-cluster aggregation as well as measured soot aggregates based on thermophoretic sampling and analysis by transmission electron microscopy (TEM) of soot for a variety of fuels (acetylene, propylene, ethylene, and propane) and both laminar and turbulent diffusion flame conditions. It was found that soot aggregate fractal properties are relatively independent of fuel type and flame condition, yielding a fractal dimension of 1.82 and a fractal prefactor of 8.5, with

experimental uncertainities (95% confidence) of 0.08 and 0.5, respectively. Relationships between the actual and projected structure properties of soot, e.g., between the number of primary particles and the projected area and between the radius of gyration of an aggregate and its projected image, also are relatively independent of fuel type and flame condition.

Kunnath, S. K.

Kunnath, S. K.
Enhancements to Program IDARC: Modeling Inelastic Behavior of Welded Connections in Steel Moment-Resisting Frames.
University of Central Florida, Orlando
NIST-GCR-95-673; 73 p. May 1995.
Available from National Technical Information Service
PB95-231601

computer programs; earthquakes flexibility formulations; hysteresis; modeling; steel frames; weld fracture

An existing computer code, IDARC, is enhanced to permit the modeling of steel moment resisting frames (SMRFs) with the potential for weld failures at beam-to-column connections. The steel member model is derived from flexibility formulations in order to allow complex degrading hysteresis behavior to be incorporated. A panel zone element is developed to account for inelastic shear deformations in the beam-to-column connection region. Finally, a new conceptual hysteresis model is developed to represent the force-deformation characteristics at a welded connection, before and after weld failure. The new models were validated using experimental data from available component tests and an existing computer program, DRAIN-2DX. The results of the study indicate that the enhanced program, referred to as IDASS, is capable of adequately reproducing observed behavior of SMRFs and can be used as an effective tool to investigate the effects of weld failure in steel structures under earthquake loading.

Kunnath, S. K.; Gross, J. L.
Inelastic Response of the Cypress Viaduct to the Loma Prieta Earthquake.
University of Central Florida, Orlando
National Institute of Standards and Technology, Gaithersburg, MD
Engineering Structures, Vol. 17, No. 7, 485-493, 1995.

bridges (structures); damage evaluation; dynamic response; highways; elevated highway structures; failure analysis; modeling; reinforced concretes; seismic analysis

The inelastic damage evaluation of a typical double-deck bent of the Cypress Viaduct which collapsed during the 1989 Loma Prieta earthquake is presented. A model of the bent consisting of spread plasticity-based beam-column elements to represent the piers and deck, and shear panel elements to represent the pedestal region was developed. To accurately determine beam and column moment-curvature relationships, separate computer analyses using an element fibre model were conducted. In addition, a smeared-crack approach finite element analysis was employed to determine the lateral load-deformation relationship of the pedestal regions. The model of the Cypress Viaduct was subjected to the Oakland Outer Harbor Wharf ground acceleration record in the plane of the bent. The analytical model was calibrated using static lateral load tests, ambient and forced vibration tests, and observed performance. The results of time-history analyses, which include a prediction of member damage, indicate that collapse was initiated by a shear failure of the pedestal regions.

L

Lattimer, B. Y.

Lattimer, B. Y.; Vandsburger, U.; Roby, R. J.
Effects of a Combustible Ceiling in a Burning Compartment on the Carbon Monoxide Levels in an Adjacent Corridor.
Virginia Polytechnic Institute and State Univ., Blacksburg
Hughes Associates, Inc., Columbia, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 21-26 pp, 1995.

fire research; ceilings; combustibles; compartments; carbon monoxide; corridors; experiments

Exhaust gas inhalation is responsible for approximately two-thirds of the deaths in building fires. Many fatalities in building fires occur in enclosed locations remote from the burning compartment. A major component of the fire exhaust gases which are transported throughout a building is the odorless and colorless gas, carbon monoxide. In 1987, three people died due to carbon monoxide poisoning in the upstairs of a townhouse in Sharon, Pennsylvania. Extremely high levels of carboxyhemoglobin, 91%, were present in one of the victim's bloodstream. This prompted an investigation by NIST/BFRL to simulate the townhouse fire. The source of the fire was in the kitchen of the townhouse where a large amount of wood (wood paneling and cabinets) was located. The CO levels existing the kitchen were found to be as high as 8.5%-dry, while the levels upstairs where the bedrooms were located was 5.0%-dry. Experiments performed by Pitts and his coworkers in a reduced-scale concentrations were 6%-dry or greater in the rear and 12%-dry in the front of the compartment. This was a dramatic increase from the CO concentrations, approximately 4%-dry in the front and 3%-dry in the rear, seen in the non-combustible compartment. The portion of the building fire research ongoing at VPI & SU presented herein involves an investigation of the evolution of exhaust gases from an underventilated liquid hexane pool fire inside a reduced-scale compartment with and without a Douglas fir plywood ceiling. The work focused on the production of carbon monoxide (CO) and unburned hydrocarbons (UHC) inside the compartment and the transport and oxidation of the fire exhaust gases in a corridor adjacent to the burning compartment. The results of the experiments were compared to those reported by Pitts.

Lawson, J. R.

Lawson, J. R.; Braun, E.; DeLauter, L. A.; Roadarmel, G.
Fire Performance of an Interstitial Space Construction System.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5560; 65 p. February 1995.
Available from National Technical Information Service
PB95-188918

interstitial spaces; structural systems; fire endurance; fire research; fire tests; floor systems

An interstitial space building construction assembly, consisting of a walk-on deck suspended from above by structural steel which also supported a functional floor, reproduce a design planned for use in a new hospital complex at Elmendorf Air Force Base, Alaska. This interstitial space assembly was built in the multi-story steel test structure at the National Institute of Standards and Technology. The construction assembly was tested by the same protocol used to evaluate the Veteran's Administration interstitial space construction assembly, tested in 1984. This protocol followed the National Fire Protection Association's, NFPA 251 Fire Tests of Building Construction and Materials Standard, 1990 edition. Fire testing of the interstitial space system was carried out during the summer of 1994. This construction assembly met the requirements for a

2 hour fire endurance rating. The maximum surface temperature on the unexposed functional floor above the interstitial space reached 33 deg C (91 deg F) at the end of the two hour period. The maximum structural steel temperature inside the interstitial space was 123 deg C (253 deg F). The structural assembly was evaluated for a total of 2 hours and 30 minutes before the test was terminated.

Levin, B. C.

Levin, B. C.; Braun, E.; Navarro, M.; Paabo, M.

Further Development of the N-Gas Mathematical Model: An Approach for Predicting the Toxic Potency of Complex Combustion Mixtures.

National Institute of Standards and Technology, Gaithersburg, MD

American Chemical Society. Fire and Polymers II: Materials and Tests for Hazard Prevention. National Meeting, 208th. Chapter 20. ACS Symposium Series No. 599. August 21-26, 1994, Washington, DC, American Chemical Society, Washington, DC, Nelson, G. L., Editor, 293-311 pp, 1995.

mathematical models; smoke; toxicity; toxicology; gas mixtures; methodology; animals; rats; nitrogen dioxide; carbon dioxide; carbon monoxide; oxygen; hydrogen cyanide

A methodology has been developed for predicting smoke toxicity based on the toxicological interactions of complex fire gas 77 mixtures. This methodology consists of burning materials using a bench-scale method that simulates realistic fire conditions, measuring the concentrations of the following primary fire gases - CO, CO2, O2, HCN, HCl, HBr, and NO2 - and predicting the toxicity of the smoke using an empirical mathematical model called the N-Gas Model. The model currently in use is based on toxicological studies of the first six of the above listed primary gases both as individual gases and complex mixtures. The predicted toxic potency (based on this N-Gas Model) is checked with a small number of animal (Fischer 344 male rats) tests to assure that an unanticipated toxic gas was not generated. The results indicate whether the smoke from a material or product is extremely toxic (based on mass consumed at the predicted toxic level) or unusually toxic (based on mass consumed at the predicted toxic level) or unusually toxic (based on the gases deemed responsible). The predictions based on bench-scale laboratory tests have been verified with full-scale room burns of a limited number of materials of widely differing characteristics chosen to challenge the system. The advantages of this approach are: 1. The number of test animals is minimized by predicting the toxic potency from the chemical analysis of the smoke and only using a few animals to check the prediction; 2. Smoke may be produced under conditions that simulate the fire scenario of concern; 3. Fewer tests are needed, thereby reducing the overall cost of the testing; and 4. Information is obtained on both the toxic potency of the smoke and the responsible gases. These results have been used in computations of fire hazard, and this methodology is now part of a draft international standard that is currently being voted on by the member countries of the International Standards Organization (ISO), Technical Committee 92 (TC92). In this chapter, a new 7-Gas Model including NO2 and the data used in its development are presented.

Linteris, G. T.

Linteris, G. T.

Acid Gas Production in Inhibited Propane-Air Diffusion Flames.

National Institute of Standards and Technology, Gaithersburg, MD

American Chemical Society. Halon Replacements - Technology and Science. National Meeting, 208th. Proceedings. ACS Symposium Series 611. Chapter 20. August 21-25, 1994, Washington, DC, American Chemical Society, Washington, DC, Miziolek, A. W.; Tsang, W., Editors, 225-242 pp, 1995.

chemical inhibition; flame chemistry; flame models; flame retardants

The proposed replacements to halon 1301, mainly fluorinated and chlorinated hydrocarbons, are expected to be required in significantly higher concentrations than CF3Br to extinguish fires. At these higher concentrations tye by-products of the

inhibited flames may include correspondingly higher portions of corrosive gases, including HF and HCl. To examine the chemical and transport-related mechanisms important in producing these acid gases, a series of inhibited flame tests are performed with several types of laboratory-scale burners, varying agent type and concentration. A wet-chemistry analsys of the final products of the flames using ion-selective electrodes for F anc Cl provides an experimental basis for quantitative understanding of the HF and HCl production. Production rates are measured for co-flow laminar and jet diffusion flames. Systematic selection of the agent concentrations, burner type, and air flow rates allows an assessment of the relative importance of agent transport and chemical kinetics on the acid gas production rates. These experimental results are then compared to a model which estimates the maximum HF and HCl productionrates based on stoichiometric reaction to the most stable products. The results demonstrate the relative significance offF, Cl, and H in the inhibitor and fuel, as well as the effect of different burner configurations.

Linteris, G. T.
Effect of Inhibitor Concentration on the Inhibition Mechanism of Fluoromethanes in Premixed Methane-Air Flames.
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society. Halon Replacements - Technology and Science. National Meeting, 208th. Proceedings. ACS Symposium Series 611. August 21-25, 1994, Washington, DC, American Chemical Society, Washington, DC, Miziolek, A. W.; Tsang, W., Editors, 260-274 pp, 1995.

chemical inhibition; flame chemistry; flame models; flame retardants; flame speed

The mechanisms of inhibition premixed methane-air flames in the presence of difluoromethane, trifluoromethane, and tetrafluoromethane are studied. The chemistry of these agents is expected to be similar to that of agents which may be used as replacements for CF3Br. The burning rates of premixed methane-air flames stabilized on a Mache-Hebra nozzle burner are determined using the total area method from a schlieren image of the flame. The three inhibitors are tested over an initial mole fraction from 0 to 8% at nominal values of the fuel-air equivalence ration, equal to 0.9, 1.0, and 1.1. The measured burning rate reductions are compared with those predicted by numerical solution of the mass, species, and energy conservation equations employing a detailed chemical kinetic mechanism reeently developed at the National Institute of Standards and Technology (NIST). Even in this first test of the kinetic mechanism on inhibited hydrocarbon flames, the numerically predicted burning rates are in excellent agreement for CH2F2 and CF4 and within 35% for CF3H. The effects of inhibitor concentration on the decomposition pathway of the inhibitors and on the H, O, and OH radical production and consumption rates are discussed. The modified decompositionpathway and the reduced radical consumptionexplain the diminishing effectiveness of CF3H and CH2F2 at higher concentrations.

Linteris, G. T.; Gmurczyk, G. W.
Inhibition of Premixed Methane-Air Flames by Iron Pentacarbonyl.
National Institute of Standards and Technology, Gaithersburg, MD
Science Applications International Corp., Gaithersburg, MD
Colloquium on the Dynamics of Explosions and Reactive Systems, 15th International. Proceedings. July 31-August 4, 1995, Boulder, CO, 1-5 pp, 1995.

chemical inhibition; flame chemistry; flame models; flame retardants; flame speed; experiments

Brominated fire suppressants are effective and widley used. Due to their destruction of stratospheric ozone, however, the productionof these chemical was halted in January 1994. Althoughtesting and development of possible substitutes is occurring, a replacement with all of the desirable properties of CF3Br (the most common fire suppressant) has yet to be identified. Consequently, the Fire Science Division at the National Institute of Standards and Technology (NIST) is conducting research to identify new chemical inhibitors, understand the mechanisms of inhibition of known or widely used agents, and evaluate the performance of proposed agents.

Linteris, G. T.; Gmurczyk, G. W.
Parametric Study of Hydrogen Fluoride Formation in Suppressed Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Science Applications International Corp., Gaithersburg, MD
Halon Options Technical Working Conference. Proceedings. May 9-11, 1995, Albuquerque, NM, 1-12 pp, 1995.

hydrogen fluorides; chemical inhibition; flame chemistry; flame models; flame retardants; experiments

Some of the proposed replacements for CF3Br, the fluorinated hydrocarbons, are required in higher concentrations to extinguish fires and contain more halogen atoms per molecule. Since they decompose in the flame, they produce correspondingly more hydrogen fluoride than CF3Br when suppressing a fire. Recent laboratory experiments with burners using heptane, propane, and methane have indicated that the amount of HF formed in steady state can be estimated within about a factor of two for diffusion flames and within 10% for premixed flames based on equilibrium thermodynamics. In this model for HF formation, the inhibitor molecule is transported to the reaction zone by convection and diffusion and is consumed in the flame sheet to form the most stable products (usually HF, CO2, and COF2). In the present work, the equilibrium model is used to estimate the upper limit of HF formation in suppressed fires. The effects of fuel and agent type, fuel consumption rate, and agent injection rate are included in the model, as are room volume, humidity, and concentration of inhibitor necessary to extinguish the fire. Results are presented for a range of these parameters, and the predictions are compared, when possible, with the results of laboratory and intermediate-scale experiments.

Linteris, G. T.; Gmurczyk, G. W.
Prediction of HF Formation During Suppression.
National Institute of Standards and Technology, Gaithersburg, MD
Science Applications International Corp., McLean, VA
NIST SP 890; Volume 2; Section 10; November 1995.
Available from Government Printing Office
SN003-003-03372-3
Available from National Technical Information Service
PB96-117783
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 2, Gann, R. G., Editor, 201-318 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; halon 1301; halon alternatives; fire suppression; premixed flames; flame structure; burning velocity; experiments; large scale fire tests

The acid gases hydrogen fluoride, hydrogen chloride, and hydrogen bromide (HX, where X denotes a halogen), are thought to be the 80 most damaging and dangerous of the potential decomposition products, and much study has been devoted to determining the amounts of these chemicals formed during fire suppression by CF3Br and halon alternatives. While CF3Br is known to readily decompose to form HF, HBr, and COF2 in laboratory premixed and diffusion flames and in larger scale fires, the amounts were not considered to be a major threat compared to that of the fire itself. The alternative agents have been found to produce significantly more acid gas than CF3Br, and consequently, there exists a need to understand and predict the mechanisms of formation of acid gases in laboratory flames, and ultimately, suppressed fires. The goal of this project is to develop an ability to predict the quantity of HF formed during suppression of aircraft fires. In order to understand the formation rates of acid gases in dry bay and engine nacelle fires it is necessary to examine the thermodynamics and chemical kinetics relevant to the formation of the acid gases as well as the effects of the flow field and mixing on the chemistry. An engine nacelle fire may be similar to a steady turbulent spray diffusion flame, whereas a dry bay fire may resemble a rapidly advancing turbulent premixed flame. Because suppression of the dry bay fires occurs in a time of about 100 ms, it is also necessary to consider transient effects on the acid gas formation. The formation of toxic and corrosive by-products in flames/fires inhibited by halogenated hydrocarbons is controlled by transport rates of the agent into the flame, chemical kinetic

rates, or equilibrium thermodynamics. These factors are affected by the fuel type, local mixture composition, inhibitor type and concentration, and the characteristics of the flow field such as mixing rate, strain rate, and stabilization mechanism in the case of laboratory burner flames. The approach taken in the present work is to examine the HF production in the fire, for a range of conditions.

Linteris, G. T.; Truett, L.
Inhibition of Premixed Methane-Air Flames by Halon Alternatives.
National Institute of Standards and Technology, Gaithersburg, MD
WL/FIVS, Wright-Patterson AFB, Dayton, OH
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 153-158 pp, 1995.

fire research; halon alternatives; chemical inhibition; flame chemistry; flame models; flame retardants; flame speed

Halogenated hydrocarbons are effective and widely used as fire suppressants. Because of their suspected destruction of stratospheric ozone, however, the production of these agents, the most popular being halon 1301 (CF3Br), has been discontinued. There exists a need to develop alternatives to the halons, to establish the relative effectiveness of alternative inhibitors, and to understand the mechanism of inhibition of the new agents. The agents which are currently being considered are most fluorinated alkanes. This article describes the first measurements of the reduction in burning rate of premixed methane-air flames inhibited by the two-carbon fluorinated species C2F6, C2HF5, C2H2F4 and the three-carbon species C3F8 and C3HF7, all of which are being considered as replacements to CF3Br. The burning rate of premixed methane-air flames stabilized on a Mache-Hebra nozzle burner is determined using the total area method from a schlieren image of the flame. The inhibitors are tested over a range of concentration and fuel-air equivalence ratio, theta. The measured burning rate reduction caused by addition of the inhibitor is compared (for the two-carbon species) with that predicted by numerical solution of the mass, species, and energy conservation equations employing a detailed chemical kinetic mechanism recently developed at the National Institute of Standards and Technology (NIST).

Linteris, G. T.; Williams, F. A.
Asymptotic and Numerical Analysis of a Premixed Laminar Nitrogen Dioxide-Hydrogen Flame.
National Institute of Standards and Technology, Gaithersburg, MD
University of California, San Diego, La Jolla
Combustion Science and Technology, Vol. 105, No. 4-6, 163-73, 1995.

premixed flames; laminar flames; nitrogen dioxide; hydrogen; burning rate; flame structure

A kinetic mechanism of eighty-some reactions for flames in mixtures of hydrogen and nitorgen dioxide is systematically reduced to twenty-four-, eleven-, seven-, two-, and one-step mechanisms. The numerically predicted burning rates for the full mechanism are compared with the results using the reduced mechanisms, and the sources of inaccuracies are identified. The two reactions NO2 + H -> NO + OH and H2 + OH <- -> H2O + H account for about 97% of the NO2 and H2 consumption and NO and H2O production and are the principal reactions involving OH and H atoms. The reactions 2 OH <- -> H2O + O and NO2 + O -> NO + O2 are important for OH and O, while the reactions NO2 + M -> NO + O + M and NO2 + H2 -> HONO + H serve as important initiation reactions. The reactions O2 + H <- -> OH + O, H2 + O <- -> OH + H, and 2NO2 -> 2NO + O2 are significant but of lesser importance. In reducing the mechanism, the steady-state assumptions for the intermediates O, H, and OH are shown to be good; however, their use is limited because the H and OH balance relations are dominated by the same reactions. Despite these limitations, an asymptotic description of the flame structure using a one-step approximation to the kinetics is still able to predict the burning rate within a factor of three of the numerical result using the full mechanism.

Lippiatt, B. C.

Lippiatt, B. C.; Norris, G. A.
Selecting Environmentally and Economically Balanced Building Materials.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 888; August 1995.
Available from National Technical Information Service
PB95-253605
National Institute of Standards and Technology. Green Building Conference and Exposition, 2nd International. Proceedings. Gaithersburg, MD, Fanney, A. H.; Whitter, K. M.; Cohn, T. B., Editors, 37-46 pp, 1995.

building technology; building materials; environmental performance; green buildings; impact assessment; impact evaluation; inventory analysis; life cycle assessment; life cycle costing; multi-attribute decisions

The building community wants to move toward the use of building materials with improved environmental performance at little or no increase in cost. A methodology for evaluating the environmental and economic performance of building materials is described. This methodology is being implemented in decision support software that will access a publicly available database of environmental and economic performance data for building materials. The software will assist designers and manufacturers in comparing the environmental/economic performance of alternative building materials. The National Institute of Standards and Technology is collaborating with the U.S. Environmental Protection Agency in this effort.

Lippiatt, B. C.; Weber, S. F.
HIST 1.0: Decision Support Software for Rating Buildings by Historic Significance.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5683; 30 p. October 1995.
Available from National Technical Information Service

analytic hierarchy process; budget allocation; decision support software; economic analysis; historic buildings; historic preservation; multi-attribute decisions; qualitative data

Sixty percent of the buildings owned by the Public Buildings Service (PBS) are classified as historic structures based solely on their age. Some of these buildings are truly historic, while others have little historic significance. In order to manage them effectively, a rating system for evaluating the relative historic importance of the PBS buildings was developed and implemented in the software HIST (Historic Importance Sofeware Tool). HIST is compatible with software currently used by PBS managers to collect detailed data on the historic characteristics of the PBS buildings. It integrates these data into a comprehensive, consistent, and reliable rating system to measure the combined historic significance at several levels of building detail. HIST is used for ranking and analyzing the PBS building inventory, and as the basis for budget planning and allocation. The report documents the rating system and the HIST software.

Liu, S. T.

Liu, S. T.; Kelly, G. E.; Terlizzi, C. P.
Performance Testing of a Family of Type I Combination Appliances.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5626; 30 p. April 1995.
Available from National Technical Information Service
PB95-220521

Annual Fuel Utilization Efficiency; ANSI/ASHRAE Standard 103;

ASHRAE Standard 124; boiler; building technology; combination appliance; combined annual efficiency; DOE test procedure; domestic water storage tank; energy factor; heating seasonal efficiency; integrated appliance; linear interpolation; rating; space heating; steady state efficiency; water heating

ANSI/ASHRAE Standard 124-1991 specifies the laboratory test and the calculation procedures for estimating seasonal and annual performance of combination appliances which are designed to provide both space heating and water heating. A boiler that includes a tankless coil for water heating or in combination with an indirectly heated storage tank is classified by ASHRAE Standard 124 as Type I combination appliances. It is common for single size tankless coil or storage tank to be used in combination with a series of boilers (called a family series) of different sizes. In an effort to minimize the test burdens on manufacturers, a family series of gas-fired hot water boilers were tested to determine if a subset of a family series of Type I combination appliances could be tested and used to predict the performance of the rest of the appliances in the family series. Tests were conducted on a family series of three different size boilers (rated input of 22, 33, and 44 kW) with an identical indirectly heated storage tank to determine their Combined Annual Efficiency (CAE) as specified in ASHRAE Standard 124. To this end, tests for the Energy Factor (EF) for water heating and the Annual Fuel Utilization Efficiency (AFUE) for space heating were conducted. For the domestic water heating test, daily hot water draw volume of 243.4 L (64.3 gal) was used. The results showed that for the three boilers, the AFUE for space heating differed by approximately 2.5 percentage points, with the smaller size boiler having a higher AFUE. On the other hand, the EF for water heating depended more strongly (differed by near 5 percentage points from the smallest (22 kW) to the largest (44 kW) capacity boilers tested on the size of the boilers for the same daily hot water drawn. However, the EF was an approximate linear function of the boiler size. The results also showed that the CAE varied by slightly over 1.6 percentage points among the three boilers. Thus a simple linear interpolation appears adequate for determining the Combined Annual Efficiency CAE within a family series.

M

Madrzykowski, D.

Madrzykowski, D.
Evaluation of Sprinkler Activation Prediction Methods.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Limited. ASIAFLAM '95. International Conference on Fire Science and Engineering, 1st. Proceedings. March 15-16, 1995, Kowloon, Hong Kong, 211-218 pp, 1995.

fire science; fire protection engineering; sprinklers; evaluation; experiments; compartments; large scale fire tests

The objective of this study was to evaluate the ability of sprinkler activation models to predict activation time. Large scale compartment fire tests were used to obtain activation times for four different types of sprinklers. The tests were conducted in an 18.9 m by 9.1 m by 2.35 m high compartment using floor based, gas burner fires with constant heat release rates of 115, 155, 215, 290 and 520 kW. Non-dimensional sprinkler radial position, r/H, of 0.67 and 1.3 were evaluated. In addition to sprinkler activation times, ceiling jet temperature, velocity and radiation measurements were made. The study included: (1) a review of public domain, personal-computer based, single-compartment thermal-detector activation models, (2) an analysis of predicted vs. experimental sprinkler activation times and (3) a method to determine the applicability of current sprinkler activation models.

Marshall, H. E.

Marshall, H. E.
Choosing Economic Evaluation Methods. Least-Cost Energy Decisions for Buildings. Part 3. Video Training Workbook.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5604; 50 p. May 1995.
Available from National Technical Information Service
PB95-253597

building economics; economic analysis; economic efficiency; energy conservation; energy economics; internal rate of return; life cycle costing; payback; savings-to-investment ratio

This workbook accompanies the video training film "Choosing Economic Evaluation Methods: Least-Cost Energy Decisions for Buildings". The workbook and its companion video are the third in a series of training video-workbook modules designed to assist you in using economic analysis to improve the long-run economy of your buildings. This module describes the types of investment decisions that you will have to deal with when you evaluate energy conservation projects--decisions to accept or reject a project, what design to choose, and what priority to assign candidate projects. Then it tells you how to match the different types of investment decisions with the appropriate economic methods. Although the video can be used alone, it is recommended that the workbook be used in conjunction with the video. The workbook supports the video with expanded descriptions of technical material shown in the video; figures and tables presented in the video; formulas for computing economic measures used in the video; exercises to give you practice; and a glossary of technical terms used by the video instructors.

Marshall, R. D.

Marshall, R. D.
Workshop on Research Needs in Wind Engineering. Proceedings. September 12-13, 1994. Gaithersburg, Maryland.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5597; February 1995.
Available from National Technical Information Services
PB95-189528
National Institute of Standards and Technology. Workshop on Research Needs in Wind Engineering. Proceedings. September 12-13, 1994, Gaithersburg, MD, 75 pp, 1995.

building technology; codes; standards; hurricanes; meteorology; technology transfer; tornadoes; wind climate; wind disasters; wind engineering; wind research; wind tunnels

This report presents findings and recommendations developed at a workshop on research needs in wind engineering convened at Gaithersburg, Maryland, on September 12-13, 1994. Representatives from universities, the private sector, and Federal agencies currently engaged in or otherwise supporting wind engineering research presented program overviews and participated in working group sessions addressing various aspects of wind engineering research and wind disaster mitigation. Research needs and topics for technology transfer were identified and prioritized. It was concluded that current funding of wind engineering research in the United States falls far short of what is needed to effectively address the problem of spiraling losses due to wind damage. There is, however, considerable wind engineering knowledge now available for implementation by the model building codes and by the building industry in general. This implementation will require coordination of the efforts of industry, universities, and State and Federal agencies, along with appropriate funding.

Marshall, R. D.; Yokel, F. Y.
Recommended Performance-Based Criteria for the Design of Manufactured Home Foundation Systems to Resist Wind and Seismic Loads.
National Institute of Standards and Technology, Gaithersburg, MD
Consulting Engineer, Bethesda, MD
NISTIR 5664; 74 p. August 1995.
Available from National Technical Information Service
PB96-128111

building technology; codes; standards; earthquake engineering; foundations; manufactured housing; mobile homes; soil anchors; structural engineering; wind engineering; wind loads; windstorm protection; structural systems

This report addresses the issue of tornadoes as a basis for the design of manufactured homes and compares base shears due to wind loading with base shears due to earthquake excitation for various wind and seismic zones. Only for annual exceedance probabilities less than about 2.5 x 10-4 will tornadic wind speeds govern the design for wind loading. In view of the accepted probabilities of attaining or exceeding design limit states for ordinary buildings, it is concluded that tornadoes should not be a part of the wind load design criteria for manufactured homes. Also, it is concluded that transverse base shear due to wind loading will always exceed the base shear due to earthquake loading, regardless of the wind or seismic zone in which the manufactured home is sited. In the longitudinal direction the ranges of base shear for wind and earthquake are approximately equal. These comparisons are based on the assumption that the structural system is properly detailed to resist earthquake forces and is capable of accommodating inelastic deformations several times greater than the deformation at first yield. In view of the uncertainty regarding the dynamic properties of manufactured homes and their support systems, a simplified equation for the determination of seismic base shear is proposed. Traditional anchor/tie/pier systems and current installation practice do not provide adequate windstorm protection for manufactured homes. Even with preloading, the effectiveness of traditional shallow, helix-plate soil anchors is limited to basic wind speeds of approximately 44.7 m/s (100 mph). However, there are several alternative anchoring and support systems on the market or under development that can provide the required resistance to wind and earthquake loads. Finally, a set of performance-based criteria for anchoring manufactured homes against wind and earthquake loads is proposed.

Martin, J. W.

Martin, J. W.; Nguyen, T.; Alsheh, D.; Lechner, J. A.; Embree, E. J.; Byrd, W. E.; Seiler, J. F., Jr.
Degradation of Powder Epoxy Coated Panels Immersed in a Saturated Calcium Hydroxide Solution Containing Sodium Chloride. Final Report. August 1992-July 1994.
National Institute of Standards and Technology, Gaithersburg, MD
FHWA-RD-94-174; 44 p. October 1995.
Available from National Technical Information Service

panels; degradation; anodic blisters; cathodic disbondment; crevice corrosion; epoxy-coated rebars; infrared thermography; peel; wet adhesion; exposure; films

Blasted-steel panels were coated with two commercial powder epoxy coatings. Approximately half (80) of the coated panels were scribed; while the other half remained defect-free. All of the panels were immersed in a saturated calcium hydroxide solution containing 3.5 percent sodium chloride maintained at either 35 or 50 DGC. None of the unscribed panels degraded after 3074 h or immersion at 35 DGC; whereas, all of the scribed panels degraded within 25 h after immersion, regardless of the immersion solution temperature. Scribed panels degraded in three ways: (1) anodic corrosion, (2) cathodic disbondmant, and (3) wet-adhesion loss. Anodic corrosion was attributed to localized crevice corrosion. The rate of anodic growth depended on the immersion solution temperature, but it did not depend on the type of coating or coating thickness. Liquid-filled blisters formed above the anodic sites after approximately 1000 h of immersion at 35 DGC. The chloride concentration of the blister fluid was four times greater than that of the bulk solution and its pH was around 5. The rate of cathodic disbondment was not affected by the type of coating or coating thickness, but it was greatly affected by an increase in the temperature of the immersion solution. Wet-adhesion loss was not affected by coating thickness, but it does depend on the type of coating and

immersion temperature. Also, even though the wet-adhesion strength of the two coatings differed by a factor of five, the rate of corrosion for the two coatings was not significantly different.

Martin, P. M.

Martin, P. M.; Jason, N. H.
BFRL Publications, 1994. Volume 1 and Volume 2.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 883; June 1995.
Available from National Institute of Standards and Technology
fire research

This CD-ROM set contains publications in full text by the National Institute of Standards and Technology/Buildingand Fire Research Laboratory (NIST/BFRL) staff and related fire research grant reports. Only items publisheduring 1994are included.

Martys, N. S.

Martys, N. S.
Numerical Simulation of Hydrodynamic Dispersion in Random Porous Media.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Chromatography A, Vol. 707, 35-43, 1995.
building technology; hydrodynamic dispersion; porous media; diffusion; convection; conductivity; chromatography

In this paper we present results demonstrating the utility of computational methods to numerically simulate and visualize hydrodynamic dispersion in random porous media. The role of Peclet number in the spread of a dye through porous media is illustrated. From examination of concentraion profiles, effective diffusion coefficients were numerically determined for different Peclet numbers. In contrast to the case of fluid-driven dispersion, we discuss the spread of a dilute concentration of ions driven by an electric field. We also consider a simple model of size exclusion chromatography where materials that advect and diffuse through pore space also diffuse through the solid matrix.

Martys, N. S.
Survey of Concrete Transport Properties and Their Measurement.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5592; 46 p. February 1995.
Available from National Technical Information Service
PB95-220489
concretes; transport properties; building materials; building technology; capillary flow; cements; chloride ions; concentration profiles; computer models; diffusion; electric migration; impedance spectroscopy; Katz-Thompson relation; mercury intrusion porosimetry; mortars; nuclear magnetic resonance; permeability; rapid chloride test; sorptivity; x-ray tomography

In this report we present a survey of the current knowledge of the transport properties of concrete. The basic theory and measurement methods are discussed. Emphasis is placed on transport properties (or mechanisms), such as diffusion, permeability, and capillary flow, that may play an important role in degradation processes in high performance concrete. It is concluded that standard test methods used to predict the service life of concrete via measurement of transport properties, especially in high performance concrete, are, in general, inadequate or need to be developed.

McGrattan, K. B.

McGrattan, K. B.; Ferek, R. J.; Uthe, E. E.
Smoke Plume Trajectory From In Situ Burning of Crude Oil: Field Experiments.
National Institute of Standards and Technology, Gaithersburg, MD
University of Washington, Seattle
Southwest Research Inst., San Antonio, TX
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 47-52 pp, 1995.

fire research; crude oil; fire plumes; in situ combustion; pool fires; smoke; in situ burning

Several regions in the United States are developing preapproval plans to use in situ burning as a possible remediation tool for oil spills. To assess the environmental impact of the smoke plume on human populations, numerical models have been used to predict the concentration of particulate matter downwind of a large fire. In order to assess the accuracy of one of these models, the NIST Large Eddy Simulations model, data from three sets of mesoscale burns have been compared to model simulations run under similar meteorological conditions. The experimental burns are: (1) the Newfoundland Offshore Burn Experiment (NOBE), August 1993; (2) the Alaska Clean Seas Burning of Emulsions, September 1994, and; (3) the U.S. Coast Guard/NIST Meso-scale Burn Series, October 1994. The analysis for the first two experiments is complete, and the results are presented. In addition to measurements made far downwind of these burns which were used to evaluate the model, near-field measurements of particulate and CO2 are presented.

McGrattan, K. B.; Walton, W. D.; Putorti, A. D., Jr.; Twilley, W. H.; McElroy, J. A.; Evans, D. D.
Smoke Plume Trajectory From In Situ Burning of Crude Oil in Alaska: Field Experiments.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5764; 40 p. November 1995.
Available from National Technical Information Service
PB96-131560

crude oil; oil spills; in situ combustion; pool fires; smoke; fire plumes; smoke movement; in situ burning

As part of their effort to assess the impact of smoke plumes from in situ burning of crude oil on nearby populations, the Alaska Regional Response Team and the Alaska Department of Environmental Conservation established a Cooperative Research and Development Agreement with the National Institute of Standards and Technology (NIST) in 1993 with the intent of developing predictive methods to estimate the downwind concentration of particulate matter from a burning oil spill. The first phase of the study consisted of laboratory-scale burns of North Slope and Cook Inlet crude oils, the results of which were used to define the source terms for the LES (Large Eddy Simulation) plume trajectory model. A number of different fire sizes and weather conditions were considered with the aim of estimating the extent to which concentrations of smoke particulate matter would exceed ambient air quality standards. Recommendations were made in a previously published report. In the present report, experimental data collected at two sets of mesoscale burns are compared with the results of the LES model run using the recorded meteorological and physical conditions. The two experiments are the Newfoundland Offshore Burn Experiment (NOBE), August 1993, and the Alaska Clean Seas Burning of Emulsions, September 1994. Each series of burns was conducted under different conditions, and different data collection techniques were employed at each. The results show that the predictions of the LES model are in good agreement with the experimental measurements, given the uncertainty of the input parameters. This increases confidence in the accuracy of the predicted results reported in the original study, and it also provides guidance on how to assess the undertainty of model predictions. The original report was written without the benefit of field data to validate the physical assumptions of the model; thus it was suggested that a factor of safety of 2 be applied to a model prediction to account for both the uncertainties in the input parameters and the physical assumptions of the model. The results of the field experiments, however, suggest that the uncertainty of the model prediction is commensurate with the

uncertainty of the input parameters. This is not to say that the model is perfect, but rather that the uncertainties due to the physical assumptions of the model are outweighted by the uncertainties due to the input parameters.

McKenna, G. B.

McKenna, G. B.; Horkay, F.; Verdier, P. H.; Waldron, W. K., Jr.
Interactions of Agents With Elastomers and Lubricants.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; Section 6; November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1. Section 6., Gann, R. G., Editor, 201-247 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; elastomers; lubricants; mechanical properties; halon 1301; halon alternatives

McKnight, M. E.

McKnight, M. E.; Seiler, J. F., Jr.; Nguyen, T.; Rossiter, W. J., Jr.
Measuring Peel Adhesion of Coatings.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Protective Coatings and Linings, Vol. 12, No. 5, 82-89, May 1995.

adhesion; building technology; peel test; coatings

An essential requirement of protective coatings is that they adhere to the substrate to which they are applied. This is an obvious requirement, but it is a difficult one to measure quantitatively. Many procedures are available for assessing coating adhesion, including ASTM D 3359 for peel, ASTM D 4541 and ISO 4642 for tensile, and a reported procedure for shear. However, all of the procedures have limitations. For example, the D 3359 peel test is qualitative, while the tensile and shear tests require gluing a loading fixture to the surface of the coating. None of the procedures is particularly suitable for determining adhesion of coatings exposed to a wet environment. This article describes a quantitative, repeatable procedure for measuring peel adhesion that was developed at the National Institute of Standards and Technology (NIST) primarily to measure the adhesion of coatings to a steel substrate exposed to a wet environment. Two examples of its application are presented. These examples are measurements of the wet adhesion strength of powder coatings to steel and the dry adhesion strength of water-borne coatings to steel.

Mell, W. E.

Mell, W. E.; Johnson, A.; McGrattan, K. B.; Baum, H. R.
Large Eddy Simulations of Buoyant Plumes.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Proceedings. Fall Technical Meeting, 1995. October 16-18, 1995, Worcester, MA, 187-190 pp, 1995.

combustion; buoyant plumes; simulation; equations; combustion models

An approach to the study of gas phase combustion and convection processes in fires using a combination of mathematical analysis and computer simulation is presented. It seeks to solve the governing equations directly (if approximately) by

decomposing the fire into a large scale convective and radiative transport problem coupled to a small scale model of combustion and radiative emission. The combustion model assumes that all of the thermodynamic properties of the fluid are tied to the local mixture fraction, which is convected by the large scale motion, which in turn is driven by the heat released by the combustion processes. The large scale flow is studied using finite difference techniques to solve large eddy simulations of the Navier-Stokes equations. As a first test of the numerical approach, a buoyant helium plume is simulated and results compared to a companion laboratory experiment.

Mell, W. E.; McGrattan, K. B.; Baum, H. R.
Large Eddy Simulations of Fire-Driven Flows.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers (ASME). National Heat Transfer Conference, 1995. Proceedings, 30th. Combustion and Fire Research. Heat Transfer in High Heat-Flux Systems. Volume 2. HTD-Vol. 304. August 6-8, 1995, Portland, OR, Peterson, R. B.; Ezekoye, O.A.; Simon, T., Editors, 73-77 pp, 1995.

heat transfer; combustion; fire research; heat flux; computer simulation; equations; combustion models; hydrodynamics

An approach to the study of gas phase combustion and convection processes in fires using a combination of mathematical analysis and computer simulation is presented. It seeks to solve the governing equations directly (if approximately) by decomposing the fire into a large scale convective and radiative transport problem coupled to a small scale model of combustion and radiative emission. The combustion model assumes that all of the thermodynamic properties of the fluid are tied to the local mixture fraction, which is convected by the large scale motion, which in turn is driven by the heat released by the combustion processes. The large scale flow is studied using finite difference techniques to solve large eddy simulations of the Navier-Stokes equations. The basic theory behind the methodology is outlined and sample results are presented.

Melvyn Green and Associates, Inc.

Melvyn Green and Associates, Inc.
Comparison of the Seismic Provisions of Model Building Codes and Standards to the 1991 NEHRP Recommended Provisions.
Melvyn Green and Associates, Inc., Torrance, CA
NIST-GCR-95-674; 92 p. May 1995.
Available from National Technical Information Service
PB95-231858

building codes; standards; methodology; wood; steels; concretes; masonry

The Interagency Committee on Seismic Safety in Construction (ICSSC) recommends use of building codes which are substantially equivalent to the National Earthquake Hazard Reduction Program Recommended Provisions for the Development of Seismic Regulations for New Buildings (NEHRP provisions) for new federal construction. The intent of this study is to review the seismic provisions of the current editions of the BOCA National, SBCCI Standard and the ICBO Uniform Codes to determine whether the codes provide an equivalent level of safety to that contained in the 1991 Edition of the NEHRP Provisions. In addition the provisions of the CABO One and Two Family Dwelling Code and ASCE 7-93 are to be reviewed. This study reviewed the changes from the 1988 NEHRP Provisions to the 1991 NEHRP provisions and compared them to the current editions of the model codes. In addition ASCE 7-93 was reviewed since its seismic provisions and are based on the 1991 NEHRP Provisions.

Mercier, G. P.

Mercier, G. P.; Jaluria, Y.
Fire-Induced Flow of Smoke and Hot Gases in Open Vertical Shafts.

Rutgers Univ., New Brunswick, NJ
Thermal Science and Engineering Symposium in Honor of Chancellor Chang-Lin Tien. November 1995, Berkeley, CA, 261-268 pp, 1995.

smoke; high temperature gases; heat transfer; building fires; temperature field; flow rate; ventilation

An experimental study on the flow and heat transfer in vertical shafts due to a building fire is carried out. Smoke or hot gases are injected into the shaft at a lower opening and the downstream flow and temperature fields are studied. The inlet temperature and flow rate of the hot gases are varied over wide ranges to simulate the flow due to fire in multi-leveled buildings with vertical open shafts under natural ventilation. The conditions at the outlet are also monitored to determine the effects of entrainment into the flow and heat transfer to the walls. Typical values of the operating conditions have been investigated, ranging from high buoyancy levels, for which the flow stays close to the vertical wall of the shaft, to much lower levels, at which the flow enters the shaft with a significant flow velocity and spreads outward very quickly. It is found that with increasing temperature at the inlet, the buoyancy effect is larger resulting in higher velocities and shorter time to reach the top. The temperature at the outlet depends on heat transfer to the walls as well as on the flow velocity and is measured. Detailed measurements of the velocity and temperature fields have also been taken. It is found that a wall plume is generated which conveys the hot fluid rapidly along the shaft wall from the inlet to the outlet. A recirculating flow arises away from this wall and this flow affects the heat transfer and flow in the wall plume. This, in turn, affects the entrainment into the flow, decay of the temperature field and rate of downstream movement. Therefore, horizontally uniform conditions can not be assumed here, as employed in several studies for tall shafts. The wall plume has to be modeled in this case, considering the entrainment into the boundary layer flow and the effect of the recirculating flow.

Milke, J. A.

Milke, J. A.
Application of Neural Networks for Discriminating Fire Detectors.
Maryland Univ., College Park
University of Duisburg. International Conference on Automatic Fire Detection "AUBE '95", 10th. April 4-6, 1995, Duisburg, Germany, Luck, H., Editor, 213-222 pp, 1995.

fire detection; fire detectors; experiments; small scale fire tests; large scale fire tests; smoke; odors; expert systems; smoldering

Research is being conducted to describe the characteristics of an improved fire detector which promptly reacts to smoke while discriminating between smoke and odors from fire and non-fire sources. This study is investigating signature patterns associated with fire and environmental sources via small- and large-scale tests toward the development of an improved fire detector. On the tests, smoke and odors are produced from a variety of conditions: flaming, pyrolyzing and heated samples, and nuisance sources, such as aerosols, household products and cooked food. Measurements include light obscuration, temperature, mass loss, CO, CO2, O2 and oxidizable gas concentrations. The feasibility of an elementary expert system to classify the source of the signatures from small-scale experiments was demonstrated in the first phase. In the recently completed second phase, a similar expert system correctly classified the source of the signatures in large-scale experiments in 85% of the cases. Neural networks have been applied to both sets of data from the small- and large-scale tests providing an even greater successful classification rate.

Mitler, H. E.

Mitler, H. E.
On the Heights of Wall-Fire Flames.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September

10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 166-171 pp, 1995.

fire research; wall fires; flame height; line fire; pyrolysis; walls; equations

A correlation between the visible height of a flame and the power output of the flame is useful for a number of reasons. Thus, observations of a fire can permit one to estimate the rate of heat release and therefore the fuel flow rate. Again, an expression for the flame height is needed in order to calculate the upward flame spread rate on walls. It is therefore important that such an expression be reliable. The heights of flames from line burners adjacent to walls have been correlated by a number of workers.

Mitler, H. E.; Steckler, K. D.
SPREAD: A Model of Flame Spread on Vertical Surfaces.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5619; 69 p. April 1995.
Available from National Technical Information Service

computer models; flame spread; fire growth; fire models; fire spread; mathematical models; upward spread; wall fires

This report describes the computer program SPREAD. SPREAD is the explicity implementation of a model which has been developed for predicting the ignition of, and the subsequent rate and extent of fire spread on flat walls in a room using the fire properties of the materials involved. It uses input data from bench-scale tests including the LIFT and the Cone Calorimeter. The principal mode of spread is upward, but the calculations also include the slow lateral spread on the wall. For the latter calculations, the fact that the room produces a two-layer environment has been taken into account (the lateral spread rate within the upper layer is greater than in the lower one). Embedded in the overall model is a general pyrolysis submodel, specially developed for this purpose, which treats arbitrary materials (ablating, char-forming, composite, etc.). SPREAD also calculates the regression of the pyrolyzing surface, including the possible burnout of the wall/slab at any point. The program has been compared to experimental data for wood particle board and for PMMA. The structure of the program is given in a set of appendices.

Mulholland, G. W.
Mulholland, G. W.
Smoke Production and Properties.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Handbook of Fire Protection Engineering. 2nd Edition. Section 2. Chapter 15, National Fire Protection Assoc., Quincy, MA, DiNenno, P. J.; Beyler, C. L.; Custer, R. L. P.; Walton, W. D., Editors, 2/217-227 p., 1995.

fire protection; fire protection engineering; smoke production; size distribution; visibility; smoke detection; wood; plastics; particle size; equations; mass optical density

The term "smoke" is defined in this chapter as the smoke aerosol or condensed phase component of the products of combustion. This differs from the American Society for Testing and Materials (ASTM) definition of smoke, which includes the evolved gases as well. Smoke aerosols, vary widely in appearance and structure, from light colored, for droplets produced during smoldering combustion and fuel pyrolysis, to black, for solid, carbonaceous particulate or soot produced during flaming combustion. A large fraction of the radiant energy emitted from a fire results from the blackbody emission from the soot in the flame. The subject of radiant heat transfer is of such importance that it is treated in a separate chapter. This chapter focuses on smoke aerosols outside the combustion zone. The effects of the smoke produced by a fire depend on the amount of smoke produced and on the properties of the smoke. The following section presents experimental results on smoke emission for a variety of materials. The smoke emission, together with the flow pattern, determines the smoke concentration as smoke moves throughout a building. The most basic physical property of smoke is the size distribution of its particles. Results on size distribution for various types of smoke and techniques used for measuring particle size are presented in the section "Size

Distribution." The section "Smoke Properties" focuses on those properties of greatest concern to the fire protection community: light extinction coefficient of smoke, visibility through smoke, and detectability of smoke. These properties are primarily determinded by the smoke concentration and the particle size distribution. References for other smoke aerosol properties, such as diffusion coefficient and sedimentaion velocity, are also provided.

N

Nabinger, S. J.

Nabinger, S. J.; Persily, A. K.; Sharpless, K. S.; Wise, S. A.
Measurements of Indoor Pollutant Emissions From EPA Phase II Wood Stoves.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5575; 65 p. February 1995.
Available from National Technical Information Service
PB95-198735

benzo[a]pyrene; emission rates; indoor air quality; particulates; polycyclic aromatic hydrocarbons; wood stoves

Measurements of indoor pollutant emissions were made on four wood stoves meeting the EPA Phase II emission requirements in a 37 m2 (400 ft2) test house at NIST. The stoves were operated in a manner consistent with typical residential use and in accordance with the manufacturers' instructions. Three tests were conducted for each stove, with each test lasting approximately ten hours. During the tests the following quantitites were monitored: combined gaseous and particulate phase concentrations of 13 individual polycyclic aromatic hydrocarbons (PAHs) averaged over the test period, including benzo[a]pyrene(B[a]P); total particulate phase PAH concentrations using a real-time monitor; mass of particulate matter below ten mm in diameter (PM10) averaged over the test period; continuous particle counts in six size ranges; continuous indoor and outdoor concentrations of carbon monoxide and carbon dioxide; building air change rates; pressures across the test house walls and in the stove flue; wind speed and direction; and indoor and outdoor air temperature and relative humidity. Based on these measurements, emission rates of total PAHs (i.e., the sum of eight individual compounds) ranged from 0.05 to 0.24 ng/s and total PAH source strengths ranged from 67 to 711 ng/kg of wood. Emission rates of B[a]P ranged from 0.003 to 0.028 ng/s and B[a]P source strengths ranged from 7 to 90 ng/kg of wood burned.

National Institute of Standards and Technology

National Institute of Standards and Technology
Building and Fire Research Laboratory (BFRL): Your Partner. VHS Video (Length 17:30).
National Institute of Standards and Technology, Gaithersburg, MD
VHS Video, 1/2"; September 1995.

building technology; fire research; research facilities

Nguyen, T.

Nguyen, T.; Bentz, D. P.; Byrd, W. E.
Method for Measuring Water Diffusion in a Coating Applied to a Substrate.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Coatings Technology, Vol. 67, No. 844, 37-46, 1995.

building technology; coatings; substrates; ft-ir; water

A method based on Fourier transform infrared-multiple internal reflection (FTIR-MIR) spectroscopy was developed for measuring the apparent diffusion coefficient of water in a coating applied to a substrate. The method requires an application of a coating of any thickness on an internal reflection element, which serves as the substrate, with the attachment of a water chamber to the coated specimen. Water is introduced to the chamber and FTIR-MIR spectra are collected automatically without disturbing the specimen or the instrument. The amount of water at the coating/substrate interface was determined using a model based on the theory of internal reflection spectroscopy. A mass-time curve for water at the interface is established, which provides the time-lag value, the time required for water to diffuse through the coating film and reach the interface. The diffusion coefficient (D) is then determined by the time-lag equation. For thick coating films (> 25 mm), D may be estimated from the FTIR-MIR in situ intensity data only. The sensitivity of FTIR-MIR spectroscopy and the strong FTIR absorption of water molecules make this an ideal method for measuring the diffusivity of liquid water through a coating applied to a substrate.

Nguyen, T.; Byrd, W. E.; Alsheh, D.; Bentz, D. P.
Relation Between Adhesion Loss and Water at the Polymer/Substrate Interface.
National Institute of Standards and Technology, Gaithersburg, MD
Adhesion Society Meeting. Proceedings. February 1995, Hilton Head Island, SC, 252-254 pp, 1995.

building technology; adhesion; water; substrate interface

The buildup of water many monolayers thick at the coating/substrate interface is the major cause of adhesion loss when an organic-coated substrate is exposed to water or high relative humidities. Until now, it has not been possible to correlate the buildup of the interfacial water layer with adhesion loss because there has been no method available to quantify the water layer at the coating/substrate interface or the adhesion loss of coated substrates. In this study, the thickness of the interfacial water layer and the adhesion loss of several organic film/substrate systems exposed to water were measured and analyzed to establish the correlation between water at the interface and the adhesion loss of organic-coated materials.

Nguyen, T.; Byrd, W. E.; Alsheh, D.; Mcdonough, W.; Seiler, J. F., Jr.
Interfacial Water and Adhesion Loss of Polymer Coatings on a Siliceous Substrate.
National Institute of Standards and Technology, Gaithersburg, MD
Materials Research Society Symposium Proceedings. Volume 385. 1995, 57-63 pp, 1995.

substrates; water; adhesion; coatings; ft-ir

Water is often the main cause of adhesion loss of a polymer coating/substrate system. The buildup of the interfacial water layer and the loss of adhesion of polymer-coated siliceous substrates exposed to liquid water has been investigated. The thickness of the interfacial water layer was measured on epoxy-coated SiO2-Si prisms using FTIR-multiple internal reflection (FTIR-MIR) spectroscopy. Adhesion loss on flat siliceous substrates was determined by a wet peel test on epoxy-coated SiO2-Si wafers and adhesion loss of composites was obtained by measuring the interlaminar shear strengths of eopoxy/E-glass fiber composites. Both untreated and 0.1% silane-treated substrates were used. Little water was observed at the interface of the silane-treated samples but about 10 monolayers of water have accumulated at the interface of the untreated samples after 100 h of exposure to 24 DGC water. Untreated, flat substrates los most of their bonding strengths within 75 h of exposure but silane-treated specimens retained 80% of their adhesion after 600 h of exposure to 24 DGC water. Adhesion loss of untreated composites immersed in 60 DGC water was greater than that of treated samples; however, the rate of loss of both silane-treated and untreated composites was much lower than that of flat substrates. Adhesion loss was found to follow the same trend as interfacial water buildup.

Nguyen, T.; Byrd, W. E.; Bentz, D. P.
Quantifying Water at the Organic Film/Hydroxylated Substrate Interface.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Adhesion, Vol. 48, 169-194, 1995.

ATR; building technology; ft-ir; interface; internal reflection spectroscopy; in situ measurement; quantitative; water

A method, based on Fourier transform infrared-multiple internal reflection (FTIR-MIR) spectroscopy, for determining the amount and thickness of water at an organic film/hydroxylated substrate interface has been developed. The analysis uses a two-layered model, which takes into account: (1) water at the organic film/hydroxylated substrate interface, (2) water taken up by the organic film within the penetration depth of the evanescent wave and (3) change of the penetration depth as water displaces the organic film from the substrate. Experimentally, the method requires the application of an organic film, transparent or opaque, of sufficient thickness on a hydroxylated internal reflection element, which is used as the substrate. A water chamber is attached to the organic-coated specimen. After adding water to the chamber, FTIR-MIR spectra are taken automatically at specified time intervals without disturbing the specimen or the instrument. Water uptake in the organic films and FTIR-MIR spectra of water on the substrates are also obtained and used for the analysis. Results of examples of three organic films: a clear epoxy, and unmodified asphalt, and a pigmented ester, on a hydroxylated SiO2-Si substrate were presented to demonstrate the method. The water layer at the interface for the ester and asphalt specimens was found to be much thicker than that for the epoxy, and this was attributed to the presence of a water-sensitive layer accumulated at the interface for the formers. The method should be equally applicable to studies of organic and inorganic compounds at the organic film/hydroxylated substrate interface and their transport rates through films adhered to a substrate.

Norris, G. A.

Norris, G. A.; Marshall, H. E.

Multiattribute Decision Analysis Method for Evaluating Buildings and Building Systems.

National Institute of Standards and Technology, Gaithersburg, MD

NISTIR 5663; 86 p. September 1995.

Available from National Technical Information Service

decision analysis; additive weighting methods; analytical hierarchy process (APH); building choice; building economics; capital budget allocation; hierarchy; multiattribute decision analysis; multiple criteria decision analysis; multiobjective decision analysis

Multiattribute decision analysis (MADA) method consider non-financial attributes (qualitative and quantitative) in addition to common financial worth measures when evaluating project alternatives. The building community needs MADA methods to evaluate building and building-related investment alternatives where non-financial attributes are important. The report reviews 14 classes of methods for performing MADA. It summarizes their usefulness for screening, ranking, and choosing among projects; their data input requirements; and how each method scores project alternatives. Two methods - the analytical hierarchy process (AHP) and non-traditional capital investment criteria (NCIC) - are described in detail. Assumptions, procedures, strengths, and limitations are described for each. AHP was selected for detailed description because of four important strengths: it is well-known and well-reviewed in the literature; it includes an efficient atrribute weighting process of pairwise comparisons; it incorporates hierarchical descriptions of attributes, which keeps the number of pairwise comparisons manageable; and most of all, its use is facilitated by available software. A case study of a hypothetical company choosing a new headquarters illustrates AHP in choosing among building alternatives. NCIC was selected for detailed description because of four strong points: it was designed to address some of the criticisms of AHP which have appeared in the literature; it includes pairwise comparisons for efficiency; it incorporates hierarchical descriptions of attributes to keep the number of pairwise comparisons manageable; and most of all, it develops "scores" for alternatives which are denominated in monetary terms, making otherwise implied valuation of attributes explicit and allowing the results to be incorporated into traditional economic worth analyses. A case study of a hypothetical company selecting the location of a new branch office illustrates NCIC. Detailed descriptions of some typical building-related decisions - choosing among office buildings, residences, building components, and building materials - provide additional examples of possible MADA applications. A list of 15 building-related attributes, with complete definitions, helps decision makers customize a MADA model for making a building choice. Although the report focuses on buildings, MADA methods apply equally to the evaluation of non-building capital budgeting decisions.

Notarianni, K. A.

Notarianni, K. A.
Report on the Navy Aircraft Hangar Research Project.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Bulletin, 8-9, Summer 1995.

aircraft hangars; experiments; aircraft fuels; jet fuels; fire spread; JP-4 jet fuel; JP-5 jet fuel; JP-8 jet fuel

The Naval Facilities Engineering Command (NAVFAC) and the National Institute of Standards and Technology (NIST) are conducting full scale fire experiments in two Navy aircraft hangars. The purpose of this project is to provide scientific data on actual jet fuel fires in high bay hangars. The Navy, and subsequently all of the Department of Defense will utilize this data to reevaluate and revise their criteria for the protection of aircraft hangars.

Nyden, M. R.

Nyden, M. R.
Photodegradation of CF3I.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; Section 3; November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1. Section 3., Gann, R. G., Editor, 77-95 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; experiments; degradation; decomposition; halon 1301; halon alternatives

CF3I has been identified as a leading candidate for the replacement of halon fire extinguishing agents because of its high degree of effectiveness as a flame suppressant and its short tropospheric lifetime and low ozone depeletion potential. Although this compound is known to undergo rapid photolysis in the presence of sunlight, the byproducts of the photodegradation process have not been determined. It is also not known whether this agent will photolyze significantly when it is exposed to radiation from fluorescent lamps and other common sources of indoor light. This knowledge is essential to assess the stability of this agent and the risk of human exposure to it and its byproducts. The spectrum of a fluorescent lamp, obtained in this laboratory, indicates a measurable radiative flux out to about 310 nm. The observation that this spectrum overlaps with the absorption spectrum of CF3I suggests that this agent should undergo appreciable photolysis when it is exposed to radiation from fluorescent lights. The objectives of this study are to determine the extent of this degradation and the nature of the compounds which are likely to be produced when CF2I is released in an indoor environment.

Nyden, M. R.; Brown, J. E.; Lomakin, S. M.
Flammability Properties of Honeycomb Composites and Phenol-Formaldehyde Resins.
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society. Fire and Polymers II: Materials and Tests for Hazard Prevention. National Meeting, 208th. ACS Symposium Series 599. August 21-26, 1994, Washington, DC, American Chemical Society, Washington, DC, Nelson, G. L., Editor, 245-255 pp, 1995.

fire retardants; flame retardants; composite materials; formaldehyde; flammability; synthetic resins; equations

The flammability properties of honeycomb composites, which are used in the interior cabin compartments of commercial aircraft, were examined. Analyses of the gases evolved during the thermal degradation of the components indicated that the

phenol-formaldehyderesin makes a significant contributionto the flammability of these composites. The possibility that a more fire resistant formulation could be developed was examined by testing a series of resins which differed in the relative amounts of phenol and formaldehyde used in the reaction mixtures. The flammabilities of resins synthesized in excess phenol were measurably less than those synthesized in excess formaldehyde.

O

Ohlemiller, T. J.

Ohlemiller, T. J.
Examination of the Correlation Between Cone Calorimeter Data and Full-Scale Furniture Mock-Up Fires.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 217-222 pp, 1995.

fire research; cone calorimeters; furniture; furniture calorimeters; heat release rate

Twenty-seven combinations of fabric, barrier and polyurethane foam were tested in the form of full-scale mock-ups in a furniture calorimeter in accord with the California Technical Bulletin 133 protocol. These same combinations were tested in triplicate in the Cone Calorimeter at a flux of 35 kW/m2. The full scale data typically revealed two peaks of heat release, the first near the end of the gas burner igniter exposure and the second, if it occurred, much later. The first peak could not be well-correlated with average Cone rate of heat release data. A more elaborate correlation, suggested by dimensional analysis, and using more parameters from the Cone tests is more successful, particularly with charring fabrics. No correlations for the second full-scale heat release peak have been deduced thus far.

Ohlemiller, T. J.
Smoldering Combustion.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Handbook of Fire Protection Engineering. 2nd Edition. Section 2. Chapter 11, National Fire Protection Assoc., Quincy, MA, DiNenno, P. J.; Beyler, C. L.; Custer, R. L. P.; Walton, W. D., Editors, 2/171-179 p., 1995.

fire protection; fire protection engineering; smoldering combustion

Smoldering is a slow, low-temperature, flameless form of combustion, sustained by the heat evolved when oxygen directly attacks the surface of a condensed-phase fuel. Smoldering constitutes a serious fire hazard for two reasons. First, it typically yields a substantially higher conversion of a fuel to toxic compounds than does flaming (though this occurs more slowly). Second, smoldering provides a pathway to flaming that can be initiated by heat sources much too weak to directly produce a flame. The term smoldering is sometimes inappropriately used to describe a non-flaming response of condensed-phase organic materials to an external heat flux. Any organic material, when subjected to a sufficient heat flux, will degrade, gasify, and give off smoke. There usually is little or no oxidation involved in this gasification process, and thus it is endothermic. This is more appropriately referred to as forced pyrolysis, not smoldering. This chapter is restricted to consideration of post-initiation behavior of smoldering. There are a few models of smolder propagation in the literature but none sheds much light on any practical smolder problem. The state of modeling is reviewed elsewhere. Lacking any definitive theoretical description, this chapter is largely restricted to examining typical experimentally determined behavior. In this overview of smoldering, an attempt is made to convey some of the qualitative interplay of processes that determines overall behavior together with specific experimental results.

Ohlemiller, T. J.; Cleary, T. G.
Upward Flame Spread on Composite Materials.
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society. Fire and Polymers II: Materials and Tests for Hazard Prevention. National Meeting, 208th. ACS Symposium Series 599. August 21-26, 1994, Washington, DC, American Chemical Society, Washington, DC, Nelson, G. L., Editor, 422-434 pp, 1995.

fire retardants; flame retardants; composite materials; flame spread; experiments; heat flux; cone calorimeters

Three existing models of upward flame spread were tested against intermediate-scale experiments on a vinyl-ester/glass composite. Characterization of rate of heat release per unit area, needed as input to the models, was obtained at external radiant fluxes below the minimum for ignition by adaptation of a method due to Kulkarni. There are several limitations on the accuracy of the material characterization when applied to composites. Each of the flame spread models has definite limitations as well. Nevertheless, all three models produced predictions of spread behavior in sufficiently quantitative agreement with the experiments that they should prove useful for engineering analyses of flame spread potential.

Ohlemiller, T. J.; Shields, J. R.
Behavior of Mock-Ups in the California Technical Bulletin 133 Test Protocol: Fabric and Barrier Effects.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5653; 76 p. May 1995.
Available from National Technical Information Service
PB95-231585

fabrics; fire barriers; cone calorimeters; furniture; furniture calorimeters; heat release rate

Twenty-seven material combinations (seven fabrics, four barriers and two polyurethane foams) were tested in four cushion mock-up form in accord with California Technial Bulletin 133 using a furniture calorimeter. These same material combinations were also tested in triplicate, mainly at 35 kW/m2, in the Cone Calorimeter. Both mock-up and Cone sample behavior were recorded on video to facilitate behavioral comparisons of the samples; distinct differences were noted for thermoplastic fabrics. Heat fluxes were also measured on both scales; the effective "external" flux in full-scale can exceed 50 kW/m2. The mock-up behavior always comprised at least a heat release peak during the 80 second gas burner exposure; it often included a later and larger peak as well. The first peak could not be adequately predicted by average heat release data from the Cone. A dimensional analysis suggested a possible dependence on four additional parameters, three of which can be obtained from the Cone. A statistical fit of the available data to these more complex types of correlations appears to work best for charring fabrics; it helps improve the correlation for all types of fabrics but two material combinations were outliers. The second heat release peak in the mock-up tests is attributable to a "basal melt fire" mechanism; efforts to correlate this behavior with Cone results have been limited thus far and show little success.

Ohlemiller, T. J.; Shields, J. R.
Effect of Suppressants on Metal Fires.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5710; NIST SP 890; Volume 1; 26 p. August 1995.
Available from National Technical Information Service
PB96-109574
PB96-117775
Available from Government Printing Office
SN003-003-03371-5

Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. NIST SP 890. Volume 1, Gann, R. G., Editor, 97-119 pp, November 1995, 1995.

metal fires; halons; halon alternatives; magnesium; suppression; titanium

As part of a study to determine the impact of halon-alternative fire suppression agents on metal fires, small diameter rods (ca. 1-2 mm) of magnesium and titanium were burned in oxidizing atmospheres containing various percentages of agent vapor. Magnesium was burned in flowing air at pressures of 0.27 and 0.79 MPa (25 and 100 psig). Add-on levels of 5% and, in some cases 10%, by weight of halon 1301, HFC-125, HFC-227ea, FC-218 and CF3I were examined. In all cases, the burning, which had been vigorously established before agent vapor introduction, was extinguished. Titanium was burned in a flowing oxidizing gas containing 40 to 50% oxygen in nitrogen at pressures from 0.31 to 0.79 MPa (30 to 100 psig). Here only halon 1301, HFC-125 and HFC-226ea were added on, at 10% and 15% by weight. All three of these agents slowed, or, in certain cases extinguished, the burning process. Very limited data showed HFC-227ea to slow the burning rate less than did an equal add-on of HFC-125 or halon 1301. The suppressive impact of the agent vapors seen in this study is counter to that in previous studies where burning enhancement has been seen.

Ohlemiller, T. J.; Villa, K. M.; Braun, E.; Eberhardt, K. R.; Harris, R. H., Jr.; Lawson, J. R.; Gann, R. G.
Quantifying the Ignition Propensity of Cigarettes.
National Institute of Standards and Technology, Gaithersburg, MD
Fire and Materials, Vol. 19, No. 4, 155-169, July/August 1995.

cigarettes; ignition; test methods; effectiveness; data analysis; self-extinguishment

Research funded under the Fire Safe Cigarette Act of 1990 (United States Public Law 101-35) has led to the development of two test methods for measuring the ignition propensity of cigarettes. The Mock-Up Ignition Test Method uses substrates physically similar to upholstered furniture and mattresses: a layer of fabric over padding. The measure of cigarette performance is ignition or non-ignition of the substrate. The Cigarette Extinction Test Method replaces the fabric/padding assembly with multiple layers of common filter paper. The measure of performance is full-length burning or self-extinguishment of the cigarette. Routine measurement of the relative ignition propensity of cigarettes is feasible using either of the two methods. Improved cigarette performance under both methods has been linked with reduced real-world ignition behavior; and it is reasonable to assume that this, in turn, implies a significant real-world benefit. Both methods have been subjected to interlaboratory study. The resulting reproducibilities were comparable to each other and comparable to those in other fire test methods currently being used to regulate materials which may be involved in unwanted fires. Using the two methods, some current commercial cigarettes are shown to have reduced ignition propensities relative to the current best-selling cigarettes.

Olson, R. A.

Olson, R. A.; Christensen, B. J.; Coverdale, R. T.; Ford, S. J.; Moss, G. M.; Jennings, H. M.; Mason, T. O.; Garboczi, E. J.
Interpretation of the Impedance Spectroscopy of Cement Paste Via Computer Modelling.
Northwestern Univ., Evanston, IL
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Materials Science, Vol. 30, 5078-5086, 1995.

building technology; cement paste; electrical properties; freezing; impedance spectroscopy; percolation

The d.c. conductivity, sigma, and low-frequency relative dielectric, kappa, constant of Portland cement paset were monitored, using impedance spectroscopy, during cooling from room temperature down to -50 DGC. Dramatic decreases in the values of sigma and kappa, as great as two order of magnitude, occurred at the initial frezzing point of the aqueous phase in the macropores and larger capillary pores. This result provides strong experimental support for the dielectric amplification mechanism, proposed in Part II of this series, to explain the high measured low-frequency relative dielectric constant of hydrating Portland cement paste. Only gradual changes in the electrical properties were observed below this sudden drop, as

the temperature continued to decrease. The values of sigma and kappa of rrozen cement paste, at a constant temperature of -40 DGC, were dominated by properties of calcium-silicate-hydrate (C-S-H) and so increased with the degree of hydration of the paste, indicating a C-S-H gel percolation threshold at a volume fraction of approximately 15%-20%, in good agreement with previous predictions. Good agreement was found between experimental results and digital-image-based model computations of sigma at -40 DGC. Freeze-thaw cycling caused a drop in the dielectirc constant of paste in the unfrozen state, indicating that measurements of kappa could be useful for monitoring microstructural changes during freeze-thaw cycling and other processes that gradually damage parts of the cement paste microstructure.

P

Peacock, R. D.

Peacock, R. D.; Bukowski, R. W.; Babrauskas, V.
Defining Flashover for Fire Hazard Calculations.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology, Inc., Damascus, MD
Interagency Working Group on Fire and Materials (IWGFM) and the Federal Aviation Administration Technical Center. Fire Calorimetry. Proceedings. July 27-28, 1995, Gaithersburg, MD, Hirschler, M. M.; Lyon, R. E., Editors, 82-91 pp, 1995.

calorimetry; flashover; fire hazards; large scale fire tests; physical properties; computer simulation; temperature; heat flux; mathematical models; equations

The occurrence of flashover within a room is of considerable interest to the fire protection specialist since it is perhaps the ultimate signal of untenable conditions within the room of fire origin as well as a sign of greatly increased risk to other rooms within the building. A number of experimental studies of full scale fires have been performed that provide an adequate, but imprecise definition of flashover in terms of measurable physical properties. Computer simulations of the growth of a fire within a room are available.

Peacock, R. D.; Reneke, P. A.; Jones, W. W.; Bukowski, R. W.; Babrauskas, V.
Concepts for Fire Protection of Passenger Rail Transportation Vehicles: Past, Present, and Future.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology, Inc., Damascus, MD
Fire and Materials, Vol. 19, No. 2, 71-87, March/April 1995.

fire protection; passenger vehicles; transportation; heat release rate; hazard analysis; fire hazard; risk assessment; railroads

Recent advances in passenger rail transportation, fire test methods, and hazard analysis necessitate re-examination of requirements for fire safety. Several studies have indicated nearly random ability of current bench-scale tests to predict actual fire behavior. Fire safety in any application, including transportation, requires a multi-faceted approach. The effects of vehicle design, material selection, detection and suppression systems, and emergency egress and their interaction, on the overall fire safety of the passenger trains must all be considered. The strengths and weaknesses of current methods for measuring the fire performance of rail transportation systems are evaluated. A systems approach to fire safety which addressed typical passenger train fire scenarios is analyzed. A rationale is presented for the direction in which most fire science-oriented organizations in the world are clearly headed - the use of fire hazard and fire risk assessment methods supported by measurement methods based on heat release rate.

Persily, A. K.

Persily, A. K.
Improving the Evaluation of Building Ventilation.
National Institute of Standards and Technology, Gaithersburg, MD
Air and Waste Management Association. Annual Meeting and Exhibition, 88th. Proceedings. June 18-23, 1995, San Antonio, TX, 1995.

ventilation; building performance; diagnostics; mechanical ventilation; commercial buildings; evaluation

Ventilation evaluation is critical in building operation and maintenance, in building performance investigations and in building research. However, activities in these fields often do not always employ consistent or reliable approaches to ventilation evaluation. One reason for the variable consideration of building ventilation is the complexity of ventilation and air movement in large, multi-zone buildings and the variability of mechanical ventilation systems in these buildings. Other more specific reasons include the lack of, or in some cases the lack of use of, standardized approaches to assessing building ventilation, the cost and performance limitations of available instrumentation, and a lack of understanding of the available instruments and their use. A project is being conducted at NIST to identify approaches to improving these evaluations, to develop selected ventilation assessment protocols, and to identify research needed to make further advances in the field. This project has included a characterization of the applications of ventilation assessment in buildings, an identification of the objectives addressed by different approaches to ventilation assessment, and a review of existing protocols.

Phan, L. T.

Phan, L. T.; Cheok, G. S.; Todd, D. R.
Strengthening Methodology for Lightly Reinforced Concrete Frames: Recommended Design Guidelines for Strengthening With Infill Walls.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5682; 63 p. July 1995.
Available from National Technical Information Services
PB95-260725

building technology; concretes; dynamic analysis; frames; infill walls; quasi-static analysis; strengthening

A study of the sensitivity of the behavior of lightly reinforced concrete frames strengthened using the infill wall method to certain variables was conducted. These variables include the infill wall type (cast-in-place and precast), wall thickness, and the amount of anchor area and anchor type. The hysteretic behavior of the frames were predicted using three parameters and equations proposed in previous NIST work. Both quasi-static and transient dynamic analyses were performed using the program IDARC. General design guidelines are proposed based on these analyses and on observations gathered from existing experimental tests.

Pitts, W. M.

Pitts, W. M.
Global Equivalence Ratio Concept and the Formation Mechanisms of Carbon Monoxide in Enclosure Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Progressin Energy and Combustion Science, Vol. 21, 197-237, 1995.

carbon monoxide; enclosures; building fires; compartment fires; fire gases; global equivalence ratio; kinetic models; pyrolysis; reduced scale enclosures; ventilation; wood

This report summarizes a large number of investigations designed to characterize the formation of carbon monoxide (CO) in enclosures fires - the most important factor in fire deaths. It includes a review analysis of the studies which form the basis for the global equivalence ratio (GER) concept. Past and very recent (some as yet unpublished) investigations of CO formation in enclosure fires are reviewed. Based on the findings, two completely new mechanisms for the formation of CO, in addition to the quenching of a fire plume by a rich upper layer, which is described by the GER concept, are identified. The first is the result of reaction between rich flame gases and air which is entrained directly into the upper layer of an enclosure fire. Detailed chemical-kinetic modeling studies have demonstrated that CO will be generated by these reactions. The second is due to the direct generation of CO during the pyrolysis of oxygenated polymers (such as wood) which are located in highly vitiated, high-temperature upper layers. The findings of these studies form the basis of an analysis that provides the guidelines for when the use of the GER concept is appropriate for predicting CO formation in enclosure fires. It is concluded that there are limited conditions for which such use is justified. Unfortunately, these conditions do not include the types of fires which are responsible for the majority of fire deaths in building fires.

Pitts, W. M.
Species Concentration Measurements.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5766; November 1995.
Available from National Technical Information Service
PB96-131479
National Institute of Standards and Technology. Solid Propellant Gas Generators: Proceedings of the 1995 Workshop. June 28-29, 1995, Gaithersburg, MD, 147-172 pp, 1995.

concentration measurement; fire extinguishing agents; literature reviews; aspirated hot films; cold wires

The objective if this effort is to evaluate possible methods for real-time measurements of concentrations of alternative fire extinguishing agents for dry-bay and nacelle fire applications. If one or more feasible approaches are identified early in the investigation, a demonstration system will be developed for characterization under actual test situations.

Pitts, W. M.; Bryner, N. P.; Johnsson, E. L.
Combustion Product Formation in Under and Overventilated Full-Scale Enclosure Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 565-570 pp, 1995.

combustion; enclosures; combustion products; natural gas; carbon monoxide; oxygen concentration

The findings of an extensive series of over 140 natural gas fires in a 2/5ths-scale model of a standard room have been previously reported. The current work extends the earlier reduced-scale enclosure (RSE) study to a full-scale enclosure (FSE) and focuses on comparing the gas concentrations and temperatures of the upper layers. Both studies are part of a larger research effort which is designed to provide a better understanding and predictive capability for the generation of carbon monoxide, the major toxicant in fires. The findings will be incorporated into realistic fire models and used in development of strategies for reducing the number of deaths attributed to carbon monoxide.

Pitts, W. M.; Mulholland, G. W.; Breuel, B. D.; Johnsson, E. L.; Chung, S.; Harris, R. H., Jr.; Hess, D. E.
Real-Time Suppressant Concentration Measurement.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 2; Section 11; November 1995.
Available from Government Printing Office
SN003-003-03372-3
Available from National Technical Information Service
PB96-117783
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 2, Gann, R. G., Editor, 319-590 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; halon 1301; halon alternatives; aspirated hot films; cold wires; concentration fluctuations; concentration measurement; infrared detectors; infrared absorption; temperature measurements

The development and testing of two approaches for recording real-time measurements (millisecond time resolution) of concentration for halon alternatives are summarized. Discussions of the background necessary to understand their operation is included. The first instrument is a combined aspirated hot-film/cold-wire probe which is calibrated to record both temperature and concentration. The second is a specially developed instrument based on infrared absorption near 8.5 mm which has been dubbed the Differential InfraRed Rapid Agent Concentration Sensor (DIRRACS). A series of tests of the instruments in the full-scale dry-bay test facility at Wright-Patterson AFB is summarized. The characteristics of the current devices used to measure halon 1301 concentrations - the Statham analyzer and Halonyzer - are reviewed. The final section contains a literature review assessing other potential techniques for making the required concentration measurements.

Pommersheim, J. M.

Pommersheim, J. M.; Nguyen, T.; Zhang, Z.; Lin, C.
Cation Diffusion at the Polymer Coating/Metal Interface.
Bucknell Univ., Lewisburg, PA
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Adhesion Science Technology, Vol. 9, No. 7, 935-951, 1995.

building technology; cation ions; coatings; defect; diffusion; model; polymer/metal interface

Theoretical and experimental studies were carried out on the transport of cations in the channel between a polymer coating and a metal substrate from a defect in the absence of an applied electrical potential. The model consists of two stages: an initial period during which ions diffuse in the coating/metal interfacial 'channel' and adsorb on the coating surface, and a propagation period during which ions also diffuse into the coating. The mathematical models were solved to predict the cation concentration and flux under the coating and the relative rate of diffusion between the initial and propagation periods. Model parameter values were derived from the results of an experiment conducted in a specially designed diffusion cell. The experiment measured the depletion of Na+ ions in a cylindrical, central reservoir, which was placed within the perimeter of a defect through the coating of an epoxy-coated steel panel. Model predictions of concentration versus time agreed well with the experimental results, which showed that most of Na+ ions were removed by lateral diffusion from the reservoir during the initial period. Further, the transport during the initial period was much faster than that during the propagation period. The results also indicated that during the propagation period, the rate-limiting step was the lateral diffusion along the coating/metal interface rather than diffusion through the coating.

Putorti, A. D., Jr.

Putorti, A. D., Jr.; Walton, W. D.; Twilley, W. H.; Deal, S.; Albers, J. C.
Santa Ana Fire Department Experiment at 1315 South Bristol, July 14, 1994. Report of Test.
National Institute of Standards and Technology, Gaithersburg, MD
City of Santa Ana Fire Dept., CA
Fire Technology, Vol. 31, No. 1, 62-76, First Quarter 1995.
FR 3995; 21 p. August 31, 1994.
Available from National Technical Information Service
PB95-188868

fire departments; experiments; home fires; residential buildings; smoke detectors; sprinklers; temperature; large scale fire tests

This report of test addresses a fire experiment conducted on July 14, 1994 in a vacant single family dwelling at 1315 South Bristol Street in Santa Ana, California. Fire phenomena measured included: temperatures within various rooms, the velocity and temperature of outflowing cases, smoke detector activation time, sprinkler activation times, and time to full room involvement.

Q

Qian, C.

Qian, C.
Turbulent Flame Spread on Vertical Corner Walls.
University of Kentucky, Lexington
NIST-GCR-95-669; 161 p. April 1995.
Available from National Technical Information Service
PB96-114764

flame spread; turbulent flames; walls; corners; fire research; experiments; fire science; fire spread; heat transfer; polymethylmethacrylate; fire growth; flow visualization

Fire science is a rapidly growing research area. The motivation of fire research is to reduce fire loss and the cost of fire protection. Fire research is devoted to better understanding and prediction of fires. Flame spread is one of the most important phenomena in fire study because the spread rate is the measure of fire growth. In reality, flames are nearly all turbulent due to the large scale of building fires. Turbulent flame spread along vertical corner walls has the fastest spread rate among building fires. Because of the complex geometrical configuration and strong unsteady properties, the conventional instrumentations encounter great limitations. Therefore, there is relatively little data directly bearing on corner fire spreads. In this study, attention is given to the corner fire spread mechanism and the flame spread behavior. Infrared (IR) radiometry and image analysis techniques have been developed in this study to measure flame spread rate on large areas with high resulution and frequency. In addition to the flame spread measurement, the fire-induced flow was studied by flow visualization, and the total incident heat flux to the wall surface from the flame was measured by Gardon-type heat flux meters. Based on these experimental studies, a thermal model for corner fire spread has been successfully developed. The burning wall temperature measurement through flames using an IR imaging technique has been studied both theoretically and experimentally. For most materials, the constant emissivity 1.0 can be used to determine the pyrolysis front temperature due to soot deposition on the surface. The flame effect consists of band emissions mostly from excited CO2 and H2O and a continuous emission from soot particles. The effects of the band emissions can be eliminated by a bandpass filter (10.6 + 0.5 mm), and the soot particle effects can be neglected (epsilon < 0.03) for wall fires due to the small optical depth. Two-dimensional flame spread rate and the area of pyrolysis zone can be obtained by the IR imaging technique.

Qian, C.; Saito, K.
Measurements of Pool-Fire Temperature Using IR Technique.
University of Kentucky, Lexington
Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 81-86 pp, 1995.

combustion; pool fires; flame temperature; infrared spectroscopy; hexane; black body; temperature measurements; emissivity measurement

We made an attempt to measure the flame temperature of four different diameter hexane-pool-fires using IR technique. Emissivities for these four flames were estimated based on measurements of transmitted energy from a blackbody radiant source. The average flame temperature half way to the flame tip was 700-800 deg C, which was in good agreement with thermocouple-temperature measurements by others for a 3 m diameter hexane pool fire.

Qian, C.; Tashtoush, G.; Ito, A.; Saito, K.
Structure of Large Scale Pool Fires.
Kentucky Univ., Lexington
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 147-152 pp, 1995.

fire research; pool fires; experiments; temperature measurements; thermocouples; velocity measurement; combustion; in situ burning

Combustion, as a tool to mitigate spilled oils on the ocean surface, turned out to be more feasible compared to other possible means by converting rapidly large quantities of oil into its primary combustion products, carbon dioxide and water, with a small percentage of other unburned and residue byproducts. According to Evans et al, "In-situ burning of spilled oil has distinct advantage over other counter measures. It requires minimal equipment and less labor than other techniques. It can be applied in areas where many other methods can't due to lack of response infra-structure and/or lack of alternatives." To establish an effective combustion method which has a high burning rate and emit only environmentally acceptable products, we need to understand the structure of large crude oil fires is not well understood.

R

Raufaste, N. J.

Raufaste, N. J.
NIST Building and Fire Research Laboratory Projects Summaries, 1995.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-8; 213 p. August 1995.
Available from Government Printing Office
SN003-003-03350-2
Available from National Technical Information Service
PB95-270047

building technology; building control; coatings; combustion; flammability; computer integrated construction; concretes; earthquakes; earthquake engineering; fire dynamics; fire hazards; fire physics; fire safety; heat transfer; moisture; indoor air quality; lighting; quality assurance; refrigeration; smoke dynamics; structural performance; suppression; test procedures; toxicity; fire research

Construction is one of the Nation's largest industries. In 1994, total construction amounted to about $847 billion whis is 12.5% of U.S. GDP (new construction put in place amounted to about $508 billion and renovation contributed about $339 billion). U.S. construction accounts for more than 10 million jobs. Fires and natural disasters destroy a significant portion of constructed facilities every year. Costs of fire safety and fire losses exceed $128 billion a year. Natural disasters cause tens of billions of dollars annually. For example, since 1993, the United States experienced significant property losses from the Mid-West Floods; Hurricanes Andrew and Iniki; the January 1994 Northridge Earthquake; the numerous west coast wildfires that resulted in significant damage to the built environment; among other natural phenomenathat occur each year. The quality of constructed facilities directly affects the productivity of the U.S. building and fire communities and affects the safety and quality of life of all constructed facilities. Over 60% of the nation's wealth is invested in constructed facilities. This report summarizes BFRL's research for 1995. The report is arranged by its research programs: structural engineering, materials engineering, mechanical and environmental systems, fire safety and engineering, fire science, and applied economics. Each summary lists the project title, the BFRL point of contact, sponsor, research, and recent results. BFRL's mission is to increase the usefulness, safety, and economy of constructed facilities and reduce the human and economic costs of unwanted fire in buildings.

Richards, R. F.

Richards, R. F.; Munk, B. N.; Plumb, O. A.; Grosshandler, W. L.
Fire Detection and Location Through Inverse Problem Solution.
Washington State Univ., Pullman
National Institute of Standards and Technology, Gaithersburg, MD
University of Duisburg. International Conference on Automatic
Fire Detection "AUBE '95", 10th. April 4-6, 1995, Duisburg, Germany, Luck, H., Editor, 170-179 pp, 1995.

fire detection; heat transfer; algorithms; heat release rate; fire data; compartment fires; fire models; simulation

A proposed method of detecting, locating, and sizing accidental fires based on the solution of an inverse heat transfer problem is described. The accuracy of the inverse problem solution algorithm, both in locating fires and determining their heat release rate is evaluated using computer synthesized fire data. The validity of the evaluation is verified using published measurements from large scale compartment fire burns.

Richards, R. F.; Plumb, O. A.
Fire Detection and Location Through Inverse Problem Solution.
Washington State Univ., Pullman
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 312-317 pp, 1995.

fire research; fire detection; fire detection systems; fire models; algorithms

A prototype system which can detect, locate, and size an accidental fire within the first few minutes of the fire's ignition is presented. The prototype system employs a black and white video camera to monitor color-changing temperature sensitive sensors distributed around the space to be protected. Transient temperatures revealed by the sensors and gathered by the video camera are used as data to locate and size the fire in an algorithm based on the solution of an inverse heat transfer problem. Limits on the accuracy of the inverse problem solution algorithm, both in locating fires and determining their heat release rate

are established using computer synthesized fire data. The validity of the computer simulations is verified with results of experimental tests of the prototype detection system in locating and sizing flame sources in a lab scale enclosure.

Rode, C.

Rode, C.; Burch, D. M.

Empirical Validation of a Transient Computer Model for Combined Heat and Moisture Transfer.

Danish Building Research Institute, Horsholm, Denmark

National Institute of Standards and Technology, Gaithersburg, MD

Thermal Performance of the Exterior Envelopes of Buildings VI Conference. Proceedings. December 4-8, 1995, Clearwater Beach, FL, 283-295 pp, 1995.

heat transfer; moisture; validation; computer models; condensation; mass transfer; measurement; modeling

A computer program for transient modeling of combined heat and moisture transfer in building constructions is introduced. The model's predictions are compared against mositure content and heat flux data obtained for six typical North American lightweight wall constructions that have been exposed to climatic conditions in a calibrated hot box. A special aspect of the work was that the basic moisture and thermal transport properties were determined for each individual material in the walls. The experiment, and thus the validation, was restricted to diffusive transport mechanisms taking place in the hygroscopic region. Using the detailed information on the material properties, the program was able to predict the measured moisture content of the walls' siding and sheathing materials to within approximately 1% moisture content by weight, and the heat flows were predicted with a satisfactory accuracy. In a subsequent sensitivity andalysis, the moisture transport properties were described as simpler functions or selected arbitrarily from a database of ordinary building materials. In some cases, this had a noticeable effect on the resulting moisture contents. It is suggested that transient heat and moisture transport models can be used in the design and analysis of constructions if the user is knowledgeable about the workings of such models and cautious in interpreting the results.

Rossiter, W. J., Jr.

Rossiter, W. J., Jr.; Byrd, W. E.; Roberts, W. E.; Bailey, D. M.

Applicability of Modern Analytical Techniques to Detection of Changes in Roofing Membrane Materials Brought About By Heat Aging.

National Institute of Standards and Technology, Gaithersburg, MD

U.S. Army Construction Engineering Research Laboratories, Champaign, IL

International Waterproofing Association. International Congress, 9th. April 26-28, 1995, Amsterdam, Netherlands, International Waterproofing Association, 244-242 pp, 1995.

building technology; roofs; heat; aging; membranes

The U.S. Army Construction Engineering Research (CERL) has been investigating the development of a test methodology for evaluating the service life of roofing membrane materials. As part of this effort, CERL conducted a study to investigate the applicability of strain energy (a mechanical test) and Fourier transform infrared (FTIR) spectroscopy (a chemical analysis) as methods for characterizing changes that roofing membrane materials may undergo upon exposure to elevated temperatures. In the case of FTIR, the intent was to evaluate whether changes in the carbonyl index as a function of thermal exposure could be used as an indicator of the stability of the membrane materials. The carbonyl index is the ratio of the intensity of the carbonyl absorption band (i.e., C=O) to that of another band (such as C-H stretching or bending) in the spectrum. Increases in a material's carbonyl index after exposure may be an indication that oxidation occurred during the exposure. Measurements of both strain energy and carbonyl index have been used for specific types of membrane materials. Neither has been applied universally to the variety of membrane materials currently available.

Rothfleisch, P. I.

Rothfleisch, P. I.
Simple Method of Composition Shifting With a Distillation Column for a Heat Pump Employing a Zeotropic Refrigerant Mixture.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5689; 27 p. July 1995.
Available from National Technical Information Service
PB95-255821

heat pump; air conditioning; distillation; refrigerant mixtures; refrigeration; zeotropic refrigerants

This work presents a simplified method of controlling heat pump capacity by shifting the composition of a zeotropic refrigerant mixture with a distillation column. Simplicity is achieved by incorporating the distillation column into the typical suction accumulator used by residential heat pumps. A U.S. patent has been applied for under the title "Accumulator Distillation Insert for Zeotropic Mixtures". An experimental system employing this distillation concept has been evaluated in the laboratory for zeotropic mixtures of R32/134a (30/70) and R32/125/134a (23/25/52). For the binary mixture the circulating refrigerant composition was shifted to R32/134a (54/46). For the ternary mixture the circulating refrigerant composition was shifted to R32/125/134a(36/36/28). Seasonal calculations have shown these composition shifts to reduce the seasonal resistance heat requirement by up to five percent compared to R22. Additionally, the instantaneous peak energy requirement of the dwelling has been reduced relative to R22 by six to nine percent depending on the climate region. The distillation insert should be capable of producing greater composition shifts after further optimization of the insert and improved integration with the heat pump system. For the ternary mixture, it is expected that the insert will be capable of producing a circulating refrigerant composition composed entirely of R32/125.

Rushmeier, H.

Rushmeier, H.; Hamins, A.; Choi, M. Y.
Volume Rendering of Pool Fire Data.
National Institute of Standards and Technology, Gaithersburg, MD
Illinois Univ., Chicago
IEEE Computer Graphics and Applications, Vol. 15, No. 4, 62-66, July 1995.

pool fires; volume; irradiation; computation

In a pool fire, an ignited puddle or pool of liquid fuel burns in the atmosphere. Understanding pool fires is important to devising methods to control the hazards resulting from spilled fuels. In this case study we consider techniques for visualizing the data measured in pool fires and for computing the radiative transfer from pool fires. Combustion challenges the development of appropriate visualization techniques. Fires are turbulent, non-steady, and multi-wavelength in emission. Moreover, fire data belongs to a class of visualization problems for which it is important to consider the radiative simulation used to generate visualizations.

S

Sanders, P. A.

Sanders, P. A.; Collins, B. L.
Post-Occupancy Evaluation of the Forrestal Building. January 1993-December 1994.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5591; 67 p. March 1995.
Available from National Technical Information Service

building technology; contrast; energy efficiency; environmental assessment; federal relighting; illuminance; lighting; luminance; post-occupancy evaluation; temperature; VDTs

A post-occupancy evaluation was performed on the Department of Energy Headquarters Building (the Forrestal Building) in Washington, DC. The lighting in the building was retrofitted with new, more energy-efficient, components to meet energy target guidelines. Occupant responses to the indoor environmental conditions, particularly the lighting, were studied to determine the impact of the relighting on the building inhabitants. In addition, physical measures of the lighting and other environmental conditions before and after the relighting were compared. The post-occupancy evaluation employed a questionnaire about the environmental conditions and physical measures of the space (lighting, space, noise, temperature, etc.) A total of 244/220 people participated (before and after the relighting, respectively). Physical measures were taken at 100 work stations before the relighting and 75 after. Analysis of the physical measurement data indicated generally higher lighting levels with more even distribution of luminances in the offices. Occupant response to the changes in the lighting was generally quite positive. The relighting was perceived to have improved the appearance of the building substantially, as well as the lighting within individual workstations. Finally, guidance is given for doing post-occupancy evaluations as part of other relighting initiatives.

Schechter, M. M.

Schechter, M. M.; Schechter, E.; Simiu, E.
Developmental Computer-Based Version of ASCE 7-95 Standard Provisions for Wind Loads.
Expert Systems Consultants, Kaiserslautern, Germany
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1415; 55 p. November 1995.
Available from Government Printing Office
SN003-003-03377-4

building technology; aerodynamics; building codes; climatology; structural engineering; wind engineering

This report includes a brief introduction to and description of the wind loading provisions of the ASCE (American Society of Civil Engineers) Standard 7-95. An interactive computer program representing those provisions was developed and tested by the authors and NIST staff. The resulting software is included in a diskette presented in this report. Instructions for the user of the program are also included. An appendix contains excerpts from a large number of calculaitons aimed at verifying the performance of the interactive program. Following its completion, the program was submitted for bets-testing by an ASCE-assembled team. The program presented in this report does not reflect the results of that testing, and is not an official version of the ASCE 7-95 Standard. A main purpose of this report is to serve the needs of professionals interested in the application of knowledge systems to the development of computer-based models of standards.

Schwartz, L. M.

Schwartz, L. M.; Garboczi, E. J.; Bentz, D. P.
Interfacial Transport in Porous Media: Application to dc Electrical Conductivity of Mortars.
Schlumberger-Doll Research, Ridgefield, CT
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Applied Physics, Vol. 78, No. 10, 5698-5908, November 15, 1995.

building technology; concretes; durability; effective medium theory; electrical conductivity; interfacial zone; mortar; percolation; fluid flow

A mortar is a composite of inert sand grains surrounded by a porous cement paste matrix. We investigate the electrical conductivity of model mortars that include enhanced electrical conduction in the matrix-sand grain interfacial region. The electrical conductivity is evaluated by a combination of finite element, finite difference, and random walk methods for periodic and disordered models of mortar. Since the effective conductivity within the interfacial zone is often much higher than the bulk matrix conductivity, the qualitative features of transport in these systems is often controlled by the connectivity of the interfacial zone. Special attention is thus given to the geometrical percolation of this zone. A family of effective medium approximations give a good qualitative description of the disordered model's electrical properties. A simple four parameter Pade approximant is found to successfully describe the electrical conductivity of the periodic model over the entire range of parameters studied. Finally, we show that our calculations can be used to obtain a reasonable estimate of the permeability to viscous fluid flow.

Shaddix, C. R.

Shaddix, C. R.; Everest, D. A.; Smyth, K. C.
Laser Measurements of Soot and CO Production in Time-Varying, Hydrocarbon Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
University of California, Berkeley. Toxic Toxic Combustion Byproducts. 4th International Congress. June 5-7, 1995, Salt Lake City, UT, 59 pp, 1995.

combustion; soot; carbon monoxide; diffusion flames; hydrocarbons; lasers

Most combustion systems of practical interest involve hydrocarbon diffusion flames, in which chemical processes are strongly coupled to fluid mechanical mixing of the reactants through heat release. In complex flowfields, such as turbulent flames, many combinations of residence times, temperature histories, local stoichiometries, and strain rates exist which are not accessible in steady, laminar diffusion flames. One might anticipate that chemistry-flowfield interactions will have a dramatic impact whenever chemical reaction times are comparable to or slower than mixing rates. In particular, the rates of soot mass growth as well as of soot and carbon monoxide oxidation are relatively slow, and thus the production and emission of soot and CO should be strongly sensitive to the complex, time-varying flowfields present in flickering flames.

Shaddix, C. R.; Harrington, J. E.; Smyth, K. C.
Comment and Reply on "Quantitative Measurements of Enhanced Soot Production in a Flickering Methane/Air Diffusion Flame."
Southwest Research Inst., San Antonio, TX
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 100, 518, 1995.

diffusion flames; extinction; lasers; incandescence; methane; soot

Shenton, H. W., III

Shenton, H. W., III; Cassidy, M. M.
Field Evaluation of the System for Calibration of the Marshall Compaction Hammer.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5553; FHWA-RD-95-063; 76 p. February 1995.
Available from National Technical Information Service
PB95-190674

compaction hammer; Marshall method; asphalt; bituminous; building technology; calibration; pavement design; standards; tests

A system for calibrating the Marshall compaction hammer has recently been developed at the National Institute of Standards and Technology, in collaboration with the American Association of State Highway Transportation Officials (AASHTO), Materials Reference Laboratory (AMRL). The calibration system consists of a spring-mass device with an integral force transducer and a high-speed data acquisition system. The force delivered by the hammer to the calibration device is recorded as a function of time and analyzed to determine the peak force and impulse. Time histories from a series of hammer blows are analyzed to determine the average peak force, average impulse, and cumulative impuse. The proposed calibration procedure is based on adjusting the number of hammer blows delivered to a specimen, such that a standard compactive effort is supplied during the compaction process, regardless of slight variations in the Marshall hammer. In an earlier laboratory evaluation program, the calibration system and procedure proved to effective in reducing the variability of Marshall test results. Presented in the report is a summary of a field evaluation program of the calibration system and procedure. In this study, Marshall specimens were prepared in bituminous laboratories using "production"Marshall hammers: twelve laboratories, or field "sites", participated in the study. Sixteen Marshall specimens were prepared at each site. Four specimens were prepared using a standard 50-blow Marshall procedure and four using a standard 75-blow Marshall procedure; these are referred to as the uncalibrated specimens. Four specimens were prepared using a calibrated blow count corresponding to a standard 50-blow cumulative impulse, and four were prepared using a calibrated blow count corresponding to a standard 75-blow cumulative impulse; these are referred to as the calibrated specimens. Height, air voids, flow and stability were determined for each of the specimens. Results were compiled and analyzed to determine the between-laboratory variability of the data for the uncalibrated and calibrated specimens. The system was, in general, ineffective in reducing the between-laboratory variability of the test results in the full data set. The variability of the calibrated test results increased or decreased relative to the uncalibrated results for different specimen properties. The system was effective, however, in reducing the variability of the test results when evaluated in the reduced data set, that included results from nine sites; data from three sites were eliminated in the statistical analysis because these results were believed to be flawed, in a way that may have compromised the Marshall test results. In the reduced data set, the variability of the calibrated test results decreased by as much as thirty percent, relative to the uncalibrated results. One possible explanation for the marginal reduction in variability with calibration is that the study sample of Marshall hammers was typical of the total population: nine of the twelve machines were from the same manufacturer, and six of those were less than three years old. The machines provided reasonably consistent results, thus, there was little room for improvement. This is supported by comparison of the uncalibrated test results to data from the AASHTO Materials Reference Laboratory, Proficiency Sample Program.

Simiu, E.

Simiu, E.
Estimation of Extreme Wind Speeds.
National Institute of Standards and Technology, Gaithersburg MD
Indian Society for Wind Engineering. Sponsored by University of Roorkee, New Delhi. International Association for Wind Engineering. State of the Art in Wind Engineering. Volume 1. Proceedings. International Conference on Wind Engineering, 9th. Davenport Sixtieth Birth Anniversary Volume. January 9-13, 1995, New Delhi, India, Wiley Eastern Limited, New Delhi, India, 109-123 pp, 1995.

wind velocity; building technology; climatology; extreme value theory; statistics; wind engineering; wind loads

Extreme wind loads used in design include nominal design wind loads (e.g., the 50-yr wind load) and ultimate wind loads. This paper breifly reviews the relationship between extreme wind loads and extreme wind speeds, assessments of epochal versus 'peak-over-threshold' approaches for estimating extreme non-tornadic winds in areas not subjected to tropical storms, and methods for estimating extremes from short records. Also reviewed are wind direction effects, and the estimation of extreme winds due to tropical cyclones (hurricanes) and tornadoes. We point out uncertainties due to model shortcomings and insufficient data, safety concerns due to current inconsistent uses of reliability concepts, and the implications of these concerns for code writing.

Simiu, E.; Franaszek, M.
Efficient Open-Loop Control for a Class of Stochastic Multistable Systems.
National Institute of Standards and Technology, Gaithersburg, MD
University of Victoria. CANCAM 95. Canadian Congress of Applied Mechanics, 15th. Proceedings. Volume 2. May 28-June 1, 1995, Victoria, British Columbia, Tabarrok, B.; Dost, S., Editors, 780-781 pp, 1995.

building technology; chaos; control; dynamical systems; exit rate; Melnikov processes; stochastic dynamics

The performance of certain nonlinear stochastic systems is deemed acceptable if, during a specified time interval, the systems have sufficiently low probabilities of escape from a preferred region of phase space. These probabilities can be reduced by using an appropriate control system. We propose a Melnikov-based approach to achieving an efficient open-loop control. The approach is applicable to the wide class of multistable systems that have dissipation- and excitation-free counterparts possessing homoclinic or heteroclinic orbits. That class includes, e.g., the rf Josephson junction and the Duffing equation, and higher- and infinitely-dimensional systems. We review the theoretical basis of our approach, use numerical simulations to test its effectiveness for the paradigmatic case of the stochastically excited Duffing equation, and discuss our results.

Simiu, E.; Frey, M.; Hagwood, C.
Melnikov Necessary Condition for Noise-Induced Escapes.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
International Conference on ICASP, 7th Proceedings. Applications of Statistics and Probability. July July 10-13, 1995, 1137-1142 pp, 1995.

noise (sound); Melnikov function; equations; escape means

For a wide class of nonlinear multistable deterministic systems, a necessary condition for the occurrence of chaos - and jumps between phase space regions associated with potential wells - is that the system's Melnikov function have simple zeros. The work presented in this paper is based on our extension of the Melnikov-based approach to a class of nonlinear stochastic differential equations with additive or multiplicative noise. The mean zero upcrossing rate for the stochastic system's Melnikov process is a weak upper bound for the system's mean escape rate. For systems excited by processes with tail-limited distributions the stochastic Melnikov approach yields a simple criterion guaranteeing the non-occurrence of chaos. This is illustrated for excitation by square wave, coin-toss dichotomous noise.

Simiu, E.; Grigoriu, M.
Non-Gaussian Noise Effects on Reliability of Multistable Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Cornell Univ., Ithaca, NY
Journal of Offshore Mechanics and Arctic Engineering, Vol. 117, No. 3, 166-170, August 1995.

noise (sound); equations; structural stability

For certain types of compliant structures the designer must consider limit states associated with the onset of fluidelastic instability. These limit states may include bifurcations from motion in a safe region of phase space to chaotic motion with exits (jumps) out of the safe region. In practice such bifurcations occur in systems with noisy or stochastic excitations. For a wide class of dynamical systems, a fundamental connection between deterministic and stochastic chaos allows the application to stochastic systems of a necessary condition for the occurrence of chaos obtained by Melnikov for the deterministic case. We discuss the application of this condition to obtain probabilities that chaotic motions with jumps cannot ocur in multistable systems excited by processes with tail-limited marginal distributions.

Simiu, E.; Hagwood, C.
Exits in Second-Order Nonlinear Systems Driven by Dichotomous Noise.
National Institute of Standards and Technology, Gaithersburg, MD
Computation of Stochastic Mechanics, 2nd International Conference. Proceedings. June 13-15, 1994, Athens, Greece, Balkema, Rotterdam, Spanos, P. D., Editor, 395-401 pp, 1995.

building technology; chaos; dichotomous noise; dynamical systems; exit time; Melnikov function; stochastic process

We consider a wide class of lightly damped second-order differential equations with double-well potential and small coin-toss square wave dichotomous noise. The behavior of these systems is similar to that of their harmonically or quasiperiodically driven counterparts: depending upon the system parameters the steady-state motion is confined to one well for all time or experiences exists from the wells. This similarity suggests the application to the stochastic systems of a Melnikov-based approach originally developed for deterministic systems. This approach accommodates both additive and multiplicative noise. It yields a generalized Melnikov function which is used to obatin (i) a simple condition guaranteeing the non-occurrence of exits from a well, and (ii) weak lower bounds for the mean time of exit from a well and for the probability that exits will not occur during a specified time interval.

Simiu, E.; Heckert, N. A.
Extreme Wind Distribution Tails: A 'Peaks Over Threshold' Approach.
National Institute of Standards and Technology, Gaithersburg, MD
NIST BSS 174; 77 p. March 1995.
Available from National Technical Information Service
PB95-219416
Available from Government Printing Office
SN003-003-03322-7

extreme value theory; threshold methods; wind effects; meteorology; building technology; building codes; climatology; load factors; structural engineering; wind velocity; structural reliability

We seek to ascertain whether the reverse Weibull distribution is an appropriate extreme wind speed model by performing statistical analyses based on the 'peaks over threshold' approach. We use the de Haan method, which was found in previous studies to perform about as well or better than the Pickands and Cumulative Mean Exceedance methods, and has the advantage of providing estimates of confidence bounds. The data are taken principally from records of the largest daily wind speeds obtained over periods of 15 to 26 years at 44 U.S. weather stations in areas not subjected to mature hurricane winds. From these records we create samples with reduced mutual correlation among the data. In our opinion, the analyses provide persuassive evidence that extreme wind speeds are described predominantly by reverse Weibull distributions, which unlike the Gumbel distribution have finite upper tail and lead to reasonable estimates of wind load factors. Instructions are provided for accessing the data and attendant programs.

Sivathanu, Y. R.

Sivathanu, Y. R.; Hagwood, C.; Simiu, E.
Exits in Multistable Systems Excited by Coin-Toss Square-Wave Dichotomous Noise: A Chaotic Dynamics Approach.
Purdue Univ., West Lafayette, IN
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review E, Vol. 52, No. 5, 4669-4675, November 1995.

noise (sound); exits; Melnikov process

We consider a wide class of multistable systems perturbed by a dissipative term and coin-toss square-wave dichotomous noise. These systems behave like their harmonically or quasiperiodically driven counterparts: depending upon the system parameters, the steady-state motion is confined to one well for all time or experiences exits from the wells. This similarity suggests the application to the stochastic systems of a Melnikov approach originally developed for the deterministic case. The noise induces a Melnikov process that may be used to obtain a simple condition guaranteeing the nonoccurrence of exits from a well. For systems whose unperturbed counterparts have phase space dimension 2, if that condition is not satisfied, weak lower bounds can be obtained for (a) the mean time of exit from a well and (b) the probability that exits will not occur during a specified time interval.

Sivathanu, Y. R.; Hamins, A.; Hagwood, C.; Kashiwagi, T.
Tomographic Reconstruction of the Local PDFS of Soot Volume Fraction and Temperature.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 92-97 pp, 1995.

combustion; soot; volume; temperature; turbulent flames; diffusion flames; probes; equations; optical pyrometers

Deconvolution of local properties from line-of-sight measurements is important in a wide variety of applications such as x-ray tomography, nuclear magnetic resonance imaging, atmospheric sciences, optical inteferometry and flow field diagnostics. The Radon Transforms form the theoretical basis for retrieving local properties from path integrated measurements under steady state conditions. These methods have found wide-spread application in tomographic spectroscopy of laminar flames. For turbulent flow fields, conventional deconvolution algorithms cause greater difficulty due to the transient nature of the phenomena being studied. Progress has been made in obtaining ultra-fast multiple angle and multiple ray measurements in a turbulent flow field over a small time interval. This technique has limited temporal resolution and suffers from a high degree of deconvolution noise due to the asymmetric nature of the instantaneous flow field. Recently, a discrete probability function (DPF) method was developed to deconvolute path integrated measurements in order to obtain the local PDFs of soot volume fractions in turbulent flames. The objective of this work is to extend the DPF method to obtain local PDFs of soot volume fraction and temperature from path integrated measurements of emission intensities. The deconvolution method is evaluated by synthetic noise-free data as well as experimental data obtained using an intrusive optical pyrometer.

Snyder, K. A.

Snyder, K. A.; Clifton, J. R.
4SIGHT Manual: A Computer Program for Modelling Degradation of Underground Low Level Waste Concrete Vaults.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5612; 73 p. June 1995.
Available from National Technical Information Service

PB95-231593

building technology; computer models; concretes; corrosion; corrosion of reinforcement; degradation; leaching; radioactive wastes; service life; sulfate attack

A computer program has been written to facilitate performance assessment of concrete vaults used in Low Level Waste (LLW) disposal faciliites. The computer program is a numerical computer model of degradation in concrete. A one-dimensional finite difference equation is used to propagate ions by precipitation/dissolution of available salts. The precipitation/dissolution of salts, in turn, changes the transport properties, which changes the rate of ion transport. The result is a model which incorporates the synergism of multiple degradation mechanisms. This Report is self-contained. It includes the installation instructions, user manual, technical details, and source code. The program was written using a literate programming tool and the "pretty-printing" output of the source code is attached at the end of this report.

Sorensen, C. M.

Sorensen, C. M.; Feke, G. D.

Post-Flame Soot.

Kansas State Univ., Manhattan

National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 281-285 pp, 1995.

fire research; smoke; soot; diffusion flames; equations; fractal dimensions; kinetics

We have used an acetylene diffusion flame to create carbonaceous soot. The soot has been physically collected from all portions of the flame and the post-flame region. Inspection of the soot was performed with both transmission electron and optical microscopy. We measure soot cluster radius of gyration and show that these clusters retain their fractal morphology over nearly four orders of magnitude in size. The average fractal dimension is consistent with diffusion Limited Cluster Aggregation (DLCA). We also give evidence that the kinetics of growth when the soot clusters are on the order of lmm may be a gelation mechanism.

Stone, W. C.

Stone, W. C.

Fast Variable-Amplitude Cold Gas Thruster.

National Institute of Standards and Technology, Gaithersburg, MD

Journal of Spacecraft and Rockets, Vol. 32, No. 2, 335-343, March/April 1995.

cold gas thruster; amplitude control; piezoelectric stack; structural dynamics; system identification

A fast response variable amplitude cold gas thruster is described. A laboratory prototype comprised of a piezoelectric stack and an associated microporcessor-based programmable dc power source, a low-loss mechanical displacement amplifier, a high-pressure spring-loaded axial valve, an integral high-pressure valve seat; an expansion nozzle, and a high-pressure gas supply were constructed and tested. The device is designed to operate as a stand-alone unit with a dedicated onboard microcontroller system and onboard energy storage system. Minimum pulse-width resolution (base-to-base) was shown to be 0.98 ms, with a lag time of 0.37 ms relative to the initiation of the drive pulse. Linear amplitude response was achieved beyond a threshold drive voltage of 80 vdc and was maintained through the limit of testing at 240 vdc.

Stone, W. C.; Cheok, G. S.; Stanton, J. F.

Performance of Hybrid Moment-Resisting Precast Beam-Column Concrete Connections Subjected to Cyclic Loading.

National Institute of Standards and Technology, Gaithersburg, MD
ACI Structural Journal, Vol. 91, No. 2, 229-249, March/April 1995.

building technology; beam-colume; concretes; connections; cyclic loading; joint; precast; post-tensioning; story drift

Test results of ten hybrid precast concrete beam-to-column connections are presented. These tests constitute Phave IV of an experimental program on 1/3-scale model precast moment resisting connections conducted at the National Institute of Standards and Technology (NIST). The objective of the test program is to develop guidelines for the design of moment-resisting precast connections in regions of high seismicity. The hybrid connections consist of mild steel used to dissipate energy and post-tensioning (PT) steel used to provide the required shear resistance. Variables examined were the amount and type of mild steel (ASTM A 615). The amount of post-tensioning steel was varied to control the relative moment capacity contributed by the PT and mild steel. The specimens were subjected to reversed cyclic loading in accordance with a prescribed displacement history. Connection performances were compared to previous NIST tests based on energy dissipation capacity, connection strength, and drift capacity. Hybrid precast connection can be designed to match or exceed the performance of a monolithic connection in terms of energy dissipation, strength, and drift capacity.

Stoudt, M. R.

Stoudt, M. R.; Fink, J. L.; Dante, J. F.; Ricker, R. E.
Compatibility With Metals.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; Section 5; November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1. Section 5, Gann, R. G., Editor, 121-200 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; metals; compatibility; experiments; corrosion; halon 1301; halon alternatives

Stroup, D. W.

Stroup, D. W.; Madrzykowski, D.
Modeling Smoke Flow in Corridors.
General Services Administration, Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 377-382 pp, 1995.

fire research; corridors; smoke; handicapped; experiments; fire models; fire risk; staging areas

The Public Buildings Service (PBS) within the General Services Administration (GSA) is the Federal government's real property manager responsible for the acquisition, design, construction, and operation and management of various types of space for Federal agencies. As part of its responsibility, the GSA must ensure the fire and life safety of the employees and visitors occupying the space under its control, protect Federal real and personal property assets, ensure continuity of the mission of occupant agencies, and provide safeguards to allow emergency forces to accomplish their missions if an incident occurs.

Stutzman, P. E.

Stutzman, P. E.; Centeno, R. L.
Compositional Analysis of Beneficiated Fly Ashes.
National Institute of Standards and Technology, Gaithersburg, MD
Centro Nacional De Metrologia, Queretaro, Mexico
NISITR 5598; 23 p. May 1995.
Available from National Technical Information Service

building technology; composition; concretes; fly ash; mineralogy; mortar; particle size; reaction kinetics

Understanding the material properties of mineral admixtures will help in providing a better understanding of the factors that control their performance in concrete. This study, a part of an effort by that includes reaction kinetics, microstructure development, and simulation modelling, examines the composition of the crystalline components of beneficiated fly ashes of different origin. Different sized fractions of fly ashes produced by burning coal in different boilers were examined by scanning electron microscopy and x-ray powder diffraction. Each fly ash fraction was predominantly glassy material with minor amounts of quartz, mullite, anhydrite, magnetite, hematite, calcium oxide, and possibly periclase. The glassy fraction increased slightly with ash fineness and, for each size fraction, was typical of silicious glasses found in other fly ashes. Images of microstructures of mortars incorporating 25%, by mass, fly ash replacement for cement show increased packing density with the finer ash fractions. The presence of unreacted fly ash and calcium hydroxide in the mortars after 60 days of wet curing indicates that the pozzolanic reaction is not complete. The similarity of ash phase compositions suggests that, at this age, strength gain may be influenced more by the particle size than by compositional differences among the ash fractions and ashes produced under different firing temperature.

Suh, J.

Suh, J.; Atreya, A.
Effect of Water Vapor on Counterflow Diffusion Flames.
University of Michigan, Ann Arbor
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 103-108 pp, 1995.

fire research; diffusion flames; water vapor; flame temperature; temperature measurements; equations; flame structure; temperature profiles; hydroxyl radicals

The chemical and physical effect of water vapor on the structure of counterflow diffusion flames is investigated both experimentally and theoretically. The experimental flame structure measurements consist of profiles of temperature, stable gases and hydrocarbons, soot and OH radical concentrations and spatially resolved radiative emission measurements. These experimental measurements are compared with numerical calculations with detailed C2 chemistry. For these computations, experimentally measured temperature profiles were used instead of the energy equation to more accurately describe the flame radiative heat losses. The flame structure results show that as the water vapor concentration is increased, the OH radical concentration increases. This increases the flame temperature and the CO2 production rate and decreases the CO production rate. However, after approximately 30% water vapor substitution, the chemical enhancement by water vapor is not observed and the flame temperature begins to decrease.

T

Tinker, S.

Tinker, S.; diMarzo, M.; Tartarini, P.; Chandra, S.; Quiao, Y. M.
Dropwise Evaporative Cooling: Effect of Dissolved Gases and Effect of Surfactants.
Maryland Univ., College Park
Universita di Bologna, Italy
University of Toronta, Ontario, Canada
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 91-96 pp, 1995.

fire research; cooling; droplets; water; surfactants; surface temperature

Todd, D. R.

Todd, D. R.
Executive Order 12941: Seismic Safety of Existing Federally Owned or Leased Buildings - Its History, Content and Objectives.
National Institute of Standards and Technology, Gaithersburg, MD
EERI Regional Seminar Series. Kobe Earthquake: Impact on the Executive Order for Existing Buildings. EERI Technical Seminar. December 5, 1995, Alexandria, VA, 1-4 pp, 1995.

building technology; earthquakes; Executive Order; existing buildings; federal buildings; seismic evaluation; seismic rehabilitation; seismic standards; seismic upgrading

Work by the Interagency Committee on Seismic Safety in Construction (ICSSC) is expected to lead to the eventual development of a systematic program of seismic upgrading for Federally owned buildings. Steps that have been taken to date include (1) the development of seismic evaluation and rehabilitation standards, (2) the drafting of an Executive Order which adopts the technical standards and calls for a seismic inventory and cost estimate, and (3) the issuance of guidance on how to efficiently and consistently inventory Federally owned buildings and how to estimate the costs of mitigating unacceptable seismic risks. The inventory and cost estimates will be forwarded to the Federal Emergency Management Agency (FEMA) by December 1, 1998. FEMA will use the data to assess the costs and impacts of a wide variety of potential seismic risk mitigation programs. By December 1, 2000, FEMA will report to Congress on the most economically feasible program for achieving acceptable levels of seismic safety in its approximately half-million owned buildings.

Todd, D. R.; Bieniawski, A. S.
ICSSC Guidance on Implementing Executive Order 12941 on Seismic Safety of Existing Federally Owned or Leased Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5734; 27 p. October 1995.
Available from National Technical Information Service
PB96-128103

building technology; buildings; cost estimate; earthquakes; Executive Order 12941; existing buildings; inventory; rehabilitation; seismic evaluation;

seismic rehabilitation; seismic safety

In this guidance document, the Interagency Committee on Seismic Safety in Construction (ICSSC) recommends appropriate approaches for Federal departments and agencies to use in implementing the inventorying and cost estimating requirements of Executive Order 12941. The inventories and cost estimates are to be submitted to FEMA by December 1, 1998. The ICSSC recommends that all Federally-owned buildings be included in an electronic inventory database of specified format. Buildings are to be identified as either exempt or non-exempt from the seismic standards adopted by the order. All exceptionally high risk buildings are to be seismically evaluated, and estimates of the cost of their rehabiliation developed. Additionally, agencies are to perform seismic evaluations on a representative sample of their non-high-risk, non-exempt buildings, and use this information to estimate the vulnerability of that population and the cost of achieving adequate seismic safety.

Todd, D. R.; Bieniawski, A. S.
Performance of Federal Buildings in the January 17, 1994 Northridge Earthquake.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5574; 25 p. January 1995.
Available from National Technical Information Service
PB95-231775

earthquakes; building performance; building technology; federal buildings; Northridge earthquake; seismic

On January 17, 1994, a magnitude 6.8 earthquake struck Northridge, California, in the northeast suburbs of Los Angeles. This report summarizes information compiled by the Interagency Committee on Seismic Safety in Construction (ICSSC) on the performance of federally-owned buildings in the Northridge earthquake. Eleven agencies reported that they owned buildings in the affected area. Collectively, over 4000 federally-owned buildings were shaken; approximately 120 were damaged by the quake. Only two sites were reported to have suffered major damage; most damage was minor. The estimated cost to repair the damaged buildings is $127 million.

Todd, D. R.; Harris, J. R.
De Facto Microzonation Through the Use of Soils Factors in Design Triggers.
National Institute of Standards and Technology, Gaithersburg, MD
J.R. Harris and Co., Denver, CO
International Conference on Seismic Zonation, 5th. Proceedings. October 17-19, 1995, Nice, France, Quest Editions, France, 510-517 pp, 1995.

building technology; design triggers; earthquakes; microzonation; seismic design; seismic zonation; soil factors

The 1994 edition of the "National Earthquake Hazard Reduction Program (NEHRP) Recommended Provisions for the Development of Seismic Regulations for New Buildings" takes a step toward becoming a microzonation-based design guideline by including soils factors in its design control factors (triggers). The Provisions Update Committee of the Building Seismic Safety Council (which publishes the NEHRP Recommended Provisions) is planning to make a full conversion to this type of microzonation in the 1997 edition by including soils factors as a critical parameter in the assignation of Seismic Performance Category. This paper discusses the effect of the changes adopted in the 1994 edition of the NEHRP Recommended Provisions, and examines the impact of full conversion to soils-factor-based control factors.

Tolocka, M. P.

Tolocka, M. P.; Miller, J. H.
Production of Polycyclic Aromatic Hydrocarbons From Underventilated Hydrocarbon Diffusion Flames.

George Washington Univ., Washington, DC
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Proceedings. Fall Technical Meeting, 1995. October 16-18, 1995, Worcester, MA, 253-256 pp, 1995.

combustion; diffusion flames; polycyclic aromatic hydrocarbons; soot

Polycyclic Aromatic Hydrocarbons (PAH) are ubiquitous products of incomplete combustion, and have been found adsorbed on the particulate emissions from wood fires, pulverized coal combustion, waste incineration, and laboratory scale flames. Because specific PAH are known to be mutagenic, measuring the concentration levels of these compounds is important in assessing risk from these combustion sources. It has been recently noted that soot generated from underventilated diffusion flames is remarkably different in structure than soot from overventilated combustion, and the smoke generated from underventilated combustion has a much higher organic composition. It is expected that the organic component of the soot is largely PAH, molecules which are thought to be the precursors to soot formation. We present here initial quantiative measurements of PAH absorbed on the surface of particles generated from overventilated and underventilated flames.

Tsongas, G.

Tsongas, G.; Burch, D. M.; Roos, C.; Cunningham, M.
Parametric Study of Wall Moisture Contents Using a Revised Variable Indoor Relative Humidity Version of the "MOIST" Transient Heat and Moisture Model.
Portland State Univ., OR
National Institute of Standards and Technology, Gaithersburg, MD
Building Research Association of New Zealand, Porirua
ASHRAE, DOE, ORNL, and BETEC. Thermal Performance of the Exterior Envelopes of Buildings VI Conference. Proceedings. December 4-8, 1995, Clearwater Beach, FL, 307-319 pp, 1995.

heat transfer; moisture; humidity; walls; computer models; MOIST

The present 2.1 version of the "MOIST" software predicts wall moisture contents and associated parameters using an assumed indoor relative humidity input that is constant for the duration of the simulation period. The authors modified the model to calculate the hourly indoor relative humidity during the heating season as a function of outdoor weather conditions, indoor air temperature, building size and airtightness, and indoor moisture generation rate. These changes were accomplished by incorporating within MOIST an indoor moisture balance and a single-zone infiltration model. The modified version of MOIST allows the summer indoor relative humidity to either float to simulate open windows/doors or to be fixed to simulate air conditioning. The new version has the advantage of incorporating many more inputs that influence the indoor relative humidity and construction-layer moisture content results. The development and details of the revisions are described. This enhanced version of MOIST was subsequently used to investigate moisture accumulation in a 5-cm by 15-cm (2-in. by 6-in.) wood-framed wall exposed to a number of different winter climates. Predictions with a constant indoor relative humidity were compared to those with a "floating" or variable indoor relative humidity. The results generally are different, with the results of the revised version agreeing closely with field measurements. In addition, the variable indoor relative humidity program was used to analyze the effect of building airtightness, the indoor moisture generation rate, and the existence of exfiltration. The need for an interior vapor retarder in walls exposed to cold climates also was examined. Moreover, the effects of exterior insulating sheathing and an exterior vapor retarder were modeled. Results and findings are presented along with pertinent conclusions regarding appropriate building construction techniques in winter heating climates.

V

VanBronkhorst, D. A.

VanBronkhorst, D. A.; Persily, A. K.; Emmerich, S. J.
Energy Impacts of Air Leakage in U.S. Office Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
Implementing the Results of Ventilation Research. AIVC Conference, 16th. Proceedings. September 19-22, 1995, Palm Springs, CA, 379-391 pp, 1995.

office buildings; building performance; energy; air leakage; infiltration

Airtightness and infiltration rate measurements in office and other commercial buildings have shown that these buildings can experience significant levels of air leakage. The energy impact of air leakage in U.S. office buildings was estimated based on the analysis of a set of 25 buildings used in previous studies of energy consumption. Each of these buildings represents a portion of the U.S. office building stock as of 1995. The energy impact of air leakage in each building was estimated by performing an hourly analysis over one year, with the infiltration rates varying linearly with the wind speed. The energy associated with each of the 25 buildings was then summed to estimate the national energy cost of air leakage. The results show that infiltration accounts for roughly 15% of the heating load in all office buildings nationwide, and a higher percentage in recently constructed buildings. A sensitivity analysis showed that the heating loads due to infiltration were particularly sensitive to uncertainty in the balance point temperature and nighttime thermostat setback. The results also show that infiltration has very little impact on cooling loads in office buildings. The results for office buildings are presented and discussed, along with the implications for the energy impacts of air leakage for the total commercial building stock in the U.S.

VanderWal, R. L.

VanderWal, R. L.; Zhou, Z.; Choi, M. Y.
Laser-Induced Incandescence Calibration via Gravimetric Sampling.
NYMA, Inc., Brookpark, OH
University of Illinois, Chicago
Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 98-103 pp, 1995.

combustion; lasers; incandescence; sampling; soot

Soot volume fraction (fv) measurements are central to studies of soot growth and radiant transport processes within flames. In the post-flame region, soot yield and specific extinction coefficient per unit mass of fuel consumed in addition to fv are key quantities of interest. Light extinction is widely used for measuring these quantities but possesses limitations. Interpretation of extinction measurements to determine fv or soot yields rely on assumptions and uncertainities regarding soot properties. Varying experimental conditions can affect the contributions to the extinction measurement of absorption by PAH's and scattering, hence these contributions are often neglected.

VanDerWege, B. A.

VanDerWege, B. A.; Bush, M. T.; Hochgreb, S.; Linteris, G. T.
Effect of CF3H and CF3Br on Laminar Diffusion Flames in Normal and Microgravity.
Massachusetts Institute of Technology, Cambridge
National Institute of Standards and Technology, Gaithersburg, MD

Microgravity Combustion, 3rd International. Proceedings. April 11-13, 1995, Cleveland, OH, 1-6 pp, 1995.

laminar flames; diffusion flames; microgravity; chemical inhibition; experiments; atmospheric pressure; low pressure

Chemical inhibition of diffusion flames through addition of halogenated inhibitors is a problem of significant practical and scientific interest. Extensive studies on diffusion flames in microgravity have shown that these flames have significantly different characteristics than those under normal gravity. However, the mechanisms through which inhibitors reach the reaction zone to suppress combustion in diffusion flames and the effectiveness of these compounds under reduced gravity have yet to be investigated. This study reports preliminary results of investigations on the behavior of laminar jet diffusion flames upon the addition of bromotrifluoromethane (CF3Br) and trifluoromethane (CF3H) to the surroundings under normal and microgravity conditions. The results show that the flame structure in microgravity is significantly different from that under normal gravity conditions, and more importantly, that conditions for flame stability are less strigent under microgravity. Experiments show that flames that cannot be stabilized under normal gravity are quite stable under microgravity conditions. In addition, normal gravity experiments at reduced pressure (low buoyancy) did not reproduce the structure or stability limits of inhibited flames in microgravity.

VanDerWege, B. A.; Bush, M. T.; Hochgreb, S.; Linteris, G. T.
Massachusetts Institute of Technology, Cambridge
National Institute of Standards and Technology, Gaithersburg, MD

Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Proceedings. Fall Technical Meeting, 1995. October 16-18, 1995, Worcester, MA, 443-446 pp, 1995.

combustion; laminar flames; diffusion flames; gravity; bromotrifluoromethane; experiments; microgravity

Due to the ban on production of bromotrifluoromethane(CF3Br) because of its high ozone destruction potential, there has been recent interest in finding a replacement for it for fire extinguishing applications. While a variety of potential replacements are being considered, halogenated hydrocarbons may be a viable alternative for some applications. Consequently, an improved understanding of their action in flames will aid in their effective use. In addition, CF3Br is used as a fire suppressant on the space shuttle, and its action in microgravity has not been tested in diffusion flames. The present study investigates the effects of CF3Br and trifluoromethane(CF3H), the simplest compound representative of the fluorocarbons, in laminar diffusion flames. The primary experiments are laminar gas-jet diffusion flames burning in a quiescent environment containing the inhibitor in normal and microgravity. Experiments were conducted with CF3Br mole fractions in the oxidizer gas of 0.5% to 3%, CF3H mole fractions of 4% to 12%, oxygen mole fractions from 18% to 30%, and ambient pressures of 101 kPa and 25 kPa. Additional opposed-jet counterflow diffusion flame experiments were used to investigate flame structures observed in the microgravity flames.

W

Wade, R. A.

Wade, R. A.; Sivathanu, Y. R.; Gore, J. P.

Soot Volume Fraction and Temperature Properties of High Liquid Loading Spray Flames.

Purdue Univ., West Lafayette, IN

Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 791-796 pp, 1995.

combustion; soot; volume; temperature; burning rate; flame length; radiative heat loss

The relationship between burning rate, visible flame length, and sooting properties of spray flames is investigated. Multiwavelength emission/absorption spectroscopy was applied to the measurement of soot volume fractions and temperatures for high liquid loading effervescent atomized flames. The statistics of the emission and absorption data were interpreted in terms of the statistics of the local properties using a novel discrete probability function based deconvolution method. The results show the coupled effects of soot volume fractions and temperature on the radiative heat loss from the spray flames. The effervescent atomized burner configuration allows a study of the radiation properties over a wider range of soot and temperature combinations than that allowed by gas jet flames. Comparison between conventional deconvolution techniques and the present method show that consideration of turbulence/radiation interactions is essential in applying tomography to time varying fields.

Wade, R. A.; Sivathanu, Y. R.; Gore, J. P.

Study of Two Phase High Liquid Loading Jet Fires. Annual Report. September 1, 1993-August 30, 1994.

Purdue Univ., West Lafayette, IN

NIST-GCR-95-678; 50 p. October 1995.

Available from National Technical Information Service

blowout fires; fire research; fuel sprays; flame length; flame temperature; heat release rate; methane; oil spills; radiative heat loss; soot; sprays

High liquid loading spray jet fires occur in accidents involving fuel pipe leaks, tank ruptures and oil well blowouts. Laboratory simulations of such fires in the 10-30 kW range has recently become feasible using a novel effervescent atomizer burner. Measurements of flame length, radiative heat loss fractions, evaporation length, path integrated temperatures, and path integrated and local soot volume fractions in high liquid loading jet fires using this burner are reported. The data show that changes in evaporation length do not affect the flame length for the present operating conditions. The flame lengths increase with increasing heat release rate in an overall power law manner. Although the exit momentum for these flames is high, the power law behavior results from the effects of changes in radiative heat loss distribution with increasing firing rates. Increase in the mass flow rate of the atomizing methane from 5% to 25% causes a decrease in the soot volume fractions and an increase in the temperatures. The decrease in soot volume fraction and the increase in flame temperature have opposite effects on the visible flame length and radiative heat loss fraction.

Walton, W. D.

Walton, W. D.
Zone Computer Fire Models for Enclosures.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Handbook of Fire Protection Engineering. 2nd Edition. Section 3. Chapter 7, National Fire Protection Assoc., Quincy, MA, DiNenno, P. J.; Beyler, C. L.; Custer, R. L. P.; Walton, W. D., Editors, 3/148-151 p., 1995.

fire protection; fire protection engineering; zone models; fire models; computer models; enclosures; computer programs

Computer programs are used in many areas of fire protection design, including suppression system design, smoke control system design, and egress analysis. The emphasis in this chapter is on zone computer fire models for enclosures. Zone fire models are computer programs designed to predict the conditions resulting from a fire in an enclosure. These models solve the equations based on the zone assumptions describing the fire-induced conditions within an enclosure. Computer fire models can provide a faster and more accurate estimate of the impact of a fire, and the measures used to prevent or control the fire, than many of the methods previously used. While manual calculation methods provide good estimates of specific fire effects (e.g., prediction of time to flashover), they are now well suited for comprehensive analyses involving the time-dependent interactions of multiple physical and chemical processes present in developing fires. The state of the art in computer fire modeling is changing rapidly. Understanding of the processes involved in fire gorwth is improving, and thus, the technical basis for the models is improving. The capabilities, documentation, and support for a given model can change dramatically over a short period of time. In addition, computer technology itself (both hardware and software) is advancing rapidly. A few years ago, a large mainframe computer was required to use most of the computer fire models. Today, all of the zone fire models can be run on personal computers. Therefore, rather than provide an exhaustive review of rapidly changing state-of-the-art available computer models, the following discussion will focus on a representative selection. The reader is guided to references 1 and 2 for a comprehensive review of computer fire models.

Walton, W. D.; Thomas, P. H.
Estimating Temperatures in Compartment Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Lund Univ., Sweden
SFPE Handbook of Fire Protection Engineering. 2nd Edition. Section 3. Chapter 6, National Fire Protection Assoc., Quincy, MA, DiNenno, P. J.; Beyler, C. L.; Custer, R. L. P.; Walton, W. D., Editors, 3/134-147 p., 1995.

fire protection; fire protection engineering; compartment fires; temperature; flashover; equations; fire models; conservation; ignition

The ability to predict temperature developed in compartment fires is of great significance to the fire protection professional. There are many uses for a knowledge of compartment fire temperatures, including the prediction of (1) the onset of hazardous conditions, (2) property and structural damage, (3) changes in burning rate, (4) ignition of objects, and (5) the onset of flashover. The fundamental principles underlying compartment fires are presented in Section 3, Chapter 5. This chapter gives a number of simplified solution techniques.

Wan, I. Y.

Wan, I. Y.; McGrath, J. E.; Kashiwagi, T.
Triarylphosphine Oxide Containing Nylon 6,6 Copolymers.
IBM Almaden Laboratories, San Jose, CA
Virginia Polytechnic Institute and State Univ., Blacksburg
National Institute of Standards and Technology, Gaithersburg, MD

American Chemical Society. Fire and Polymers II: Materials and Tests for Hazard Prevention. National Meeting, 208th. ACS Symposium Series 599. August 21-26, 1994, Washington, DC, American Chemical Society, Washington, DC, Nelson, G. L., Editor, 29-40 pp, 1995.

fire retardants; flame retardants; nylon (trademark); copolymers; monomers; polymerization; cone calorimeters

A hydrolytically stable triarylphosphine oxide containing dicarboxylic acid monomer bis(4-carboxyphenyl)phenyl phosphine oxide P(O)(Ph)(C6H4COOH)2 was synthesized via Friedel-Crafts reactions and chemically incorporated into the poly(hexamethyleneadipamide) backbone to produce melt processible, improved flame resistant copolymers. The content of triarylphosphineoxide comonomer in the melt synthesized copolymers was controlled from 0-30 mole%. The copolymers were crystallizable at 10 and 20 mole% incorporation of the phosphine oxide comonomer and produced tough solvent resistant films. The crystallinity was totally disrupted at 30 mole%, but the Tg values systematically increased from 58 deg C to 89 deg C. Dynamic TGA results in air at 10 deg C/minute showed that the char yield increased with phosphine oxide content. Cone calorimetric tests in a constant heat environment (40 kW/m2) were employed to investigate the fundamental flame retardancy behavior of the copolymers. Significantly depressed heat release rates were observed for the copolymers containing phosphine oxide, although carbon monoxide values appeared to increase. ESCA studies of the char show that the phosphorus surface concentration was significantly increased relative to copolymer composition. It was concluded that the triaryl phosphine oxide containing nylon 6,6 copolymers had improved flame resistance and that tough melt processible films and fibers could be produced from these modified copolyamides.

Womeldorf, C. A.

Womeldorf, C. A.; Grosshandler, W. L.
Selection of a CF3Br Simulant for Use in Engine Nacelle Certification Tests.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 2; Section 12; November 1995.
Available from Government Printing Office
SN003-003-03372-3
Available from National Technical Information Service
PB96-117783
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 2, Gann, R. G., Editor, 591-621 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; halon 1301; halon alternatives; aircraft certification; pentafluoroethane; sulfur hexafluoride; boiling point; halon simulants

This section describes the requirements and selection of a simulant of CF3Br for the purpose of certification testing engine nacelle fire suppression systems. To illustrate the storage, delivery, and distribution requirements of CF3Br, relevant characteristics of engine nacelle fire suppression systems and certification tests are briefly summarized. An initial screening of over 1300 chemicals based on the boiling point, critical temperature, and molecular weight of CF3Br is described, and the nine potential candidate simulants that were found are listed. Three final candidates (SF6, C2HF5, and CHC1F2) were selected for experimental testing based upon their saturated vapor pressures, Jakob numbers, and the requirements of this application: ozone depletion potential, flammability, corrosiveness, toxicity, stability and atmospheric lifetime. To evaluate the hydraulic properties of the simulants, as compared to CF3Br, pressure traces of discharges through a piping system into cooled recovery bottles and to atmosphere are compared with like tests of CF3Br. To compare the discharge spray distribution of the simulants with CF3Br, high speed movies of the plumes at the end of the piping system were taken and are described. Results and conclusions from comparisons of the three candidate simulants with CF3Br are presented and discussed.

Womeldorf, C. A.; King, M. D.; Grosshandler, W. L.
Lean Flammability Limit as a Fundamental Refrigerant Property. Interim Technical Report. Phase 1. October 1, 1994-March 31, 1995.
National Institute of Standards and Technology, Gaithersburg, MD
DOE/CE/23810-58; 32 p. March 31, 1995.
Available from National Technical Information Service
flammability limits; refrigerants; difluoromethane; pentafluoroethane; counterflow burner

Due to the ozone-depleting effects of commonly used chlorofluorocarbon refrigerants, safe environmentally-firendly replacements must be found. HFC-32 (CH2F2) and other hydrochlorofluorocarbons are potential candidates; however, in contrast with the CFCs, many of these compounds are flammable. Testing the flammability limits of these hydrochlorofluorocarbons using traditional ASTM E-681 methods has produced a range of limits depending upon the vessel and ignition source used. This project demonstrates the feasibility of defining a fundamental flammability limit of HFC-32, that occurs at the limit of a zero strain rate and is independent of ignition source. Using a counterflow twin-flame burner to define extinction points for different strain rates, an extrapolation to zero strain rate is performed. Using this technique, preliminary results on the lean flammability limit of HFC-32 and the critical flammability ration of HFC-125 (C2HF5) in HFC-32 are reported.

Womeldorf, C. A.; Mitchell, M. D.; Grosshandler, W. L.
Selection of a Simulant of CF3Br for Use in Engine Nacelle Certification Tests.
National Institute of Standards and Technology, Gaithersburg, MD
Walter Kidde Aerospace, Wilson, NC
Halon Options Technical Working Conference. Proceedings. May 9-11, 1995, Albuquerque, NM, 197-210 pp, 1995.
aircraft certification; halon 1301; pentafluoroethane; sulfurhexafluoride; halon simulants; nacelle fires; fire suppression; aircraft engines; boiling point

This paper describes the selection of a simulant of CF3Br for the purpose of certification testing engine nacelles fire suppression systems. In order to illustrate the storage, delivery, and distribution requirements of CF3Br, relevant characteristics of engine nacelle fire suppression systems and certification tests are briefly summarized. An initial screening of over 1300 chemicals based upon the boiling point, critical temperature, and molecular weight of CF3Br is described, and the nine potential candidate simulants that were found are listed. Three final candidates (SF6, C2HG5, and CHCIF2) were selected for experimental testing based upon their vapor pressures, Jakob numbers, and the requirements of this application: ozone depletion potential, flammability, corrosiveness, toxicity, stability, and atmospheric lifetime. To evaluate the hydraulic properties of the simulants compared to CF3Br, pressure traces of discharges through a piping system are compared. A second comparison using high speed movies of the spray plumes at the end of the piping system is described. Results from these comparisons of the three candidate simulants with CF3Br are presented.

Wright, R. N.

Wright, R. N.
Government and Industry Working Together.
National Institute of Standards and Technology, Gaithersburg, MD
Construction Business Review, Vol. 5, No. 1, 44-49, January/February 1995.
industries; research facilities; construction

Construction is one of the nation's largest industries and a critical asset for enhnacing the international competitiveness of U.S. industry. In 1993, new construction put in place amounted to $470 billion, eight percent of the GDP, and provided employment for six million persons. New construction put in place in 1993 was 44 percent residential, 28 percent public works. When renovation is included, construction probably amounts to about $800 billion annually, 13 percent of GDP and 10 million jobs. Constructed facilities shelter and support most human activities. Their quality affects the competitiveness

of U.S. industry, the safety and quality of life of the people and environmental quality. For U.S. industries to compete internationally, their technologies must be superior and their production facilities must be more cost-effective than their competitors'. Morover, the quality of construction strongly affects the wealth of the nation; over five-eights of the nation's fixed reproducible wealth is invested in constructed facilities.

Wright, R. N.; Rosenfeld, A. H.; Fowell, A. J.
Construction and Building: Federal Research and Development in Support of the U.S. Construction Industry.
National Institute of Standards and Technology, Gaithersburg, MD
32 p. 1995.

building technology; federal agencies; construction; national construction goals; private sector; industries

This report outlines the Federal strategy for research, development, and deployment in support of the industries of construction, developed with industry by the Construction and Building Subcommittee of the National Science and Technology Council's Committee on Civilian Industrial Technology. The vision is a competitive U.S. industry producing high quality, efficient, sustainable and hazard resistant constructed facilities. Goals for better constructed facilities and improved health and safety of construction workers are described. These have been endorsed by the industry as National Construction Goals. The strategy for reaching the goals involves working closely with all sectors of the industry. Advances in seven areas of technology that have been identified as contributing to meeting the goals for the industry are cited. Examples of important proposed development projects that can act as showcases for technology developments are described. A brief summary of the role of member Federal agencies in support of the industry is included.

Wright, R. N.; Rosenfeld, A. H.; Fowell, A. J.
National Planning for Construction and Building R&D.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5759; 102 p. December 1995.
Available from National Technical Information Service
PB96-137104

building technology; construction; building construction

This planning report is a resource document designed to provide the private sector with a straw man on a direction and strategy for construction and building research, development, and demonstration to achieve the National Construction Goals, and the products likely to be produced by that effort. The report also will provide federal agencies with information on each other's R&D programs to facilitate coordination of effort. The Federal and private sector plans will be coordinated to form an industry-led National Plan to meet the National Construction Goals. This report provides background on each of the goals, the measures by which progress can be gauged, and research needed. The industry perspective on relative importance of the different goals by the various sectors of the construction industry is reported, and the initial strategy proposed by some of those sectors to provide a platform for the National Plan is outlined.

Y

Yang, J. C.

Yang, J. C.; Cleary, T. G.; Vazquez, I.; Boyer, C. I.; King, M. D.; Breuel, B. D.; Grosshandler, W. L.; Huber, M. L.; Weber, L.
Storage and Discharge Characteristics of Halon Alternatives.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology, Boulder, CO
Alliance for Responsible Atmospheric Policy; U.S. Environmental Protection Agency; Environment Canada; United Nations Environment Programme; U.S. Department of Agriculture.
Stratospheric Ozone Protection for the 90's. 1995 International CFC and Halon Alternatives Conference and Exhibition. Proceedings. October 21-23, 1995, Washington, DC, 594-603 pp, 1995.

halon alternatives; aircraft fires; dry bays; discharge; halons; pipes; sprays; thermophysical properties

Three important issues regarding the use of halon alternatives for in-flight fire protection applications were studied as part of the current halon alternative research program at the National Institute of Standards and Technology (NIST): (1) the conditions inside the vessel at different ambient temperatures before discharge, (2) the discharge of the contents into a confined space, and (3) the distribution of the agent/nitrogen mixture in piping systems. The first issue addresses the resultant pressure inside the vessel before discharge. Such information dictates the vessel structural integrity and subsequent discharge behavior of the agent/nitrogen mixture. The second deals specifically with military aircraft dry bay fire protection, and the third concerns general (commercial and military) aircraft engine nacelle fire protection applications. To establish the internal vessel conditions, the effects of fill density, initial nitrogen pressure, and ambient temperature were studied. For the discharge of agent/nitrogen mixture into a confined space, the effects of vessel geometry, initial nitrogen pressure, fill density, initial vessel temperature, discharge mechanism, discharge orientation, and orifice size were examined. For the distribution of agent/nitrogen mixture in piping systems, the effects of initial nitrogen pressure, fill density, initial bottle temperature, and piping geometries (sudden pipe expansion and contraction, different piping diameters, tees, and elbows) on the two-phase flow behavior were explored. Experimental results and model predictions will be presented and discussed for each issue.

Yang, J. C.; Cleary, T. G.; Vazquez, I.; Boyer, C. I.; King, M. D.; Breuel, B. D.; Womeldorf, C. A.; Grosshandler, W. L.; Huber, M. L.; Weber, L.; Gmurczyk, G. W.
Optimization of System Discharge.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 890; Volume 1; Section 8; November 1995.
Available from Government Printing Office
SN003-003-03371-5
Available from National Technical Information Service
PB96-117775
Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations. Volume 1. Section 8., Gann, R. G., Editor, 407-782 pp, 1995.

fire suppression; aircraft engines; nacelle fires; simulation; thermophysical properties; nitrogen; discharge rate; computer simulation; halon 1301; halon alternatives

Current aircraft fire suppression bottles for dry bay and engine nacelle applications, which are designed to meet Military Specification MIL-C-22284A (proof pressure of 9.62 MPa and minimum burst pressure of 12.37 MPa), are normally filled with liquid halon 1301 (CF3Br) to about half of the bottle volume, and the bottle is then pressurized with nitrogen to a specified equilibrium pressure (typically 4.1 MPa) at room temperature. The purpose of using the pressurization gas is to expedite the discharge of the agent and to facilitate the dispersion of the agent. Without nitrogen pressurization, the bottle pressure, which is simply the vapor pressure of the agent, can be so low (even sub-atmospheric) at extremely cold ambience that there is virtually no driving force to expel the agent from the bottle in case of a fire, thus hindering a rapid release of the mixture. From the above description, three important issues have emerged and need be considered when using a halon alternative as an in-flight fire suppressant: (1) the system hardware, (2) the thermophysical properties of the agent/nitrogen mixture, and (3) the agent/nitrogen mixture behavior during a discharge. The results obtained from this study provide important technical information on bottle design and agent discharge for new generation aircraft that may use the halon alternatives, for the existing aircraft that may undergo retrofitting, or simply for possible "drop-in" replacements.

Yang, J. C.; Grosshandler, W. L.
Solid Propellant Gas Generators: An Overview and Their Application to Fire Suppression.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 88-90 pp, 1995 AND National Institute of Standards and Technology. Solid Propellant Gas Generators: Proceedings of the 1995 Workshop. Appendix B. NISTIR 5766. June 28-29, 1995, Gaithersburg, MD, 15-17 pp, November 1995, 1995.

fire research; solid propellants; fire suppression

A solid propellant gas generator is essentially an airbag inflator without a bag. That is, the gas generated is discharged directly into ambience rather than into a bag. A typical solid propellant gas generator consists of solid propellant tablets which will, upon ignition, rapidly react to generate gas-phase combustion products and particulates, an ignitor to initiate the combustion of the propellant, a filter system to prevent or minimize the release of the particulates from the combustion reactions into the ambience, a heat transfer mechanism (normally the filter itself) to cool the high temperature combustion gas before being discharged into the ambience, and an exhaust mechanism to disperse the gas efficiently. In this article, an overview of the current status on solid propellant gas generators will be discussed, and potential areas for future research will be suggested.

Yang, J. C.; Grosshandler, W. L.
Solid Propellant Gas Generators: Proceedings of the 1995 Workshop. National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5766; 223 p. November 1995.
Available from National Technical Information Service
PB96-131479
National Institute of Standards and Technology. Solid Propellant Gas Generators: Proceedings of the 1995 Workshop. June 28-29, 1995, Gaithersburg, MD, 1995.

fire research; fire suppression; halons; propellants; propellant combustion; test methods

A workshop on solid propellant gas generators was held on June 28-29, 1995 at the National Institute of Standards and Technology under the sponsorship of the Building and Fire Research Laboratory. Gas generator technology was first proposed as alternative to halon 1301 (CF3Br) for in-flight fire protection. Because the technology is still in a developing stage as a fire

suppression method, there is no standard test apparatus for evaluating the performance of gas generators, and there remain many unanswered technical questions for the potential users. The specific objectives of the workshop were (1) to identify certification procedures, (2) to determine which critical parameters were required to characterize the performance of a gas generator, (3) to develop a standard test method for gas generator evaluation, (4) to identify other potential applications, and (5) to search for next generation of propellants. The participants at the workshop included representatives from aircraft and airframe manufacturing industries, airbag and propellant manufacturers, fire fighting equipment companies, military services, government agencies, and universities. The agenda of the workshop encompassed eleven presentations on various topics relevant to the applications of gas generators as a fire fighting tool, followed by several discussion sessions. Various important issues related to the achievement of the objectives set forth were addressed, and recommendations regarding what role NIST should play in this new technology were suggested.

Yang, J. C.; Huber, M. L.; Boyer, C. I.
Model for Calculating Alternative Agent/Nitrogen Thermodynamic Properties.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology, Boulder, CO
Halon Options Technical Working Conference. Proceedings. May 9-11, 1995, Albuquerque, NM, 137-145 pp, 1995.

computer models; pressure; temperature; thermophysical properties

A thermodynamic model based on the extended corresponding states principle has been developed to calculate the solubilities of nitrogen in five selected agents, HFC-227ea, CF3I, FC-218, HFC-125, and CF3Br and the pressure-temperature relationship for agent/nitrogen mixtures. The model only requires four pieces of input information: (1) agent mass, (2) vessel volume, (3) fill temperature, and (4) either nitrogen mass needed to pressurize the vessel or the fill pressure of the vessel. Comparing to the experimental data obtained at 150 deg C and -60 deg C, the model predictions were generally found to be within 10% or less of the experimental measurements.

Youssef, N. F. G.

Youssef, N. F. G.; Bonowitz, D.; Gross, J. L.
Survey of Steel Moment-Resisting Frame Buildings Affected by the 1994 Northridge Earthquake.
Nabih Youssef and Associates, Los Angeles, CA
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5625; 174 p. April 1995.
Available from National Technical Information Service
PB95-211918

earthquakes; steel structures; building technology; connections; cracking (fracturing); damage; earthquake engineering; facture; frame structures; steels; surveys

The January 1994 Northridge earthquake damaged a variety of building types throughout greater Los Angeles. Perhaps the most alarming pattern of structural damage involved brittle failures at beam-to-column connections in steel moment-resisting frames (MRF's). This damage has called into question the predictability of the behavior of steel MRF's and the reliability of conventional connections used in California buildings over the last two decades. In response to this damage, emergency changes to the Uniform Building Code now require specific test results in lieu of reliance on a prescribed detail. This report presents results of a survey of MRF's inspected for connection damage since the earthquake. As a catalogue of inspected MRF's, both damaged and undamaged, the survey is intended to provide an overall view of the greater Los Angeles steel frame population, as well as a single-source building-specific record of observed conditions. Tabulated survey responses can help form a quantitative context for future research, hazard assessment, and policy making. A computerized database was developed to track submittals, compile basic survey data, and generate the summary tables show in the report. Principal conclusions from the survey data support the observation that MRF connection damage is not well correlated to any single structural characteristic. On the contrary, the survey data show that connection performance may be best understood in probabilistic,

not deterministic, terms, with emphasis on construction and inspection quality. In other words, when the connection works, it works extremely well. But it might not work, if any link in the chain of design assumptions and construction procedures is weak. It is essential to note, however, that current survey data does not include analysis results or estimates of actural seismic demands from the Northridge earthquake. Without these, any reading of survey results must remain open to the possibility that conventional MRF connections are flawed by their basic configuration and are simply incapable of ductile behavior at high strain rates. This alternate theory, which would fundamentally change the way engineers think about steel MRF behavior, can only be discarded if analysis with recorded ground motions can show that damage did not correlate with demand. Survey results reported here show only that damage did not correlate well with design.

Z

Zarr, R. R.

Zarr, R. R.; Burch, D. M.; Fanney, A. H.
Heat and Moisture Transfer in Wood-Based Wall Construction: Measured Versus Predicted.
National Institute of Standards and Technology, Gaithersburg, MD
NIST BSS 173; 83 p. February 1995.
Available from National Technical Information Service
PB95-200655

heat transfer; mass transfer; moisture transfer; walls; wood; apparatus; building science; building technology; calibrated hot box; computer models; experiments; MOIST; relative humidity; temperature; thermal resistance; validation

The National Institute of Standards and Technology has developed a personal computer program, MOIST, that predicts the transient one-dimensional heat and moisture transfer in building envelopes. MOIST allows the user to vary building materials, their relative placement within the building envelope, and the geographic location of the building. For a given geometry and location, it predicts the resulting moisture accumulation and transfer across each construction layer as a function of time. This report describes a comprehensive laboratory study to verify the accuracy of MOIST for 12 different wall specimens. The rate of heat transfer through each of the 12 wall specimens was measured. The moisture content of the exterior construction materials were measured for eight of the twelve wall specimens. For the remaining four walls, the relative humidity level was measured at the interior side of the exterior sheathing. The measured heat transfer rates, moisture content levels and relative humidities were compared to the predictions of MOIST. In general, the agreement between MOIST and the experimental measurements was good. The moisture content predicted by MOIST was within one percent of the measured values for seven of the eight walls that contained moisture content sensors. The measured relative humidities for two of the remaining four walls agreed well with the MOIST predictions. The relative humidity measurements from the ohter two walls could not be compared to MOIST since the walls were constructed with vapor retarder defects that introduced two-dimensional effects. The heat flux predicted by MOIST was within ten percent of the values measured under steady-state conditions. When the walls were subjected to a series of diurnal ambient temperature cycles, the root-mean-square difference between the measured and predicted heat flux values ranged from four to fifteen percent. MOIST heat flux predictions were also in close agreement with the values predicted by the Thermal Analysis Research Program (TARP). A comparison was made between measured steady-state thermal resistances and corresponding calculated values using procedures recommended by The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). The ASHRAE calculations agreed with the measured values within thirteen percent.

Zhang, Z.

Zhang, Z.; Ezekoye, O. A.
Acetylene Air Diffusion Flame Computations: Comparison of State Relations Versus Finite Rate Kinetics.
University of Texas, Austin
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 286-291 pp, 1995.

fire research; smoke; acetylene; diffusion flames; equations; combustion; chemical reactions; kinetics

Fire propagation is driven by the coupling of heat and mass transfer processes between the gaseous and the condensed phases. A significant portion of the heat transfer rate is provided by radiative heat transfer mechanisms of which soot radiation contributes significantly for many flames. Although time history effects are suspected to affect the dynamics of soot evolution within heavily sooting non-premixed flames, the majority of soot chemistry calculations have been conducted for steady flame configurations.

Zhang, Z.; Ezekoye, O. A.
Computational Study of State Relationships for Acetylene-Air Diffusion Flames With Soot Radiation.
University of Texas, Austin
American Society of Mechanical Engineers (ASME). National Heat Transfer Conference, 1995. Proceedings, 30th. Combustion and Fire Research. Heat Transfer in High Heat-Flux Systems. Volume 2. HTD-Vol. 304. August 6-8, 1995, Portland, OR, Peterson, R. B.; Ezekoye, O.A.; Simon, T., Editors, 45-51 pp, 1995.

heat transfer; combustion; fire research; heat flux; diffusion flames; soot; acetylene; kinetics; reaction kinetics; experiments; reaction kinetics

Time history effects are suspected to affect the dynamics of soot evolution within heavily sooting non-premixed flames. The majority of soot chemistry calculations have been conducted for steady flame configurations. In this study, the combustion processes for a spherical acetylene-air diffusion flame element are computed using two fundamentally different approaches. In the first case, the state relationship data from experiments are used to specify the major gas species distributions, while in the second case, a finite rate reaction mechanism is used. A simplified soot mechanism which incorporates the effects of soot nucleation, surface growth, oxidation and agglomeration processes is used to specify the soot species evolution. It is found that as the net radiative losses for the diffusion flame element approach zero, the predictions of the state relationships match the results from the finite rate calculations.

Zhou, X. C.

Zhou, X. C.; Gore, J. P.
Air Entrainment Flow Field Induced by a Pool Fire.
Purdue Univ., West Lafayette, IN
Combustion and Flame, Vol. 100, No. 1/2, 52-60, 1995.

pool fires; air entrainment; flow fields; experiments; laser doppler velocimetry; toluene; diffusion flames; equations

Zhou, X. C.; Gore, J. P.; Baum, H. R.
Measurements and Predictions of the Velocity Field Induced by Pool Fires.
Purdue Univ., West Lafayette, IN
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 578-583 pp, 1995.

combustion; pool fires; velocity; entrainment; fluid flow; equations; flow fields

Due to the importance of the air entrainment rate in determining fire size, radiation properties, and soot production, various techniques have been applied to its measurement. The measurement techniques can be roughly classified into four categories. The first category involves monitoring of the air flow rate needed to meet the entrainment requirement of the fire while maintaining ambient pressure. The second category is to sample combustion products and solve a set of global mass balance equations to obtain equivalence ratio and hence the entrainment rate. The third category involves measurement of the velocity and the temperature profiles inside the flame and subsequent calculation of the axial flow rate by either direct radial integration or integrations of resulting curve fits. One common disadvantage of the above three experimental methods is that information about the details of the entrainment flow field itself is not obtained. The fourth measurement category addresses the problem by obtaining detailed measurements of the flow induced by the fire. The mean and the fluctuating velocity field around a 7.1 cm tolune pool fire was mapped with a Laser Doppler Velocimeter (LDV). It was found that the value of the entrainment rate depends strongly on its defintion implied by the first three measurement categories. In addition to the experimental work, a few studies involving analyses and computations of the entrainment flow field have also been reported. Taylor calculated the air flow outside a thermal jet originating from a point source with the assumption that the entrainment rate is proportional to the jet velocity. Utilizing published experimental data, Baum and McCaffrey applied a kinematic approach to predict the flow pattern induced by unconfined fires. The present paper reports application and extension of their methodology to the prediction of the entrainment flow field around 7.1 cm and 15 cm pool fires burning heptane and toluene.

Zhou, Z.

Zhou, Z.; Choi, M. Y.
Measurement of Dimensionless Extinction Constant of Soot Generated Using Various Fuels.
University of Illinois, Chicago
Combustion Institute/Central and Western States (USA) and Combustion Institute/Mexican National Section and American Flame Research Committee. Combustion Fundamentals and Applications. Joint Technical Meeting. Proceedings. April 23-26, 1995, San Antonio, TX, Gore, J. P., Editor, 87-91 pp, 1995.

combustion; soot; fuels; extinction; premixed flames; light extinction

Even though the soot volume fraction is a key property for describing soot both in the flame and above the flame, there has been little work to verify the accuracy of measurements by light extinction techniques. Choi et al studied the effects of source wavelength, scattering by soot particles, light extinction by 'large' molecules and the use of different indices of refraction reported in the literature on the measurement of soot volume fraction. The experiments indicated that the measured soot volume fractions were sensitive to the absorption constant (which was calculated using the reported refractive indices). For example, at a wavelength of 632.8 nm, the absorption constant can vary by a factor of two depending on the choice of indices of refraction. The focus of this paper is on the use of an independent method for characterizing soot volume fraction to assess the accuracy and to calibrate the light extinction method for soot generated using rich premixed flames. In short, the method consists of isokinetically sampling the soot at a known flow rate, measuring the mass of soot collected, and determining the density of the soot by helium pycnometry. The optical measurements can then be calibrated with the gravimetric measurements. In this manner, the dimensionless extinction constant can be determined without making assumptions regarding the optical properties of soot which can introduce significant uncertainties. The accurate measurement of the dimensionless extinction constant can improve the usefulness of the optical extinction technique.

Zhou, Z.; Choi, M. Y.
Measurement of Dimensionless Extinction Constant of Soot Generated Using Various Fuels.
University of Illinois, Chicago
National Institute of Standards and Technology (NIST) and Society of Fire Protection Engineers (SFPE). International Conference on Fire Research and Engineering. Proceedings. September 10-15, 1995, Orlando, FL, SFPE, Boston, MA, Lund, D. P.; Angell, E. A., Editors, 292-297 pp, 1995.

fire research; soot; light extinction; premixed flames; extinction; acetylene; experiments

Simultaneousoptical light extinction and gravimetric measurements are performed in the post-flame regions of premixed flames to determine the dimensionless soot extinction constant, Ke. This method consisted of isokinetically sampling the soot at a known flow rate, measuring the mass of soot collected and determining the density of soot through helium pycnometry. The optical measurements were then calibrated with accurate values of soot volume fraction measured gravimetrically. To reduce the uncertainties associated with soot reactions within the sampling probe experiments were performed at lower temperatures (500 K) using nitrogen dilution in the mixing chamber. In these experiments using acetylene/air flames, the dimensionless extinction constant was determined to be 8.8+ 1.5. It is expected that soot generated from various fuels will display marked differences in morphology. Therefore, these experiment will be used to determine whether Ke is sensitive to the soot morphology (including radius of gyration, Rg, and primary soot particle size dp).

Zukoski, E. E.

Zukoski, E. E.
Review of Flows Driven by Natural Convection in Adiabatic Shafts.
California Institute of Technology, Pasadena, CA
NIST-GCR-95-679; 46 p. October 1995.
Available from National Technical Information Service
PB96-147897

buoyant flow; heat transfer; high rise buildings; high temperature gases; leakage; smoke; stack effect; natural convection; turbulent mixing

Experimental and analytic studies of the motion of hot gases through vertical shafts under the influence of buoyancy forces, carried out from 1973 to 1976 at the California Institute of Technology, are reviewed. Such flows originate in and have a hazardous effect during accidental fires in facilities that involve vertical shafts. Two mechanisms are primarily responsible for vertical motion of buoyant gas within a building: stack effect and the turbulent mixing process. This review focuses on the turbulent mixing process, where the vertical dimension of spaces of interest is much larger than the horizontal, i.e., relatively tall shafts. Particular emphasis of the work reviewed is on the transient development of the mixing process within the shaft as hot buoyant gas (e.g., smoke) is introduced into the lower part of a shaft, which is at some initial, uniform, and relatively low temperature.

2. AUTHOR INDEX

3. KEYWORD INDEX

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fire research; building technology; fire extinguishing agents; refrigerants; earthquakes; fire detection; fire models; expert systems; building construction; cements; robotics; oil spills; urban fires

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