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ABSTRACT

Building and Fire Research Laboratory Publications, 1994 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 1994.

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1. LITERATURE CITATIONS ARRANGED BY FIRST AUTHOR

A

Ahmed, G. N.

Ahmed, G. N.; Dietenberger, M. A.; Jones, W. W.
Calculating Flame Spread on Horizontal and Vertical Surfaces.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5392; 56 p. April 1994.
Available from National Technical Information Services
PB94-187283

flame spread; computer algorithms; fire models; zone models; test methods

The flame spread model described in this paper is a new algorithm which provdes the capability to calculate a self-consistent fire based substantually on bench scale fire data. The flame spread model simulates object fire growth and burnout of a slab in a room and produces acceptable predictions of the spread of fire, smoke and production of both toxic and nontoxic gases. The purpose of the flame spread model is to allow a fire to grow realistically, possibly making a hole in the material surface. This is one mechanism for barrier penetration. The algorithm is based on empirical data, gathered from standard test apparatus, including the Cone Calorimeter and the LIFT (lateral ignition flame spread test method). By basing the pyrolysis on test methods, we avoid the practical difficulties associated with an explicit calculation of radiation blocking and material charring. The objective of including the flame spread model is to predict the accelerative growth of a fire from ignition to a peak value and then the gradual termination normally seen in a fire. The intent of the project was to develop an algorithm which could be utilized in a complete model of a fire in a building. The three-dimensional aspects of the flame spread model include: first, panels made of combustible materials with different thicknesses and at various orientations; second, flames of two basic types, pool fire and purely wall fire; third, a radiation heat exchange between objects, flames, and gases. The pool fire has a flame spreading polygon on a horizontal panel and the wall fire is used either for inclined or vertical panels.

Alpert, R. L.

Alpert, R. L.; deRis, J.
Prediction of Fire Dynamics. Final and Fourth Quarterly Report. June 28, 1992-August 28, 1992.
Factory Mutual Research Corp., Norwood, MA
NIST-GCR-94-642; 36 p. June 1994.
Available from National Technical Information Services
PB94-193620

algorithms; ceilings; computer models; fire codes; heat flux

This report summarizes accomplishments of a Factory Mutual Research Corporation (FMRC) project on the Prediction of Fire Dynamics for the NIST grant period August 1991 through August 1992. Work performed under a subcontract by Professor H. W. Emmons on Ceiling-Jet Dynamics and on Development of Strategies for Performance Fire Codes is first described under Task 1. The accomplishment of three tasks performed at FMRC are then presented in summaries of Tasks 2-4. All of this work is aimed at the development of subroutines or algorithms that can be used in NIST/BFRL comprehensive computer models. During the past year, there has been further progress in the development of predictive models for flame radiant heat flux and in the development of a practical laboratory test method for measuring the smoke point of solid noncharring or charring materials. This progress should allow continuing improvements in the accuracy and applicability of fire propagation theories.

B

Babrauskas, V.

Babrauskas, V.; Parker, W. J.; Mulholland, G. W.; Twilley, W. H.
Phi Meter: A Simple, Fuel-Independent Instrument for Monitoring Combustion Equivalence Ratio.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology Inc., Damascus, MD
Review of Scientific Instruments, Vol. 65, No. 7, 2367-2375, July 1994.

combustion; oxygen consumption; instruments; equations; measuring instruments

An instrument has been developed to monitor the equivalence ratio in combustion systems. It is based on a novel oxygen consumption measuring method. The instrument does not require knowledge of the chemical composition of the process being monitored. Both gaseous and solid (soot) products of incomplete combustion are successfully handled. The device is relatively compact and can be developed for moderate cost and portable use.

Bakkom, A. W.

Bakkom, A. W.; Richards, R. F; Plumb, O. A.
Design of a Prototype Video-Based Fire Detection System.
Washington State Univ., Pullman, WA
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 141-142 pp, 1994.

fire research; fire detection systems; fire protection; industrial plants; cameras

A video-based fire detection system currently under development at Washington State University is presented. The prototype system is intended to be a practical solution to the need for fire protection in industrial settings, such as in warehouses and on factory floors, or in situations in which a black and white video camera is already in use (e.g., for surveillance).

Baum, H. R.

Baum, H. R.
Large Eddy Simulation of Fire Phenomena.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 67-74 pp, 1994.

fire safety; fire research; simulation; vapor phases; equations

An approach to the simulation of gas phase fire phenomena based on the computation of the convection and combustion processes directly from the governing equations is presented. The methodology involves the explicit calculation of the large eddy structure induced by the fire from the geometric length scales describing the fire scenario down to a few centimeters. These computations are coupled to a local scale "thermal element" model which solves the equations governing combustion and radiation processes in a local coordinate system moving with the large scale motion. The basic theory behind the methodology is outlined and sample results of computations of both large and small scale phenomena are presented.

Baum, H. R.; McGrattan, K. B.; Rehm, R. G.
Mathematical Modeling and Computer Simulation of Fire Phenomena.
National Institute of Standards and Technology, Gaithersburg, MD
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 185-193 pp, 1994.

fire research; fire safety; fire science; mathematical models; computer simulation; enclosures; smoke transport; high temperature gases

A method of studying the large scale transport of smoke and hot gases induced by fires in enclosures is described. The approach is based on solving the governing equations directly (if approximately) by decomposing the fire-driven flow field into large scale convective and small scale combustion components. In this work, results involving large scale convective transport generated by flow fields associated with typical fire scenarios are presented. The large scale flow is studied using finite difference techniques to solve large eddy simulations of the Navier-Stokes equations at high Reynolds numbers. No empirical turbulence models are employed. The basic theory behind the methodology is outlined and sample results of both large and small scale phenomena are presented and compared with related experiments.

Baum, H. R.; McGrattan, K. B.; Rehm, R. G.
Simulation of Smoke Plumes From Large Pool Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Symposium Papers. Session 02-B: Pool Fires. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 11 pp, 1994.

combustion; pool fires; smoke plumes; simulation

A large eddy simulation model of smoke plumes generated by large outdoor pool fires is presented. The plume is described in terms of steady-state convective transport by a uniform ambient wind of heated gases and particulate matter introduced into a stably stratified atmosphere by a continuously burning fire. The Navier-Stokes equations in the Boussinesq approximation are solved numerically with a constant eddy viscosity representing dissipation on length scales below the resolution limits of the calculation. The effective Reynolds number is high enough to permit direct simulation of the large scale mixing over two to three orders of magnitude in length scale. Particulate matter, or any non-reacting combustion product, is represented by Lagrangian particles which are advected by the fire-induced flow field. Background atmospheric motion is described in terms of the angular fluctuation of the prevailing wind, and represented by random perturbations to the mean particle paths. Sample computations are presented and compared with plumes generated by large crude oil pool fires. Also presented is an assessment of the potential environmental hazard posed by burning marine oil spills.

Beazley, W. G.

Beazley, W. G.; Chapman, J. B.
Framework for Information Technology Integration in Process Plant and Related Industries.
National Institute of Standards and Technology, Gaithersburg, MD
NIST-GCR-94-657; 74 p. July 1994.
Available from National Technical Information Services
PB94-219086

industrial plants; industries; building design; building construction

The benefits of developing re-usable, integrated data during the design and construction of process plants have been difficult to quantify and achieve. Although Engineering and Construction (E&C) firms are generally willing to develop such data and owner/operators are receptive to the benefits of re-usable data, the clear justification of the additional costs and process changes needed to use such added value information has proved difficult. The main problem lies in assessing the impact of re-usable information on the support of the entire plant life cycle. This problem is solved by introducing a constraint framework capable of capturing all requirements placed on the plant during its life cycle. The root constraints on the process plant are attributed to the business case, external and agent-specific constraints applied to the plant constructed during its entire life cycle. The business case includes processes that produce the plant, such as work performed by E&C firms. In most cases, when concurrent and downstream (during a later phase) constraints are addressed early during E&C work, costs are avoided in later work. Many of these constraints

call for data elements, relationships, and work processes that are similar to or derived from those produced during earlier E&C work processes.

Bentz, D. P.

Bentz, D. P.
Survey of Recent Cementitious Materials Research in Western Europe.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5480; 32 p. August 1994.
Available from National Technical Information Services
PB94-218583

building technology; cements; fracture mechanics; high-performance concretes; hydration; microstructure; shrinkage; transport properties

This report summarizes recent research on cementitious materials in western Europe, based on a perspective gained during a six-month stay at the Centre Scientifique et Technique du Batiment in Grenoble, France. During this period, the author visited sixteen laboratories in seven European countries. Numerous publications, all included in the reference list of this report, were obtained during these visits. Research is grouped into topical areas with a brief description of separate activities at each institution. Emphasis has been placed on those research topics of interest to the Building Materials Division of the National Institute of Standards and Technology. A list of researchers working on cementitious materials in western Europe is also provided for those readers wishing to obtain further information on specific topics.

Bentz, D. P.; Coveney, P. V.; Garboczi, E. J.; Kleyn, M. F.; Stutzman, P. E.
Cellular Automation Simulations of Cement Hydration and Microstructure Development.
National Institute of Standards and Technology, Gaithersburg, MD
Modelling and Simulation in Materials Science and Engineering, Vol. 2, 783-808, 1994.

cements; hydration; microstructures; algorithms

Cellular automation algorithms, which operate on a starting digital image of a water-cement suspension, are described. The algorithms simulate the microstructure development process due to hydration reactions that occur between cement and water. This paper describes the evolution of the cement model from a simple model, which treated the cement particles as single-phase materials, with a greatly simplified hydration chemistry, into a model which has many more chemical species and includes numerous reactions which eventually convert the viscous water-cement suspension into a rigid porous solid. Methods are presented for generating two- and three-dimensional images representing suspension initial conditions; these are derived from both micrographs of real cements and computer-based algorithms. The 2D initial images are based on the processing of backscattered electron and x-ray images of real cement suspensions. The 3D images employ either spheres to represent cement particles or more realistic randomly shaped particles via an algorithm which smooths and thresholds a 3D lattice whose sites are initially populated with random white noise. A convenient measure of the point at which the initial paste turns into a solid material is the percolation threshold of the solids. Consideration of these models has already led to the prediction and subsequent experimental observation of a sharply defined onset of shear wave propagation, from ultrasonic measurements through hydrating cement slurries. The amount of hydration needed to reach the percolation threshold can be determined in the present simulations, and our results are compared with time of shear wave onset in actual cement slurries. Variants of the basic model provide insight into both early-time behavior that is of primary interest to oil well cementing and the later-time microstructural properties that are of interest in the consturction industry.

Bostelman, R.

Bostelman, R.; Albus, J.; Pagalakis, N.; Jacoff, A.; Gross, J. L.
Applications of the NIST ROBOCRANE.
National Institute of Standards and Technology, Gaithersburg, MD
Robotics and Manufacturing, Vol. 5, 403-407, 1994.

robotics; cranes; construction equipment; measurements; cables; winches

The Robot Systems Division of the National Institute of Standards and Technology (NIST) has recently been experimenting with a variety of applications for the NIST ROBOCRANE. The ROBOCRANE design utilizes the basic idea of the Stewart Platform parallel link manipulator. The unique feature of the NIST approach is to use cables as the parallel links and to use winches as the

actuators. Depending on what is suspended from its work platform, the ROBOCRANE has land, air, water, and space applications. A 2-meter version and a 6-meter version of the ROBOCRANE have been built and critical performance characteristics analyzed. Through these and other conceptual models, example applications for ROBOCRANE are: flexible mobility, heavy material handling, and flexible fixturing on land, rescue and personnel/equipment maneuverability in air; subsea pipe-laying/removal, lifting, and salvage from stable or unstable references on water; and lightweight, long distance lunar rover capabilities in space. All applications of ROBOCRANE include a large work volume, six degree-of-freedom control, precision maneuverability, and enhanced crane capabilities. This paper describes ROBOCRANE's present and future performance measurements, control system designs, and the conceptual designs for a multitude of applications.

Braun, E.

Braun, E.; Peacock, R. D.; Forney, G. P.; Mulholland, G. W.; Levin, B. C.
Human Exposure and Environmental Impact.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; April 1994.
Available from Government Printing Office
SN-003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 9, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 765-828 pp, 1994.

halons; exposure; human beings; environmental effects; halon 1301; large scale fire tests; toxicity; accidents; compartments; experiments; temperature distribution; fire extinguishing agents; fire suppression

Although these agents are typically employed in unoccupied sections of an aircraft, the possibility of human exposure still exists during handling, storage, and transport. Thus, it is important to know if the accidental release of the 12 agents in areas of typical occupancy would result in differing threats to life safety. At least two topics are important in assessing the impact of a potential release of an agent: 1) how does the agent distribute in an occupied space upon an accidental release, and 2) how does this release affect personnel who may be exposed? For the former, a series of tests was conducted to study the release of four of the twelve agents in a sealed compartment to measure the airborne concentration of agent that results from complete venting of containers of typical size into spaces of typical volume. These tests were augmented with field modeling to extend the range of the test results to other compartment geometries. For the latter, published toxicological results for chronic or acute exposure are summarized. It is important to note that in these tests, no humans were exposed.

Brown, J. E.

Brown, J. E.; Kashiwagi, T.
Effect of Gas Phase Oxygen on Chain Scission and Monomer Content in Bulk Poly(Methyl Methacrylate) Degraded by External Thermal Radiation.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 103-104 pp, 1994.

fire research; polymethylmethacrylate; vapor phases; oxygen; monomers; thermal radiation; thermal decomposition; heat flux

The effect of the atmosphere on the thermal degradation and gasification of bulk polymeric materials is not fully understood with respect to ignition and flame spread. It is of interest to know whether molecular oxygen influences these aspects of polymer flammability through direct attack on the condensed phase. To investigate, at the molecular level, the effect of the concentration of atmospheric oxygen on the decomposition of bulk PMMA at different incident heat flux levels simulating radiative heating on the surface by fires.

Bryner, N. P.

Bryner, N. P.; Benner, B. A., Jr.
Ground-Based Smoke Sampling Techniques Training Course and Collaborative Local Smoke Sampling in Saudi Arabia.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5306; 85 p. Issued January 1994.
Available from National Technical Information Services
PB94-143542

smoke sampling; aerosols; environmental effects; fire research; oil spills; well fires; polycyclic aromatic hydrocarbons; smoke; smoke collection; carbon monoxide; carbon dioxide

Smoke and gaseous emissions such as those generated by multiple oil-well fires can significantly impact the health of the local population. To assess the immediate risk to public health, the chemical and physical properties of the smoke and gaseous emissions must be quickly characterized. Local sampling via portable gas analyzers, filters, and pumps, and particle sizing instrumentation provides real-time characterization of pollutant levels. The Ground-Based Smoke Sampling Techniques Training Course and Collaborative Local Smoke Sampling project was initiated between the Ministry of Defense and Aviation (Kingdom of Saudi Arabia) and the National Institute of Standards and Technology (USA) to train Saudi medical personnel. A team of Saudi and NIST researchers assembled in December 1992 to collect smoke and gas samples in Saudi Arabia for analysis. Sample analysis included determination of polycyclic aromatic hydrocarbons (PAHs), CO, CO2 and total particulate concentrations. Split-sample analysis was conducted with some samples being analyzed in Saudi Arabia and other samples being returned to NIST for more specialized analysis, including micro-Raman, laser micro-probe, and environmental scanning electron microscopy. These analyses provide a snapshot of the physical and chemical properties of the aerosols sampled in Saudi Arabia, but due to the very limited number of samples, they do not provide a reasonable basis for estimating the short- or long-term health risk due to exposure to smoke and gaseous emissions. Concentrations of PAHs measured in the samples were about the same order of magnitude as samples collected in Roanoke, Virginia, but 3 to 10 times lower than samples from Boise, Idaho. While these results do suggest significant levels of PAH and dust particulates, the data set is very limited and a program involving the collection and analysis of air samples in or around Saudi Arabian urban areas would provide valuable data for determining current airborne PAH concentrations as well as for devising air pollution control strategies for the future. The appearance of significant concentrations of PAHs in what was expected to provide background levels indicates that a more comprehensive sampling program should be implemented to characterize the levels and the distribution of PAHs throughout the Kingdom.

Bryner, N. P.; Johnsson, E. L.; Pitts, W. M.
Carbon Monoxide Production in Compartment Fires: Full-Scale Enclosure Burns.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 53-54 pp, 1994.

fire research; carbon monoxide; compartment fires; large scale fire tests; enclosures; generation; natural gas

Recent studies attribute a large percentage of fire injuries and deaths to the generation of carbon monoxide (CO) and indicate that in roughly two-thirds of the fire deaths the fire victims have fatal or incapacitating levels of carboxyhemoglobin in their blood. A series of natural-gas fires within reduced- and full-scale rooms have been designed to improve the understanding of and to develop a predictive capability for CO formation in compartment fires. The findings will be used in realistic fire models and in the development of strategies for reducing the number of deaths attributed to carbon monoxide.

Buch, R.

Buch, R.; Hamins, A.; Shields, J. R.; Borthwick, P.; Baum, T.; Nyden, M. R.; Kashiwagi, T.
Pool Burning of Silicone Fluids.

National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 77-78 pp, 1994.

fire research; silicones; pool burning; transformers

Siloxane fluids have a number of industrial applications including use as transformer fluids. The objective of the present study was to improve our understanding of the burning of siloxane fluids. The fluids studied are octamethylcyclotetra siloxane, [(CH3)2SiO]4 which is known as D4, and trimethylsily end-blocked polydimethyl siloxane, [(CH3)3Si-O[-Si(CH3)2-O]n-Si(CH3)3], where n indicates the polymer chain length and the number of silicon atoms in the molecule. These fluids are ranked by viscosity which is related to the average polymer chain length as shown in Table 1.

Bukowski, R. W.

Bukowski, R. W.
FORUM for International Cooperation on Fire Research: 1994 Annual Report.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Bulletin, 7-9, November/December 1994.

fire research; fire safety; safety engineering

This is the first annual report of the activities of the FORUM and therefore briefly reviews FORUM activities to date. The intent is that these reports will be issued as soon as practical after the FORUM's annual meeting as a means to disseminate information and solicit comment. As such, these reports may be freely distributed. Comments on any of the issues addressed herein or suggestions on priorities for research may be directed to the chair or any of the FORUM members.

Bukowski, R. W.
Review of International Fire Risk Prediction Methods.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 232-240 pp, 1994.

fire safety; fire research; fire risk; risk assessment; methodology; risk analysis

Over the decade of the 1980's computer models and other predictive methods were increasingly applied to a board range of practical problems in fire safety. Experience gained in this way showed that careful treatment of complex problems resulted in more consistant and defensible solutions than relying solely on expert judgement. Further, uncertainties in the models' predictions were no greater than those associated with the traditional, but much more expensive full-scale experimental studies. Separate, multi-year research projects in Japan and the United States resulted in the publication of prorotype fire hazard analysis systems which demonstrated the ability to account for the complex interactions of the fire, building, active protection systems, occupant actions, and detailed outcomes including damage estimates and fatality counts.

Bukowski, R. W.; Babrauskas, V.
Developing Rational, Performance-Based Fire Safety Requirements in Model Building Codes.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology, Inc., Damascus, MD
Fire and Materials, Vol. 18, No. 3, 173-191, May/June 1994.

building codes; fire safety; smoke movement; fire spread; fire detection; fire suppression; evacuation; rescue

The technical and philosophical basis for performance-based assessment of building fire performance is reviewed. A strategy for the evolution of a performance code is described. Current efforts toward the development of performance codes in the USA and Japan are reviewed. Recommendations for critical steps necessary to advance the development and acceptance of performance

codes are presented. The table of contents of the Japanese risk methodology for assessing 'Article 38 equivalencies' is included in an appendix.

Bukowski, R. W.; O'Laughlin, R. J.
National Institute of Standards and Technology, Gaithersburg, MD
Consultant, Knoxville, TN
Fire Alarm Signaling Systems. 2nd (Second) Edition, National Fire Protection Assoc., Quincy, MA, NFPA FASS-94, 440 p., 1994.

fire alarm systems; signals; power supplies; fire detection systems; heat detectors; smoke detectors; installing; tests

Until now, there has been no single source for general information about the signaling systems industry and the basic requirements for alarms. With new technology and intensifying certification requirements for electricians and engineers, the need for such a text is great. This new text consolidates vital information about the installation and operation of signaling systems.

Bukowski, R. W.; Scawthorn, C.
Earthquake and Fire in Japan: When the Threat Became a Reality.
National Institute of Standards and Technology, Gaithersburg, MD
EQE International, San Francisco, CA
NFPA Journal, Vol. 88, No. 3, 89-92,94,96, May/June 1994.

earthquakes; fire investigations; fire departments; fire spread

At 10:17 p.m. on July 12, 1993, an earthquake that measured 7.8 on the Richter Scale struck in the Japan Sea off southwest Hokkaido, the northernmost main island of Japan. The earthquake and the resulting tsunami, or tidal wave, caused widespread, sporadic damage to northern Japan, with the heaviest damage ocurring on the small island of Okushiri.

Bushby, S. T.

Bushby, S. T.
New Age in Building Control Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Construction business Review, 60-65, March/April 1994.

communication protocol; standards

The emerging BACnet standard brings multi-vendor control systems and intelligent buildings closer to reality.

Bushby, S. T.; Newman, H. M.
BACnet: A Technical Update.
National Institute of Standards and Technology, Gaithersburg, MD
Cornell Univ., Ithaca, New York
ASHRAE Journal, Vol. 36, No. 1, 72-86, January 1994.

communication protocol; energy management and control systems

BACnet is a communication protocol for Building Automation and Control networks that has been developed by ASHRAE Standards Project Committee (SPC) 135P. The committee has been working on the standard since the middle of 1987 and published a draft version for public review in August, 1991. As a result of the public review (which generated 507 formal comments), numerous substantive changes have been made to the proposed standard. Included are changes in object type definitions, application layer services, and the network layer, MS/TP and Point-to-Point protocols. Before describing these changes and why they were made, a brief overview of BACnet would be helpful.

Butler, K. M.

Butler, K. M.; Baum, H. R.; Kashiwagi, T.
Three-Dimensional Kinetic Model for the Swelling of Intumescent Materials.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 109-110 pp, 1994.

fire research; intumescent coatings; kinetics; swelling; heat transfer; gasification; fire models

An intumescent coating protects the underlying surface from fire by swelling into a thick insulating char. Design of intumescent materials has proceeded largely by systematic testing of a variety of formulations, since the mechanisms of physical, thermal and chemical behavior are not as yet well understood. Previous models of intumescent behavior have treated the system as a one-dimensional heat transfer problem through a coating consisting of a char layer and a layer of virgin material separated by a thin pyrolysis zone. In this work, a fully three-dimensional, time-dependent numerical model combining the dynamics of the swelling process, the heat transfer through the coating, and the chemistry of gasification is described.

C

Carino, N. J.

Carino, N. J.
Nondestructive Testing of Concrete: History and Challenges.
National Institute of Standards and Technology, Gaithersburg, MD
American Concrete Institute (ACI). Concrete Technology: Past, Present and Future. ACI SP-144. 1994, American Concrete Inst., Detroit, MI, 623-678 pp, 1994.

concretes; infrared spectroscopy; in-place testing; nondestructive tests; penetration tests; probes; pullout tests; radar; rebound hammer; statistical methods; tests; thermography; ultrasonic tests

A brief history of nondestructive testing of hardened concrete over the past 50 years is presented. The contributions of V. M. Malhotra towards the development and promotion of nondestructive testing are emphasized. The underlying principles and inherent limitations of the methods are reviewed, and historical highlights of their development are presented. Test methods are grouped into those which assess in-place strength and those which evaluate non-strength characteristics, such as flaws and deterioration. The paper concludes with a discussion of the challenges for the 21st century in the area of nondestructive testing.

Carino, N. J.; Guthrie, W. F.; Lagergren, E. S.
Effects of Testing Variables on the Measured Compressive Strength of High-Strength (90 MPa) Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5405; 145 p. October 1994.
Available from National Technical Information Services
PB95-179040

concretes; building technology; capping; high-strength concrete; compressive strength; cylinder size; experiments; standards; statistical analysis; stress rate; testing machine

A review is presented on the factors affecting the measured compressive strength of concrete specimens, with particular emphasis on the testing of high-strength concrete. A full factorial experiment was designed to examine the effects of cylinder size, end preparation, stress rate and type of testing machine on the measured compressive strength. Two concrete mixtures (45 MPa and 90 MPa) were used to determine whether there were interactions between strength level and the other factors. In addition, a 65-MPa mixture was required to allow testing four combinations of specimen size and testing machine. The cylinder sizes were 100

x 200 mm and 150 x 300 mm. The ends of the cylinders were either capped with sulfur mortar or ground flat. The stress rate was either 0.14 MPa/s or 0.34 MPa/s, which are limits currently specified in ASTM C 39 (AASHTO T 22). One hydraulic testing machine was of the manually-operated type with a capacity of 1.33 MN. The other hydraulic testing machine was of the servo-controlled type with a capacity of 4.45 MN. The general linear model technique and analysis of variance were used to analyze the results. Statistical analyses showed that all the factors had statistically significant effects on the measured compressive strength. On average, the 100-mm cylinders resulted in 1.3% greater strength, the faster stress rate produced about 2.6% greater strength, the ground cylinders were 2.1% stronger than the capped cylindérs, and the 1.33-MN testing machine resulted in about 2.3% greater strength. There were significant interactions among the factors, so that the effects were greater (or smaller) than the average values depending on the particular factors settings. For example, the effect of end preparation depended on the strength level. For the 45-MPa concrete, there was no strength difference due to the method of end preparation, but for the 90-MPa concrete, grinding resulted in as much as 6% greater strength in certain cases. Besides the main test series, supplementary tests were done to investigate the effects of a defective spherically-seated bearing block. The defective bearing block had a concave depression within the central 100 mm. The maximum value of the depression was more than 0.2 mm, compared with the value of 0.025 mm currently allowed by ASTM C 39 (AASHTO T 22). Comparative tests with 68-MPa concrete showed no difference in mean strength due to the defective bearing block. Analysis of dispersion showed that the 100-mm cylinders had higher within-test variability, but the differences were not statistically significant. Recommendations for modifications to testing standards and future research are provided.

Cheok, G. S.

Cheok, G. S.; Stone, W. C.
Performance of 1/3-Scale Model Precast Concrete Beam-Column Connections Subjected to Cyclic Inelastic Loads. Report No. 4.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5436; 65 p. June 1994.
Available from National Technical Information Services
PB95-179024

building technology; beam-columns; concretes; connections; cyclic loading; joints; precast; post-tensioning; story drift

Test results of four hybrid post-tensioned concrete beam-to-column connections are presented. These tests represent Phase IV B of an experimental program on 1/3-scale model precast concrete moment resisting connections being 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 resistant precast connections in regions of high seismicity. The hybrid connections consist of mild steel used as energy dissipators and post-tensioning steel used to provide the required shear resistance. Variables examined were different amounts and type of mild steel. The amount of post-tensioning steel was kept constant. The specimens were subjected to reversed cyclic loading in accordance with a prescribed displacement history. The performances of the connections were evaluated based on comparisons of energy dissipation capacity, connection strength, and drift capacity with previous NIST tests (Phases I-IV A). The results show that a hybrid precast connection can be designed so that it matches the performance of a monolithic connection in terms of energy dissipation, strength, and drift capacity.

Cheok, G. S.; Stone, W. C.; Stanton, J.; Seagren, D.
Beam-to-Column Connections for Precast Concrete Moment-Resisting Frames.
National Institute of Standards and Technology, Gaithersburg, MD
Washington Univ., Seattle
Charles Pankow Builders, Ltd., Altadena, CA
Precast Seismic Structural Systems, 4th Joint Technical Coordinating Committee, Proceedings. May 16-17, 1994, Tsukuba, Japan, 1-8 pp, 1994.

concretes; beams; columns; tests; construction

Precast concrete frame construction is not used extensively in seismic regions of the USA. The UBC [ICBO, 1991] currently permits only certain specific building systems to be used and a precast frame is not one of them. The reason is that extensive research on cast-in-place frames has led to the development of reinforcement details that provide suitable ductility, and these details are now prescribed in the UBC. Im most cases, these details cannot be easily achieved in a purely precast system. The result is that most precast structures can be made to satisfy the UBC only under the guise of an "undefined structural system" which must "...be shown by technical and test data which establish the dynamic characteristics and demonstrate the lateral force resistance and energy

absorption capacity to be equivalent to systems listed in Table No. 23-O for equivalent Rw values." This requirement makes approval of a precast frame very difficult. In addition, another UBC requirement calls for "reinforcement resisting earthquake-induced" forces to conform to ASTM A 706 and A 615 Grades 40 and 60 specifications which excludes prestressing steel. Since the advantages of precasting and prestressing are interlinked, this provision on prestressing inhibits the use of precast concrete.

Choi, M. Y.

Choi, M. Y.; Hamins, A.; Mulholland, G. W.; Kashiwagi, T.
Simultaneous Optical Measurement of Soot Volume Fraction and Temperature in Premixed Flames.
University of Illinois, Chicago
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 99, 174-186, 1994.

soot; temperature; premixed flames; absorption; emission; extinction; scattering; temperature measurement

The performance of a three-wavelength optical probe technique for measuring soot volume fraction and temperature was assessed by conducting experiments in the homogeneous environment of a premixed flame. Using a premixed ethylene/air flame, the temperatures and soot volume fractions (fva, based on absorption measurements at 633 nm and fve, based on emission measurements at 900 nm and 1000 nm) were compared with previously reported results. Although the temperatures and mean soot volume fractions compared favorably, the discrepancy between fva and fve prompted new measurements to evaluate the importance of source wavelength on the fva measurements, scattering by soot particles, light absorption by "large" molecules and the use of different indices of refraction reported in the literature. The experiments on the degree of soot scattering and light absorption by "large" molecules indicated that these effects cannot reconcile the observed discrepancy in the soot volume fractions. The measured soot volume fractions were, however, sensitive to the absorption constant and therefore varied significantly when different sets of refractive indices were used. Furthermore, the agreement between fva and fve was improved when extinction measurements were performed with longer wavelength light sources. Isokinetic soot sampling experiments were also performed to compare with the optically-measured soot volume fractions. This technique does not rely on the refractive indices of soot and therefore provides an independent measure of the soot volume fraction. The soot volume fractions measured using this technique compared favorably with the optically measured values (calculated using various indices of refraction).

Choi, M. Y.; Hamins, A.; Rushmeire, H.; Kashiwagi, T.
Simultaneous Optical Measurement of Soot Volume Fraction, Temperature and CO2 in Heptane Pool Fire.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Symposium Papers. Session 02-B: Pool Fires. July 31-August 5, 1994, Irvine, CA,
Combustion Institute, Pittsburgh, PA, 11 pp, 1994.

combustion; pool fires; soot; volume; temperature; carbon dioxide; heptane

Detailed measurements of the temperature, soot volume fraction and CO2 have been performed for a 10 cm diameter heptane fire. In addition, the concentrations of H2O and CO were inferred from generalized state relationships. The heat feedback to the surface was calculated by using a reverse Monte-Carlo method in conjunction with RADCAL. The calculated heat fluxes to the surface with and without gas emission indicate that the contributions from the gaseous combustion products to total radiation are significant for heptane due to its mildly sooting nature. Simultaneous optical measurements using two probes were used to investigate the importance of temporal correlations on the heat transfer calculations. Measurements made throughout the fire incident that non-simultaneous data sets can be used to accurately predict the heat transfer to the surface.

Choi, M. Y.; Mulholland, G. W.; Hamins, A.; Kashiwagi, T.
Experimental Study of the Optical Properties of Soot and Smoke.
University of Illinois, Chicago
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services

PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 123-124 pp, 1994.

fire research; soot; smoke; optical properties

The accurate measurement of flame-generated particlates is a problem of current interest to researchers in the fire and combustion community. Within the flame, the soot concentration measurement is central to the study of soot growth and for radiant transport analysis. In the post-flame region of large fires, particulate measurements are important in developing computational modeling of smoke plume movement, in the detection fires, in assessing the reduction in visibility arising from a fire within a building and for estimating the health and environmental impacts.

Christensen, B. J.

Christensen, B. J.; Coverdale, R. T.; Olson, R. A.; Ford, S. J.; Garboczi, E. J.; Jennings, H. M.; Mason, T. O.
Impedance Spectroscopy of Hydrating Cement-Based Materials: Measurement, Interpretation, and Application.
Northwestern Univ., Evanston, IL
National Institute of Standards and Technology, Gaithersburg, MD
Journal of the American Ceramic Society, Vol. 77, No. 11, 2789-2804, November 1994.

cements; spectroscopy; hydration; microstructure; computer models; equations; permeability

This work concerns the state of the art for use of impedance spectroscopy for studying the evolving microstructure of cement-based materials during hydration. Features of the spectra are discussed and related to components of the microstructure with the assistance of pixel-based computer modeling techniques. It is proposed that the enormously high relative dielectric constants ($\sim 10^5$) observed just after set are the result of dielectric amplification and are related to the distribution of pore sizes and the thickness of product C-S-H layers separating the pores. The conductivity is related to the volume fraction of porosity, the conductivity of the pore solution, and the interconnectivity of the porosity. The conductivity, when normalized by that of the pore solution, i.e., inverse formation factor, is a measure of this interconnectivity and can be used to predict such engineering properties as ionic diffusivity and water permeability. Composite mixing laws are employed to aid in explaining the behavior of the conductivity and to obtain a qualitative measure of the pore shape with hydration. Procedures for predicting the conductivity of the pore solution and for subtracting out electrode lead effects at high frequency are discussed.

Cleary, T. G.

Cleary, T. G.; Grosshandler, W. L.; Yang, J. C.
Flow of Alternative Agents in Piping.
National Institute of Standards and Technology, Gaithersburg, MD
Halon Options Technical Working Conference, Proceedings. May 3-5, 1994, Albuquerque, NM, 105-115 pp, 1994.

halons; pipes; nacelle fires; fire protection; aircraft engines; fire suppression; fire extinguishing agents

As part of the USAF, Army, Navy and FAA sponsored halon replacement project, the pipe flow characteristics of selected alternative agents for engine nacelle fire protection are being studied. Due to the remote location of the agent storage bottle, piping is required to transport the agent to various locations in an engine nacelle. The pipe flow from an agent bottle is characterized as a transient, two-phase flow. Since the selected alternative agents have thermo-physical properties different from halon 1301, the flow characteristics will be different, which may require system design changes. An experimental apparatus to study the flow characteristics of the alternative agents was designed and is described. A key feature of the experimental set-up is the ability to provide a constant heat in the simulated storage bottle. This will allow quasi-steady state pressure drop data to be gathered. It may then be possible to use the quasi-steady data to estimate the transient case. The pipe flow characteristics for different initial vessel temperatures and pressures, and pipe configurations will be examined. Preliminary results on the flow characteristics of HFC-227ea and halon 1301 are presented.

Cleary, T. G.; King, M. D.; Yang, J. C.; Grosshandler, W. L.
Pipe Flow Characteristics of Alternative Agent/Nitrogen Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 11-12 pp, 1994.

fire research; pipes; nitrogen; nacelle fires; halons; fire suppression; fire extinguishing agents

The evaluation of alternative agents for application in engine nacelle fire protection includes delivery efficiency of agent from a remote storge bottle through piping to the nacelle injection loacation. Present military requirements for halon systems specify a maximum discharge time from the remote bottle to the injection location of 1 second. A similar performance criterion for the replacement agent delivery will more than likely be required. The applicability of retro-fitting existing systems or optimal design of new systems necessitates a thorough understanding of the two-phase flow in piping. As part of the halon replacement project, an experimental pipe flow apparatus was constructed and is being used to examine alternative agent flow in various horizontal piping configurations and conditions. The selected agents for engine nacelle fire protection are CF3I, HFC-227ea, and HFC-125. Halon 1301 is included in this study in order to establish a reference for comparison.

Cleary, T. G.; Ohlemiller, T. J.; Villa, K. M.
Influence of Ignition Source on the Flaming Fire Hazard of Upholstered Furniture.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 23, 79-102, 1994.

upholstered furniture; ignition source; chairs; fabrics; fire statistics; fire hazard; furniture calorimeters; hazard analysis; home fires

A set of upholstered chairs constructed from five different fabric/foam combinations was subjected to a variety of ignition sources suggested by fire statistics. The sources included a cigarette, a small match-like flame, an incandescent lamp, a space heater, and a large flame source (CTB 133 equivalent gas burner). The tests were performed in a furniture calorimeter where heat release rate and species production rates were obtained. For any chair type, the time to the peak heat release rate depended on the ignition sequence, but the magnitude of the peak did not, within the scatter of the data for any given chair. HAZARD I, the fire hazard assessment method developed at NIST, was used to quantify the hazard posed by the different ignition scenarios. No deaths were predicted when a working smoke detector was present. When a detector was not present, the results from the limited number of scenarios considered confirm the importance of a low peak heat release rate and a slow rate of rise to lessen the hazard of upholstered furniture fires. No one of the ignition scenarios examined consistently yielded the greatest potential hazard for all chair types tested when ignition and sustained burning was achieved. It is recommended that the hazards of upholstered furniture for residential use be assessed on the basis of resistance to small flame and cigarette ignition combined with peak heat release rate and time to peak subsequent to ignition by a strong source such as the CTB 133 equivalent gas burner.

Clifton, J. R.

Clifton, J. R.; Pommersheim, J. M.
Sulfate Attack of Cementitious Materials: Volumetric Relations and Expansions.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
NISTIR 5390; 22 p. April 1994.
Available from National Technical Information Services
PB94-187317

building technology; cements; concretes; ettringite; expansion; modeling; sulfate attack; tricalcium aluminate

A model was developed which predicts the conditions under which volumetric expansion of cementitious materials are most likely and the amount of expansion expected. Model parameters include concrete composition, phase densities, water-cement ratio, degree of hydration, extent of expansive reaction and reaction stoichiometry. The model was applied to several different reactions involving sulfate attack of concrete, including gypsum and ettringite formation reactions. The model predicted that ettringite formation from monosulfate would not cause general expansion. However, local expansion could occur if ettringite occupied the same space vacated

by reacting monosulfate. The model predicted that if sufficient unhydrated tricalcium aluminate (C3A) was available in mature cement paste and it reacted with gypsum to form ettringite, the reaction could cause expansion at low water-to-cement ratios.

Collins, B. L.

Collins, B. L.; Treado, S. J.; Ouellette, M. J.
Performance of Compact Fluorescent Lamps at Different Ambient Temperatures.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of the Illuminating Engineering Society, Vol. 23, No. 2, 72-84, Summer 1994.

compact fluorescent lamps; lighting equipment; temperature; evaluation; conservation; costs

Compact fluorescent lamps are used to replace incandescent lamps to aid in energy conservation in commercial and domestic lighting applications. In particular, they offer the benefits of much longer life and lower operating costs in a reasonably similar package. Some of the performance characteristics familiar to residential users may differ for the newer lamp technology. Such characteristics include response to ambient thermal conditions, sensitivity to lamp position, flicker, harmonics, etc. Of particular concern is the response to ambient thermal conditions, since lamps are used in unconditioned spaces, such as garages, basements, barns, and similar spaces where they may be subjected to extremes in temperature, both hot and cold. While it is well known that fluorescent lamp performance is determined by the cold spot on the lamp and can be affected by the ambient temperature in the room, the extent to which these findings, particularly for extreme in temperatures, apply to compact fluorescent lamp applications is not well understood.

Cooper, L. Y.

Cooper, L. Y.
Combined Buoyancy- and Pressure-Driven Flow Through a Horizontal Vent.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5384; 48 p. April 1994.
Available from National Technical Information Services
PB94-210077

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 near the elevation of the vent are filled with fluids of different density in an unstable configuration, with the density of the top space larger than that of the bottom space. With zero-to-moderate cross-vent pressure difference the instability leads to a bi-directional exchange flow between the two spaces. For relatively large cross-vent pressure difference the flow through the vent is unidirectional, from the high- to the low-pressure space. An anomaly of a standard vent flow model, which uses cross-vent pressure difference to predict stable unidirectional flow according to Bernoulli's equation (i.e., flow-rate is proportional to [equation], where [equation] is an orifice coefficient), is discussed. Such a model does not predict the expected bi-directional flow at small to moderate [equation] or non-zero flow at [equation]. Even when cross-vent pressure difference exceeds the critical value which defines the onset of unidirectional or "flooding" flow, it has been determined experimentally that until cross-vent pressure difference exceeds many times [equation] there is a significant dependence of [equation] on the relative buoyancy of the upper and lower fluids. Also, it has been shown theoretically that the location of the high-pressure side of the vent, i.e., the top or bottom, can be expected to influence vent flow characteristics. Previously published experimental data and results of an analysis of the relevant boundary value problems are used to develop a flow model which takes all of these effects into account. The result is a uniformly valid algorithm to calculate flow through shallow (small depth-to-span ratio), horizontal, circular vents under the high-Grashof number conditions. This is suitable for general use in zone-type compartment fire models (e.g., an ambient temperature environment above the vent and a hot smokey environment below). The algorithm is used in example applications where steady rate-of-burning in a ceiling-vented room is estimated as a function of room temperature, vent area, and oxygen concentration. Results of the analysis are 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

American Society of Mechanical Engineers. Heat Transfer With Combined Modes. International Mechanical Engineering Congress and Exposition. HTD-Vol. 229. November 6-11, 1994, Chicago, IL, Beasley, D. E.; Cole, K. D., Editors, 1-12 pp, 1994.

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.
Dispersion of Fire Suppression Agents Discharged From High Pressure Vessels: Establishing Initial/Boundary Conditions for the Flow Outside the Vessel.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5219; Paper XIII-2; 37 p. September 1993.
Available from National Technical Information Services
PB94-103660
Institute for Liquid Atomization and Spray Systems (ILASS-Europe) and CORIA. Liquid Atomization and Spray Systems, 6th International Conference Proceedings. ICLASS 94. July 18-22, 1994, Rouen, France, Begell House, Inc., NY, Yule, A. J.; Dumouchel, C., Editors, 1031-1038 pp, 1993.

fire extinguishing agents; aircraft safety; discharge pressure; fire extinguishment; fire safety; halons; fire suppression

This work reports on part of an effort to study the dispersion and extinguishment effectiveness of Halon and Halon-alternative fire extinguishment agents discharged from N2-pressurized vessels. In the systems under consideration, as the agent exits from the vessel, thermodynamic and fluid-dynamic instabilities lead to flashing and break-up of the agent into a two-phase droplet/gaseous jet mixture. This occurs in a transition region relatively close to the vessel exit orifice/nozzle. Downstream of this region the two-phase agent jet then mixes with the ambient air environment and is dispersed in the protected space. A mathematical model has been developed previously to simulate the time-dependent discharge of the agent from the pressure vessel. Using the output of this model and thermodynamic and fluid-dynamic considerations of the phenomena in the transition section, the present work develops a method for determining a set of initial/boundary conditions at an initial section of the jet, downstream of the transition region. These initial/boundary conditions are in a form that can be used to formulate and solve the problem of the development and dispersal of the ensuring mixed air/two-phase-agent jet. Example applications of the developed methodology are presented. These are for agent discharge from a half-liter cylindrical discharge vessel with a circular discharge nozzle/orifice of diameter 0.019m. Simulations involve discharge of the vessel when it is half-filled with either Freon 22 or Halon 1301 and then pressurized with N2 to 41.37x105Pa (600 psi).

Cooper, L. Y.
Generation Rate and Distribution of Products of Combustion in Two-Layer Fire Environments: A Model and Applications.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 23, 245-270, 1994.

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

A model is developed for predicting the generation rates of oxygen, fuel, and any other products of combustion in rooms containing fires and time-dependent fire environments. The model is called the Generalized Global Equivalence Ratio Model (GGERM). It extends the steady state global equivalence ratio model established previously from data of several steady-state experimental studies. After describing the GGERM, a concise algorithm is outlined for implementing it in two-layer zone-type compartment fire models. With the algorithm in place, such models could be used to simulate the distribution of combustion products in single or multi-room fire environments under conditions of arbitrary ventilation. In example applications, the GGERM is used to simulate the time-dependent environment, including that of steady-state, in some of the above-mentioned experimental studies. For arbitrary experimental conditions and for both complete stoichiometric combustion and 'read' combustion of methane, solutions for concentration of products of combustion are obtained and presented. For the case of complete stoichiometric combustion, the solutions are used to predict the time-to-extinguishment of a burning methane fuel source embedded in an initially ambient-atmosphere upper layer. In another application, the GGERM is used to simulate the combustion of hexane in an enclosure fire scenario where data has been reported in the literature. Predicted and measured concentrations of fuel and products are found to compare favorably.

Cooper, L. Y.
Overview of a Theory for Simulating Smoke Movement Through Long Vertical Shafts in Zone-Type Fire Models.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 93-94 pp, 1994.

fire research; smoke movement; zone models; fire models; compartment fires

A limitation of the two-layer quasi-steady-buoyant-plumes approach to modeling compartment fires. The modeling strategy which uses the concepts of one-to-two uniform layers per room, room-to-room mass exchanges by vent flows, and layer-to-layer mass exchange by quasi-steady buoyant plumes has proven to be very robust. However, there are important practical room configurations and associated fire scenarios where these basic concepts are inadequate. If the basic concepts are not applicable to a particular room configuration, then, to the extent that room plays a significant role in the spread of fire and smoke throughout the facility (e.g., the room is the connecting flow path between the room of fire origin and a threatened space), the inadequacy of the simulation in that room can render inadequate the entire simulation.

Cooper, L. Y.
Simulating Smoke Movement Through Long Vertical Shafts in Zone-Type Compartment Fire Models.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5526; 30 p. November 1994.
Available from National Technical Information Services
PB95-143152

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

A limitation of traditional zone-type compartment fire modeling concepts is identified; namely, the inadequacy of two-layer quasi-steady-buoyant-plume analyses to simulate the fire-generated environment in room configurations with large height-to-span ratios, e.g., elevator shafts and long, vertical, ventilation shafts and ducts. A possible means of removing this limitation is developed. This involves a method of analysis and associated model equations that can be implemented and used to advance zone-type models. The model equations simulate time-dependent flows in a long, ventilated, vertical shaft/duct with an arbitrary vertical density distribution, including one or more intervals along the shaft/duct length where the vertical distribution of the average cross-section density may be unstably stratified, i.e., density increasing with increasing elevation. The model equations are partially verified by favorable comparisons between solutions and previously published data from unsteady experiments in long vertical tubes involving initially unstable configurations: salt-water over fresh-water and heavy-gas over light-gas. Additional verification of the proposed equation set with cold-air over hot-air systems and with fire-driven smoke flows, both of which involve gas-to-surface heat transfer, is required before this model can be used with confidence in professional practice.

Cooper, L. Y.
Some Factors Affecting the Design of a Furniture Calorimeter Hood and Exhaust.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Fire Protection Engineering, Vol. 6, No. 3, 99-112, 1994.
NISTIR 5298; 25 p. December 1993.
Available from National Technical Information Services
PB94-139193

furniture calorimeter; exhaust systems; buoyant plumes; calorimeters; fire plumes; flame length; wall flows

This work considers factors affecting the design of an effective and versatile furniture calorimeter hood and exhaust system. The purpose of the furniture calorimeter, design functions, and inherent limitations of a particular design are discussed. The interactions between the hood structure and the fire and its plume are analyzed in the context of avoiding: flame impingement on the hood; enhanced combustion of a test article, over and above that of a free-burn; loss of combustion product plume gases due to "spill-over" below the hood; and unacceptable dilution of plume gases in the measurement section of the exhaust duct. The concept of the ideally designed hood is introduced, where, throughout the course of the burn of a test article the hood is always immediately above the flame tip and the exhaust rate always exactly matches the hood-ceiling-elevation plume-flow rate. Methods to partially or completely achieve the ideal design are presented. These include the combined features of adjustable hood elevation and adjustable hood exhaust rate. The ideas and results of analyses developed are applied in examples relevant to the existing furniture calorimeter hood and exhaust system of the NIST Building 205 Fire Research Laboratory. Recommendations for improvements to this facility are presented.

Cooper, L. Y.
VENTCF2: An Algorithm and Associated FORTRAN 77 Subroutine for Calculating Flow Through a Horizontal Ceiling/Floor Vent in a Zone-Type Compartment Fire Model.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5470; 71 p. August 1994.
Available from National Technical Information Services
PB94-210127

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

An algorithm and associated FORTRAN 77 subroutine, called VENTCF2, is presented for calculating the effects on two-layer compartment fire environments of the quasi-steady flow through a circular, shallow (i.e., small ratio of depth to diameter), horizontal vent connecting two spaces. The two spaces can be either two inside rooms of a multi-room facility or one inside room and the outside ambient environment local to the vent. The description of the flow through the vent is determined by combing considerations of the uni-directional-type of flow driven by a cross-vent pressure difference and, when appropriate, the combined pressure- and boundary-driven flows which occur when the density configuration across the vent is unstable, i.e., a relatively cool, dense gas in the upper space overlays a less dense gas in the lower space. In the algorithm, calculation of the rates of flow exchange between the two spaces is based on previously reported model equations. Characteristics of the geometry and the instantaneous environments of the two spaces are assumed to be known and specified as inputs. The outputs calculated by the algorithm/subroutine are the rates and the properties of the vent flow at the elevation of the vent as it enters the top space from the bottom space and/or as it enters the bottom space from the top space. Rates of mass, enthalpy, and products of combustion extracted by the vent flows from upper and lower layers of inside room environments and from outside ambient spaces are determined explicity. VENTCF2 is an advanced version of the algorithm/subroutine VENTCF2 in that it includes an improved theoretical and experimental basis. The subroutine is completely modular and it is suitable for general use in two-layer, multi-room, zone-type fire model computer codes. It has been tested over a wide range of input variables and these tests are described.

Coverdale, R. T.

Coverdale, R. T.; Christensen, B. J.; Mason, T. O.; Jennings, H. M.; Garboczi, E. J.
Interpretation of the Impedance Spectroscopy of Cement Paste Via Computer Modelling. Part 2. Dielectric Response.
Northwestern Univ., Evanston, IL

National Institute of Standards and Technology, Gaithersburg, MD
Journal of Materials Science, Vol. 29, 4984-4992, 1994.

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

Dielectric properties of cement pastes are measured using impedance spectroscopy, and the effective dielectric constants of the low frequency bulk arcs are reported. The unusually high values thereby obtained, and their dependence on reaction time and water: cement ratio, are explained by the presence of microstructural features that serve to amplify the dielectric constants of the individual material phases. The dielectric properties of three-dimensional cement paste models and of simple two-dimensional models of the hypothesized microstructural features are analysed. The model results provide insight into the proposed dielectric amplification mechanism in real cement paste.

Culver, C. G.

Culver, C. G.; Marshall, R. D.; Rendon-Herrero, O.
Investigation of L'Ambiance Plaza Building Collapse.
Occupational Safety and Health Admin., Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Performance of Constructed Facilities, Vol. 8, No. 2, 160-161, May 1994.

building collapse; investigations; shear stress; failure

In describing their investigation of the collapse of L'Ambiance Plaza in Bridgeport, Connecticut, the authors of the paper introduce new and crucial evidence that, when combined with other information that has surfaced over the past four years, makes a compelling case for shear-head failure as the triggering mechanism at L'Ambiance Plaza. While we do not find fault with the evidence presented in the paper, our interpretation of that evidence leads us to a failure scenario that differs in certain important aspects from the scenario advanced by the authors.

D

Dai, Z.

Dai, Z.; Tseng, L. K.; Faeth, G. M.
Self-Preserving Round Buoyant Turbulent Plumes: Implications for Turbulence Models.
University of Michigan, Ann Arbor
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 161-162 pp, 1994.

fire research; fire plumes; turbulence; fire models

Turbulence models are often used to analyze practical fires due to the computational intractability of fully resolved three-dimensional time-dependent simulations of practical buoyant turbulent flows. Developing reliable turbulence models, however, has been inhibited due to the absence of measurements; therefore, the objective of the present investigation is to complete measurements within round buoyant turbulent plumes, emphasizing self-preserving conditions far from the source. Present considerations include classical similarity concepts and turbulence models of varying complexity.

Dai, Z.; Tseng, L. K.; Faeth, G. M.
Structure of Round, Fully Developed, Buoyant Turbulent Plumes.
Michigan Univ., Ann Arbor
Journal of Heat Transfer, Vol. 116, No. 2, 409-417, May 1994.

fire plumes; tests; mixing; experiments

An experimental study of the structure of round buoyant turbulent plumes was carried out, emphasizing conditions in the fully developed (self-preserving) portion of the flow. Plume conditions were simulated using dense gas sources (carbon dioxide and sulfur hexafluoride) in a still air environment. Mean and fluctuating mixture fraction properties were measured using single-and two-point laser-induced iodine fluorescence. The present measurements extended farther from the source (up to 151 source diameters) than most earlier measurements (up to 62 source diameters) and indicated that self-preserving turbulent plumes are narrower, with larger mean and fluctuating mixture fractions (when appropriately scaled) near the axis, than previously thought. Other mixture fraction measurements reported include probability density functions, temporal power spectra, radial spatial correlations and temporal and spatial integral scales.

Dai, Z.; Tseng, L. K.; Faeth, G. M.
Velocity Statistics of Round, Fully-Developed, Buoyant Turbulent Plumes.
University of Michigan, Ann Arbor
American Society of Mechanical Engineers. Fire, Combustion, and Hazardous Waste Processing. HTD-Vol. 296. November 6-11, 1994, Chicago, IL, American Society of Mechanical Engineers, NY, Acharya, S.; Annamalai, K.; Presser, C.; Skocypec, R. D., Editors, 47-54 pp, 1994.
combustion; hazardous materials; waste disposal; fire plumes; velocity; scaling

An experimental study of the structure of round buoyant turbulent plumes was carried out, limited to conditions within the fully developed (self-preserving) portion of the flow. Plume conditions were simulated using dense gas sources (carbon dioxide and sulfur hexafluoride) in a still air environment. Velocity statistics were measured using laser velocimetry in order to supplement earlier measurements of mixture fraction statistics using laser-induced iodine fluorescence. Similar to the earlier observations of mixture fraction statistics, self-preserving behavior was observed for velocity statistics over the present test range (87-151 source diameters and 12-43 Morton length scales from the source), which was farther from the source than most earlier measurements. Additionally, the new measurements indicated that self-preserving plumes are narrower, with larger mean streamwise velocities near the axis (when appropriately scaled) and with smaller entrainment rates, than previously thought. Velocity statistics reported include mean and fluctuating velocities, temporal power spectra, temporal and spatial integral scales and Reynolds stresses.

Daikoku, M.

Daikoku, M.; Venkatesh, S.; Saito, K.
Use of Cellulose Sample for Material's Flammability and Pyrolysis Tests.
Kentucky Univ., Lexington
Journal of Fire Sciences, Vol. 12, No. 5, 424-441, September/October 1994.
pyrolysis; cellulose; flammability tests; polymethylmethacrylate; thermal conductivity; cone calorimeters; radiation absorption

During transient pyrolysis tests of charring and non-charring materials, we noticed that sample preparation is crucial to obtain reliable data, on which theoretical models are based. Different researchers use different sample preparation techniques which some time causes disagreement in the results and create ambiguity when test results are compared. In this paper, we propose a bench mark sample preparation technique to clarify the experimental ambiguity and establish a reliable/common data base. Pyrolysis tests were performed by exposing PMMA, douglas-fir particle board (DFPB), and cellulose samples to external radiant heat using quartz and cone heaters. The cellulose sample is suggested for its homogeneity and combustion characteristics similar to natural wood in order to eliminate a variety of experimental uncertainties due to inhomogeneity of particle board and wood samples for use in pyrolysis tests. Temperatures were measured at the front and back surfaces and at other intermediate locations using fine thermocouples. Thermal conductivity of DFPB and cellulose was then approximated from the measured temperature distributions as the sum of a linear temperature dependent term and a radiation penetration effect into the porous structure in the pre-pyrolysis zone. Effect of in-depth radiation absorption through the surface of the PMMA samples was estimated for various external radiant heat flux values; and it was found that in-depth radiation is an important factor in controlling the rate of heat transfer into the sample.

Davis, W. D.

Davis, W. D.; Forney, G. P.; Bukowski, R. W.
Simulating the Effect of Sloped Beamed Ceilings on Detector and Sprinkler Response.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 147-148 pp, 1994.

fire research; ceilings; simulation; detector response; sprinkler response; detectors

The rapid activation of fire detection and suppression systems in response to a growing fire is one of the important factors required to provide for life safety and property protection. Rapid activation requires that sensors be located at optimal distances both beneath the ceiling and radially from the fire. Ceiling obstructions, such as beams and joists, and ceiling slope can significantly modify the flow of smoke along the ceiling and must be taken into consideration when a particular detection system is designed. At present, the standards used to guide the design of these systems contain very little quantitative information concerning the impact of beamed, sloped ceilings on detector placement.

Deal, S.

Deal, S.
Technical Reference Guide for FPEtool Version 3.2.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5486; 132 p. August 1994.
AVAILABLE FROM National Fire Protection Association, Quincy, MA 02269 USA Telephone: + 01 + 617/984-7469
AVAILABLE FROM International Conference of Building Officials, Whittier, CA 90601 Telephone: + 01 + 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.

deRis, J.

deRis, J.; Orloff, L.
Similarity of Turbulent Wall Fires.
Factory Mutual Research Corp., Norwood, MA
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 157-158 pp, 1994.

fire research; wall fires; flammability; heat release rate; fire spread rate; heat transfer

This study was undertaken to help resolve the general flammability problem - namely, to predict heat release rates and fire spread rates in terms of readily measured material flammability properties. At present much of the problem is understood; however we

do not have established procedures for predicting the radiative heat transfer to adjacent fuel surfaces. These predictions must be quite accurate because upward spread and burning processes are very sensitive to flame heat transfer from the flames due to positive feedback. The present work parallel Markstein's investigation of the radiant heat transfer blockage by the cold gas and soot near the fuel surface.

Didion, D. A.

Didion, D. A.
Impact of Ozone-Safe Refrigerants on Refrigeration Machinery Performance and Operation.
National Institute of Standards and Technology, Gaithersburg, MD
Society of Naval Architects and Marine Engineers. Transaction of Naval Architects and Marine Engineering. November 1994, 10/1-15 pp, 1994.

refrigerants; ozone; machinery; thermodynamic performance; mixtures; safety; toxicity; flammability; materials compatibility; alternatives

The current ozone depletion crisis has impacted the refrigeration and air conditioning industry like no other event in history. The limitations placed on the development of machinery working fluids is causing major design changes in new equipment and modifications to existing equipment that will require owner/operators to face many decisions in what was previously a rather staid purchasing process. The elimination of chlorine from the refrigerants has forced the adoption of ester based lubricants in lieu of mineral oils. Molecular and thermodynamic constraints have brought about the expansion of the use of azeotropic refrigerant mixtures and the introduction of azeotropic refrigerant mixtures, with their variable composition problems. For the first time in many years, flammable refrigerants are being used, at least as minor components in mixtures. The transition period of the next several decades is likely to require the use of "drop-in" replacement fluids which can cause a capacity and/or efficiency change in the machine's performance. Furthermore, all the new alternative refrigerants (i.e., replacements) may themselves be unable to meet future environmental restrictions if the global warming crisis proves to be a political reality.

Didion, D. A.
Recent Developments in the Design of New Refrigerant Mixtures for Existing and Future Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Proceedings of the International Seminar: New Technology in Refrigeration. September 1994, Padua, Italy, 1994.

refrigerants; mixtures; zeotropic mixtures

The primary approach industry has taken to fill the void resulting from the elimination of the most important CFC's (i.e., CFC-11 and CFC-12) has been to develop other single component refrigerants (i.e., HCFC-123 and HFC-134a) which have very low or zero ozone depletion potential. These alternatives were attractive mostly because they had similar pressure-temperature property profiles relative to that which they were replacing and, thus, required minimal machinery design changes for adoption.

Didion, D. A.
Role of Refrigerant Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
Bulletin of International Institute of Refrigeration, No. 94-3, 6-11, January 1994.

refrigerants; mixtures; azeotropes; near-azeotropes; zeotropes

The primary approach industry has taken to fill the void resulting from the elimination of the most important CFCs (i.e., R11 and R12) has been to develop other single component refrigerants (i.e., HCFC-123 and HFC-134a) which have very low or zero ozone depletion potential. These alternatives were attractive mostly because they had similar pressure-temperature profiles relative to that which they were replacing and, thus, required minimal machinery design changes for adoption.

Dobbins, R. A.

Dobbins, R. A.; Mulholland, G. W.; Bryner, N. P.
Comparison of a Fractal Smoke Optics Model With Light Extinction Measurements.
Brown Univ., Providence, RI

National Institute of Standards and Technology, Gaithersburg, MD
Atmospheric Environment, Vol. 28, No. 5, 889-897, 1994.

smoke; extinction; absorption; aging (materials); optical density

Optical cross-sections of carbonaceous aggregates (smoke) formed by combustion sources have been computed based on fractal concepts. Specific extinction depends upon the primary particle size, the structure of the aggregate as represented by the fractal dimension, the fractal prefactor, and the real and imaginary components of the refractive index of the particle material. While the fractal dimension and primary particle diameter are narrowly defined, the refractive index, to which the results are highly sensitive, are disputed. Specific extinction was measured at lambda=450,630 and 1000 nm in a smoke-filled chamber with an optical path length of 1.0 m that was equipped to continuously monitor both particle mass and number concentration as the smoke aged during a 90-120 min interval. The smoke was generated by the burning of crude oil in a pool fire. Specific extinction at all three values of lambda was found to be constant even though the aggregate number concentration decreases by a factor of 24 owing to cluster-cluster aggregation. The refractive indices at several wavelengths that are required to give agreement with the measured specific extinction are compared with literature values. The inadequacy of Mie theory for spheres in predicting the optical properties of soot aggregates is reiterated.

Dols, W. S.

Dols, W. S.; Persily, A. K.
Measurements of Outdoor Air Distribution in an Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5320; 54 p. June 1994.
Available from National Technical Information Services

office buildings; age of air; air flow; building performance; commercial buildings; measurement; tracer gas; ventilation; ventilation effectiveness

The National Institute of Standards and Technology (NIST) has performed a study of outdoor air distribution in an office building. This study, performed in the Portland East Federal Office Building in Portland, Oregon, is a follow-up to a study in which outdoor airflow rates to the whole building were measured. This report focuses on the delivery of outdoor air to smaller sections of the building. The technique used to measure these "local" outdoor airflow rates is referred to as the multiplicative method. It consists of measuring the supply airflow rate and the percentage of outdoor air in the supply air, and then multiplying them together to obtain the outdoor airflow rate. Outdoor airflow rates were measured to various zones of the building ranging in size from an individual workstation or office cubicle to the entire space served by an air handler. In addition, both automated and manual sampling techniques were demonstrated for measuring local age of air to determine air change effectiveness and to provide information on the distribution and mixing of ventilation air. Some of the major findings of this study are as follows. When performing supply airflow rate measurements, the selection of the measurement location and the use of recommended guidelines were important for obtaining reliable results. Measurements of the same supply airflow rate made at different locations in the system were generally within 20% of each other. Also, while appropriate levels of outdoor air were brought in by the main air handling system, this outdoor air did not always reach the individual diffusers in the occupied space. In this study, the measured outdoor airflow rates per person, when considered on the scale of an air handler, were consistent with the recommendations of 10 L/s per person given in ASHRAE Standard 62-1989. However, measured outdoor airflow rates per person on smaller scales, i.e., in spaces served by individual terminal units and at individual workstations, were sometimes below the recommended levels of the current ASHRAE Standard 62-1989 and ASHRAE Standard 62-1981 to which the building was designed to conform. Several instances were observed when terminal units were completely shut off, thus eliminating the flow of outdoor air to as many as fifteen diffusers at a time. Measured values of air change effectiveness based on tracer gas decay measurements of local age of air were consistent with good mixing of the ventilation air in the occupied space.

Dols, W. S.; Persily, A. K.; Nabinger, S. J.
Development and Application of an Indoor Air Quality Commissioning Program in a New Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). Engineering Indoor Environments. IAQ'94 Conference. October 30-November 2, 1994, St. Louis, MO, 23-33 pp, 1994.

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

An indoor air quality commissioning program has been developed and is being implemented in a new office building in Rockville, Maryland. New buildings can have an increased potential for indoor air quality (IAQ) problems due to new building materials and deficiencies in mechanical ventilation system operation during construction and initial occupancy. This IAQ commissioning effort is being implemented to reduce the potential for such problems in this building. This commissioning program consists of three tasks: (1) evaluate the mechanical ventilation system design; (2) develop a set of criteria that will be used to evaluate IAQ in the building, and (3) measure various environmental parameters for comparison with the criteria developed in Task 2. Tasks 1 and 2 have been completed and Task 3 is in progress. The evaluation of the mechanical ventilation system design was based on the recommendations of ASHRAE Standard 62-1989 and the 1987 BOCA mechanical code. The design evaluation showed that the system ventilation rates were consistent with the recommendations of the ASHRAE standard and the requirements of the BOCA code. The IAQ criteria developed in Task 2 address ventilation system performance, indoor pollutant levels, and thermal comfort. These criteria are based on appropriate standards and guidelines and on the results of previous IAQ research. Task 3 consists of the measurement of these IAQ parameters in three phases of building construction: after completion of interior buildout, after the installation of the systems furniture, and roughly one month after occupancy. The first phase of Task 3 is complete and the results indicate compliance with the IAQ criteria prior to installation of the systems furniture.

Domanski, P. A.

Domanski, P. A.; Didion, D. A.; Mulroy, W. J.; Parise, J.
Simulation Model and Study of Hydrocarbon Refrigerants for Residential Heat Pump Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Proceedings of a Conference on New Applications of Natural Working Fluids in Refrigeration and Air Conditioning. May 10-13, 1994, Hanover, Germany, [unknown] pp, 1994.

refrigerants; hydrocarbons; heat pumps; temperature differences; transport properties; verification; evaluation

To conduct a systematic study of Natural Fluids as working fluids for heat pumping applications, it was necessary for NIST to simultaneously expand its analytical tools and evaluate what design changes American industry would most readily accept. The problem was approached by categorizing all potential working fluids into one of three vapor pressure groups - high, intermediate, and low - and evaluating disadvantages presented by each category. The intermediate group spans the range covered by the CFCs that have been traditionally used (i.e., R-502 to R-11). An example of the high and low-pressure refrigerants are CO2 and H2O, respectively.

Domanski, P. A.; Mulroy, W. J.; Didion, D. A.
Glide Matching With Binary and Ternary Zeotropic Refrigerant Mixtures. Part 2. A Computer Simulation.
National Institute of Standards and Technology, Gaithersburg, MD
International Journal of Refirgeration, Vol. 17, No. 4, 226-230, 1994.

refrigerants; zeotropic mixtures; boiling points; refrigerant mixtures; simulation

The glide-matching study presented in Part 1 was a laboratory investigation which demonstrated the evaporator performance in detail. However, since it was not possible to instrument the condenser sufficiently, some computer simulation work was conducted using a semi-theoretical model CYCLE-11, which has been under continual development at NIST for the past five years. As in the experimental effort, R22,R142b, R22/142b,R23/22/142b and R23/142b working fluids were investigated, but the simulation work did not include heat pump operation with liquid-line/evaporator heat exchange. By utilizing the model to quantify entropy generation at various state points within the cycle, it was possible to locate the likelihood of temperature profiles pinch points in both the condenser and evaporator. This information clarified the impact of non-linearities on the system performance.

Dutta, P.

Dutta, P.; Gore, J. P.; Sivathanu, Y. R.; Sojka, P. E.
Global Properties of High Liquid Loading Turbulent Crude Oil + Methane/Air Spray Flames.
Purdue Univ., West Lafayette, IN

Combustion and Flame, Vol. 97, No. 3-4, 251-260, 1994.

crude oil; blowout fires; atomizing; flame heights; temperature; methane; temperature measurements; turbulent flow; combustion; oil well fires

Measurements of atomization quality, flame heights, radiative fractions, emission temperatures, and transmittance for Alberta sweet crude oil/methane flames established on a novel burner for simulating well-blowout fires are reported. The results show the effects of two-phase flow on flame heights. The measurements of radiative fractions and the optical properties suggest relatively low soot loading. The measured high temperatures suggest almost complete combustion of crude-oil. However, larger-scale tests as well as information concerning the physical processes in the present atomizer and burner are essential for the application to practical fires and combustion devices.

Dutta, P.; Sivathanu, Y. R.; Gore, J. P.
Investigation of Oil and Gas Well Fires and Flares. Final Report.
Purdue Univ., West Lafayette, IN
NIST-GCR-94-653; 68 p. June 1994.
Available from National Technical Information Services
PB94-193976

oil well fires; fire research; heat flux; jet flames; fire safety; pool fires; fire size

A theoretical and experimental study of jet flames with applications to large fires resulting from oil well and gas well accidents is reported. The results have been used in the interpretation of the single point radiation heat flux data collected around well fires in Kuwait. The significant accomplishments during the grant include: development of a technique to find total radiative heat flow from turbulent jet flames based on measurements of heat flux at a single location; design and successful operation of an effervescent atomizer/burner; study of global properties of the high liquid loading jet flames have shown that their lengths are affected by two-phase flow effects and that their soot loading and radiant output is lower than equivalent pool flames. The first time opportunity to study high liquid loading jet flames in the laboratory has led to a study with applications in the industrial safety and insurance-cost containment areas. Design of liquid handling and storage systems, areas around storage tanks and pipes, and fire safety and fire fighting procedures and effectiveness will benefit from the laboratory information concerning fire size, shape and radiant output.

E

Emmerich, S. J.

Emmerich, S. J.; Persily, A. K.
Indoor Air Quality Impacts of Residential HVAC Systems. Phase 1 Report. Computer Simulation Plan.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5346; 117 p. February 1994.
Available from National Technical Information Services
PB95-135596

air flow; heating; ventilation; air conditioning; indoor air quality; computer models; residential buildings; computer simulation

NIST has completed the first phase 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. This project will use computer simulations to assess the ability of modifications to central forced-air heating and cooling systems to control the concentrations of selected pollutants in single-family residential buildings. The first phase consisted of three major efforts: conducting a literature review, developing a plan for computer analysis, and holding an expert workshop to discuss the plan. The second phase of the project will involve performing the computer simulations and analyzing the results. This report details the results of the Phase 1 efforts. The objective of the literature review was to obtain information for planning computer simulations that will be performed in Phase 2 of the project. Specific subjects reviewed include indoor air quality simulation tools, previous studies of the impacts of residential HVAC systems on indoor air quality, residential pollutant sources, and indoor air quality control technologies associated with residential HVAC systems. The development of the plan for the computer simulations included the following items: selection of

appropriate computer simulation techniques, definition of buildings to be analyzed in the simulations (including building and HVAC system designs and building locations), specification of pollutant source profiles, and selection of HVAC technologies for indoor air quality control. After the initial plan was developed, an expert workshop was held at NIST to discuss the proposed project plan and obtain feedback on its technical merit and relevance to residential indoor air quality issues. The overall reaction to the project objective and approach was positive and most of the workshop discussion focused on the details of the plan or on potential follow-up work. The workshop discussions were considered in developing the final plan as presented in this report.

Emmerich, S. J.; Persily, A. K.; Walton, G. N.
Application of a Multi-Zone Airflow and Contaminant Dispersal Model to Indoor Air Quality Control in Residential Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
AIVC Conference, 15th. The Role of Ventilation. September 27-30, 1994, 494-507 pp, 1994.
airflow modeling; indoor air quality; building technology; residential buildings; infiltration

A new multizone airflow and contaminant dispersal model CONTAM93 is described, along with a demonstration of its application in a study of ventilation and contaminant control in single-family residential buildings. While CONTAM93 is based on existing theory of network airflow analysis and contaminant dispersal, the model employs a unique graphic interface for data input and display. The interface uses a sketchpad to describe the connections between zones and icons to represent zones, openings, ventilation system components, and contaminant sources and sinks. The model, its graphic interface and plans for its further development are described.

Evans, D. D.

Evans, D. D.
In Situ Burning of Oil Spills: Smoke Production and Plume Behavior.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 867; August 1994.
Available from National Technical Information Services
PB95-104907
National Institute of Standards and Technology and Minerals Management Service. In Situ Burning Oil Spill. Proceedings. January 26-28, 1994, Orlando, FL, Jason, N. H., Editor, 29-37 pp, 1994.
in situ burning; oil spills; smoke production; smoke plumes; crude oil; experiments; dispersion; smoke yield

In 1985, the National Institute of Standards and Technology (NIST) began a study of in situ burning of crude oil to provide information to support decisions about the use of this technology for oil spill response. Measured smoke production from burning of crude oils in the laboratory, in mesoscale experiments, and in an offshore experiment are presented. Calculations of smoke plume dispersion for an oil spill burn in the vicinity of Cook Inlet, Alaska show that beyond 5 km downwind of the burn, smoke particulate concentrations near the ground averaged over 1 hour do not exceed 150 mg/m3.

Evans, D. D.
Progress Report on Suppression and Detection Research in the U.S.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 76-80 pp, 1994.
fire safety; fire research; fire suppression; fire detection; halon 1211; halon 1301; sprinklers

Progress in the area of fire suppression and detection has been dominated by the search for environmentally friendly replacements for Halons 1211 and 1301 and the investigation of new technologies borrowed from other fields for application in fire detection. New methods of characterizing the suppression of furnishing fires have lead to means of incorporating the fire suppression effects

of sprinklers into predictive fire models. A limited water supply sprinkler system has been developed for installation in mobile homes. The minimum flow requirement for the system is 0.82 l/s from a reservoir with a minimum capacity of 378 liters.

Evans, D. D.
Sprinkler Fire Suppression Algorithm for HAZARD.
National Institute of Standards and Technology, Gaithersburg, MD
U.S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 114-120 pp, 1994.

sprinklers; fire suppression; hazard analysis; cribs; crib fires; fire protection; algorithms

Measurements of the heat release rate of a fully involved square base wood crib both before and during fire suppression with water spray from commercial sprinklers were used to develop a correlation for the exponential decay time constant of the fire heat release rate from the value at sprinkler actuation. This correlation is the basis for prediction of limits for heat release rates of furnishings during fire suppression. For 0.61 m square base wood cribs that are 0.61 m in height, the time constant varies with spray density. Using this result, the time constant for suppression at a sprinkler spray density of 0.07 mm/s is 410 s.

Evans, D. D.; Madrzykowski, D.; Haynes, G. A.
Flame Heights and Heat Release Rates of 1991 Kuwait Oil Field Fires.
National Institute of Standards and Technology, Gaithersburg, MD
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 1279-1289 pp, 1994.

fire research; fire safety; fire science; oil well fires; flame height; heat release rate; blowout fires; crude oil; flame radiation; jet flames

A series of measurements were made in the Al Mawqa/Al Ahmadi oil field region of Kuwait to explore the feasibility of assessing the heat release rate of individual well fires through flame height and thermal radiation measurements. The heat release rate (in kW) of crude oil well fires was correlated with the flame height (zeta,in meters) using rate of heat release = (zeta/0.21)5/2. The 12 Kuwait oil field fires measured ranged in calculated heat release rate from 90 MW to 2 GW which correspond to flow rates of 0.003 m3/s (1500 bbls/day) to 0.059 m3/s (30000 bbls/day). Based on these twelve burning well measurements, the estimated total flow from the 651 damaged wells, both burning and leaking in March 1991, was 14 m3/s (7,400,000 bbls/day) which is only 20 percent greater than published National Oceanic and Atmospheric Administration (NOAA) estimates based on information from the Kuwait Oil Company.

Evans, D. D.; Walton, W. D.; Notarianni, K. A.; Baum, H. R.; Koseki, H.
Large Fires: Burning of Oil Spills.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Research Institute, Tokyo, Japan
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 365-371 pp, 1994.

fire safety; fire research; oil spills; combustion; burning rate; smoke yield; particle size distribution; fire plumes

In 1991 a series of 14 mesoscale fire experiments were performed to measure the burning characteristics of crude oil on salt water. These oil burns in a pan ranged in size from 6 m square to 15 m square. Results of the measurements for burning rate and smoke emissions are compared to those from previous smaller scale burns conducted both in the U.S. and in Japan. The burning rate as indicated by the regression rate of the oil surface was found to be 0.055 + 0.01 mm/s for pan fires with effective diameters greater than 7 m. Smoke particulate yields from fires greater than 2 m in diameter were found to be approximately 0.13 of the oil burned on a mass basis. Predictions of smoke plume trajectory and particulate deposition at ground level from the Large Eddy Simulation (LES) model developed as part of this research effort were found to be different from those predicted by the EPA approved

SCREEN model. LES is a steady-state three-dimensional calculation of smoke plume trajectory and smoke particulate deposition based on a mixed finite difference and Lagrangian particle tracking method.

Ezekoye, O. A.

Ezekoye, O. A.; Zhang, Z.
Simulation of a Jet Diffusion Flame Using Lagrangian Thermal Elements.
University of Texas, Austin
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 165-166 pp, 1994.

fire research; diffusion flames; jet flames; combustion

An obstacle to the accurate simulation of the combustion processes in various turbulent combustion phenomena is the inability to model all scales of interactions on the computational grid. Several modeling strategies are presently used to overcome this obstacle. The laminar flamelet approach to combustion appears to provide a means of resolving many of the complexities associated with turbulent combustion. Unfortunately, however, problems exist with the temporal and spatial temperature and soot species specifications in heavily sooting and radiating flames.

F

Fahy, R. F.

Fahy, R. F.
EXIT89: An Evacuation Model for High-Rise Buildings. Model Description and Example Applications.
National Fire Protection Association, Quincy, MA
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 657-668 pp, 1994.

fire research; fire safety; fire science; evacuation; high rise buildings; egress

EXIT89 is an evacuation model designed to handle the evacuation of a large population of individuals from a high-rise building. It has the ability to track the location of individuals as they more through the building so that the output from this model can be used as input to a toxicity model that will accumulate occupant exposures to combustion products. The model has been enhanced to allow the user to specify whether the occupants of the building will follow the shortest exit paths or their familiar route from the building, as well as to allow evacuation delays to be set by the user by locations and additional delays to be distributed randomly among the occupants. It allows smoke input to be read in from a smoke movement model or from user-defined blockages. EXIT89 models queuing effects by using occupant densities in building spaces to compute each occupant's walking speed. One proposed future use for EXIT89 is as the evacuation module of Hazard I, allowing that software package to extend its use to larger, more complex buildings. The model described in this paper was designed to use the smoke movement data generated by one component of Hazard I and to provide the occupant location data required by the tenability model incorporated in Hazard I. The program has been tested using data from evacuation drills in several buildings. Examples of the applications are presented in this paper. The model is written in FORTRAN.

Fang, J. B.

Fang, J. B.; Persily, A. K.
CONTAM88 Building Input Files for Multi-Zone Airflow and Contaminant Dispersal Modeling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5440; 54 p. June 1994.

Available from National Technical Information Services
PB94-194388

air flow modeling; contaminant dispersal; building technology; computer modeling; infiltration; modeling; ventilation

Input files for the multi-zone airflow and contaminant dispersal computer program CONTAM88 are described for four large buildings. The files were developed for a 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 school building. The physical characteristics of each building and its idealization as a multi-zone airflow system are described. These input files enable a user to employ CONTAM88 to study airflow and contaminant dispersal in these large buildings without developing building idealizations and inputting them into CONTAM88. Results of selected computer simulations are presented to demonstrate the effects of wind speed, indoor-outdoor temperature difference, and the percentage of outdoor air intake in the supply air on air change rates and interzonal airflows for these four buildings. Appendices are also included that contain a building component leakage database useful in multi-zone airflow modeling and updated information on the use of CONTAM88.

Fanney, A. H.

Fanney, A. H.; Saunders, C. A.; Hill, S. D.
Test Procedures for Advanced Insulation Panels.
National Institute of Standards and Technology,
Gaithersburg, MD
Alliance for Responsible Atmospheric Policy; U. S. Environmental Protection Agency; Enviornment Canada and United National Environmental Program. International CFC and Halon Alternatives Conference, 1994. Stratospheric Ozone Protection for the 90's. October 24-26, 1994, Washington, DC, 1994.

halons; ozone; thermal measurement; calorimeters; heat flow; thermal resistance; metal cladding; powder filling; insulation systems

Advanced insulation technologies are being developed in order to meet increasing stringent minimum efficiency standards for appliances and building envelopes. Numerous advanced insulation concepts have been developed to the stage that full-scale prototypes and, in some cases, commercial products are available. These concepts include powder, aerogel, foam, glass fiber filled evacuated panels, and low conductivity gas based systems, some of which are operated at a vacuum whereas others are operated at atmospheric pressure. These emerging insulation technologies offer the potential for extremely high thermal resistance values. The National Institute of Standards and Technology (NIST) has undertaken a research program to develop thermal measurement techniques appropriate for advanced insulation panels. This paper describes the design of a calorimetric apparatus, compares the calorimetric results to measurements made using a heat flow meter apparatus for homogenous materials, and describes the procedure used to determine the thermal resistance of an advanced insulation panel. Finite-element modelling results are presented which show the effect of various physical parameters on the overall thermal resistance of a metal-clad powder-filled vacuum insulation system.

Fanney, A. H.; Whittier, K. M.; Traugott, A. E.; Simon, L. N.
National Institute of Standards and Technology, Gaithersburg, MD
U.S. Green Building Council, Washington, DC
NIST SP 863; June 1994.
Available from National Technical Information Services
PB94-206364
National Institute of Standards and Technology and the U.S. Green Building Council (USGBC). U.S. Green Building Conference, 1994. February 16-17, 1994, Gaithersburg, MD, Fanney, A. H.; Whitter, K. M.; Traugott, A. E.; Simon, L. N., Editors, 150 pp, 1994.

building technology

This report constitutes the proceedings of the Green Building Conference held in Gaithersburg, Maryland, February 16-17, 1994. The conference was co-sponsored by the National Institute of Standards and Technology (NIST) and the U.S. Green Building Council (USGBC). Over 450 individuals attended the conference representing building product manufacturers, building owners

and managers, environmental groups, utilities, contractors, builders, architects, engineers, and the local, state, and the federal governments. The conference provided an opportunity to acquire practical, useful information on green buildings, resources, and guidelines. The conference commenced with welcoming remarks from David Gottfried, USGBC President and Samuel Kramer, Associate Director of NIST. Cathy Zoi from the White House Office of Environmental Policy gave the keynote address entitled "Green Buildings - The White House Perspective." The remainder of the conference focused on the following topics: (*) International Activities: A presentation of assessment methodologies and performance criteria for green buildings in Canada, the United Kingdom, and the United States; (*) U.S. Activities: An overview of the leading national non-profit organizations and government agencies involved in the development of green building programs, standards, and educational resources; (*) Exemplary Green Buildings: A presentation of green building case studies, including residential, commercial, and institutional structures; (*) Current and Future Technology Needs: A discussion of current and promising new technologies in the areas of building materials, lighting, and indoor air quality.

Fernandez-Pello, A. C.

Fernandez-Pello, A. C.
Fire Propagation in Concurrent Flows. Final Progress Report. September 1, 1992-August 31, 1993.
California Univ., Berkeley
NIST-GCR-94-644; 66 p. June 1994.
Available from National Technical Information Services
PB94-193844

fire spread; buoyant flow; fire research; flame size; polymethylmethacrylate; turbulent burning; turbulent flow; turbulent heat transfer

A research program has being conducted to study the mechanisms controlling the spread of flames in an oxidizing gas flow moving in the direction of flame propagation. During this reporting period research has been conducted to study the effect of the oxidizer flow characteristics on the concurrent flame spread over thick PMMA sheets. The parameters varied in the experiments are the oxidizer flow velocity, turbulence intensity and oxygen concentration, and the geometrical orientation (floor and ceiling). Their effect on the flame spread process is studied by measuring the rate of flame spread, flame length, surface heat flux, products of combustion and soot. The results of the experiments show that the combined effect of flow velocity, turbulence intensity, and oxygen concentration has a complex influence on the flame spread process. At low flow velocity, the flame spread rate increases monotonically with turbulence intensity. At high flow velocity, however, the flame spread rate increases with flow turbulence at low turbulence intensities, but it decreases at high turbulence intensity values. The effect is more pronounced at high oxygen concentration. These trends appear to be due to a strong influence of the turbulence intensity on the flame temperature and length, and on the heat flux from the flame to the solid fuel. Turbulence enhances mixing, which increases the flame temperature and then the heat flux. The effect of turbulence on the flame length comes from two opposing factors. In one hand the enhanced mixing results in a stronger reaction with faster reactant consumption, which tends to produce a shorter but hotter flame. On the other hand, the higher flame temperature results in an increased mass burning rate, which tends to increase the flame length. It appears that at low flow turbulence, the latter effect dominates and thus there is an increase in the flame length. As the turbulence level continues to rise, the reactant consumption dominates, which leads to a decrease in the flame length. For the present experiments, the transition between the two regimes shifts from u'/U=5% at U=2.0 m/s, to u'/U=15% at U=1.0 m/s, and no transition point is observed at U=0.5 m/s within our experimental conditions. The flame spread rate is the outcome of the combined effect of the flame length and the heat flux. Under all flow velocities and turbulence intensities, the flame spread rate increases with the oxygen concentration. For low oxygen concentrations, a linear dependence is observed between the flame spread rate and the oxygen concentration. For high oxygen concentrations, the dependence of the flame spread rate on the oxygen concentration follows a second power law. By comparing the floor and ceiling results, it is found that buoyancy has two opposite effects, one is enhancing the heat transfer to the surface by reducing the flame stand-off distance and the other reducing the chemical reaction completeness by intensifying the flame quenching at the wall. The overall buoyancy effect on the flame spread and mass burning processes depends on the flow condition.

Fleischmann, C. M.

Fleischmann, C. M.
Backdraft Phenomena. Final Report. 1990-1992.
California Univ., Berkeley
NIST-GCR-94-646; 238 p. June 1994.

Available from National Technical Information Services
PB94-193927

backdraft; building fires; deflagration; fire research; fireballs; glass; gravity; room fires; ventilation; windows

The purpose of this project was to develop a fundamental physical understanding of backdraft phenomena. The research was divided into three phases: exploratory simulations, gravity current modeling, and quantitative backdraft experiments. The primary goal of the first phase was to safely simulate a backdraft in the laboratory. A half-residential-scale compartment was built to conduct exploratory experiments. The initial experiments concluded with a scenario describing the fundamental physics of backdrafts. The importance of the gravity current which enters the compartment after opening was identified. In the second phase, the gravity current speed and the extent of its mixed region was investigated in a series of scaled salt water experiments. The scaled compartment (0.3m x 0.15m x 0.15m) was fitted with a variety of end openings: full, slot, door, and window. Video and photo data indicate that the mixing layer which rides on the gravity current in the full opening case, expands to occupy nearly the entire current in the partial opening cases. The Froude number and nondimensional head height are independent of beta and are in good agreement with numerical simulations and special limits from the literature. In the final phase, 28 backdraft experiments were conducted in a 1.2m by 1.2m by 2.4m compartment. A methane burner was ignited inside a closed compartment and allowed to burn as long as oxygen was available. After the flame extinguished due to oxygen starvation, the burner was left on to allow the unburned fuel fraction to increase. Upon opening the hatch a gravity current enters the compartment and travels across the floor to the ignition source. After ignition a deflagration rips through the compartment and out the opening culminating in a large fireball. Histories recorded included: fuel flow rates, upper layer temperatures, lower layer temperatures, opening velocities, compartment pressures, upper layer species concentrations for O2, CO2, CO, and HC. Results indicate that unburned fuel mass fractions >15% are necessary for a backdraft to occur and that the backdraft severity strongly depends on the delay time and species concentrations.

Fleischmann, C. M.; Pagni, P. J.
Preliminary Backdraft Experiments.
California Univ., Berkeley
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 208-215 pp, 1994.

fire safety; fire research; experiments; deflagration; backdraft

Backdraft is defined as a rapid deflagration following the introduction of oxygen into a compartment filled with accumulated excess pyrolyzates. A scenario describing the physical and chemical fundamentals underlying backdraft phenomena is presented. A half-scale apparatus, designed to avoid dangerous over-pressures, is used to obtain data from backdraft experiments. A gas burner supplied a 150 kW natural gas fire in a 1.2 m high, 1.2 m wide, 2.4 m long compartment with a small, 2.5 cm high 30 cm wide, vent at floor level. Significant excess pyrolyzates accumulate in 180 sec, when a hatch covering a 0.4 m high 1.2 m wide vent, centered on a short wall, is opened. A gravity current carries a flammable mixed region to a spark located near the burner on the opposite wall. The rapid deflagration which results upon ignition of the mixed region is the backdraft.

Fleischmann, C. M.; Pagni, P. J.; Williamson, R. B.
Quantitative Backdraft Experiments.
University of Cantebury, Christchurch, New Zealand
California Univ., Berkeley
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 337-348 pp, 1994.

fire research; fire safety; fire science; backdraft; experiments; compartment fires; explosion hazards

This paper focuses on 17 experiments in a 1.2 m by 1.2 m by 2.4 m compartment. A methane burner, flowing at either 70 kW or 200 kW, was ignited inside a closed compartment and burned until the initially available oxygen was consumed. After the fire self-extinguished, the burner was left on allowing the unburned fuel mass fraction in the compartment to increase. After removing a hatch, covering a 1.1 m wide by 0.4 m high slot opening, a gravity current entered the compartment. It traveled across the floor, mixed with the unburned fuel, and was ignited by a spark near the burner. After mixture ignition, a backdraft occurred as a

deflagration ripped through the compartment culminating in a large external fireball. Histories recorded prior to backdraft included: fuel flow rates, upper layer temperature, lower layer temperatures, upper layer species concentrations for O2, CO2, CO, and HC. Data collected to quantify the backdraft included opening gas flow velocities and compartment pressures. Results indicate that unburned fuel mass fractions >10% are necessary for a backdraft to occur.

Fleischmann, C. M.; Pagni, P. J.; Williamson, R. B.
Salt Water Modeling of Fire Compartment Gravity Currents.
University of Cantebury, Christchurch, New Zealand
California Univ., Berkeley
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 253-264 pp, 1994.

fire research; fire safety; fire science; salt water models; compartment fires; gravity current; backdraft; explosion hazards

In order to investigate the gravity current speed and the extent of its mixed region in backdraft experiments, a series of scaled salt water experiments were conducted. The scaling parameters are the Froude number, [equation], and the normalized density difference, betta=(rho0-rho1)/rho1, where 1 indicates initial conditions in the compartment (fresh) and 0 indicates conditions in the ambient (salt). The scaled compartment (0.3m x 0.15m x 0.15m) was fitted with a variety of end openings: full, slot, door, and window. Video and photo data indicate that the mixing layer which rides on the gravity current in the full opening case, expands to occupy nearly the entire current in the partial opening cases. Results for the scaled current height, h*=h0/h1 and v* respectively are: full (0.5, 0.44), slot (0.38, 0.32), door (0.33, 0.35), and window (0.29, 0.22). These data are independent of betta and are in good agreement with limit calculations from the literature.

Forney, G. P.

Forney, G. P.
Computing Radiative Heat Transfer Occurring in a Zone Fire Model.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology, Vol. 14, No. 1, 31-74, 1994.

radiative heat transfer; zone models; numerical analysis

Radiation, convection and conduction are the three mechanisms which a zone fire model must consider when calculating the heat transfer between fires, wall surfaces and room gases. Radiation dominates the other two modes of heat transfer in rooms where there are fires or hot smoke layers. The computational requirements of a radiation model can also easily dominate the work required to calculate other physical sub-models in a zone fire model. This report presents algorithms for efficiently computing the radiative heat exchange between four-wall surfaces, several fires and two interior gases. A two-wall and a ten-wall radiation model are also discussed. The structure of this radiation model is exploited to show that only a few configuration factors need to be calculated directly (two rather than 16 for the four-wall model and eight rather than 100 for the ten-wall model) and matrices needed to solve for the net radiative flux striking each surface are shown, after the appropriate transformation is taken, to be diagonally dominant. Iterative methods may then be used to solve the linear equations more efficiently than direct methods such as Gaussian elimination. The radiation exchange algorithms are implemented as FORTRAN subroutines named RAD2, RAD4 and RAD10. These subroutines along with a test driver are available from the author.

Forney, G. P.; Bukowski, R. W.; Davis, W. D.
Simulating the Effect of Flat Beamed Ceiling on Detector and Sprinkler Response.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers. Fire, Combustion, and Hazardous Waste Processing. HTD-Vol. 296. November 6-11, 1994, Chicago, IL, American Society of Mechanical Engineers, NY, Acharya, S.; Annamalai, K.; Presser, C.; Skocypec, R. D., Editors, 143-150 pp, 1994.

combustion; hazardous materials; waste disposal; beams; detector location; detector response; fire simulation; fluid flow; smoke detection; ceilings; sprinkler response

This paper documents a portion of the work performed during the first year of the International Fire Detection Research Project sponsored by the National Fire Protection Research Foundation (NFPRF). The first task was to confirm that fire sensor response can be evaluated using computational data obtained from numerical simulations. A field model was verified for this application by showing that its temperature predictions match experimental results obtained earlier by Heskestad and Delichatsios. This paper concentrates on the second task which was to perform a parameter study to show the effect of sensor response under beamed ceilings for various geometries and fire sizes. One question that is addressed is under what conditions can sensors be located on beams rather than in beam pockets. Time to sensor activation contour plots are presented that address this question. Twenty cases were run for various fire sizes, beam depths, beam spacings and ceiling heights. These data are summarized and recommendations are made on placing sensors in rooms with beamed ceilings.

Forney, G. P.; Moss, W. F.
Analyzing and Exploiting Numerical Characteristics of Zone Fire Models.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology, Vol. 14, No. 1, 49-60, 1994.
zone models; fire models; computer models; numerical analysis

In order to design robust and stable zone fire modeling algorithms, the numerical properties of computer arithmetic and modeling differential equations must be understood. This report examines some of these properties and provides tools for their analysis. Many sets of different equations for zone fire modeling can be derived using the conservation of mass and energy. A comparison between various possible formulations is made in terms of numerical properties. One property that many formulations possess is the presence of multiple time scales. Pressures equilibrate much faster than other quantities such as density and temperature. Numerically, this property is known as stiffness. Stiffness, in the context of fire modeling, and numerical methods for handling it are discussed.

Fowell, A. J.

Fowell, A. J.
Overview Publication: STP 1233 Fire and Flammability of Furnishings and Contents of Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
3 p. 1994.
flammability; interior furnishings; wall linings; building fires; furniture; linings

The severity and impact of building fires is dictated by the flammability of the furnishings and contents, the performance of fire protection systems, and the actions of occupants and firefighters. Furnishings are the items first ignited in a large fraction of building fires including those fires responsible for many of the fire deaths in the United States. A primary tool used to limit fire growth in buildings is regulation of wall and ceiling materials, based on standard tests of the flammability and fire resistance. The development, revision, and approval of fire tests standards has been a role of ASTM Committee E5 on Fire Standards. Recent advances in fire science and engineering have led to the development of computer models to predict the development of fire in buildings and new measurement methods to provide input data for those models. These analytical tools have highlighted the importance of ignitability, heat release, and flame spread rate of furnishings and contents on the growth of fire. Other scientific advances, particularly in the United States and in Europe on material flammability, are resulting in products such as upholstered furniture, mattresses, curtains, drapes, wall, and floor covering materials which will reduce the incidence, severity, and impact of building fires.

Fowell, A. J.
White Papers Prepared for the White House--Construction Industry Workshop on National Construction Goals.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5610; 152 p. 1994.
Available from National Technical Information Services
White Papers Prepared for the White House--Construction Industry Workshop on National Construction Goals. December 14-16, 1994, Fowell, A. J., Editor, 1994.
construction; industries; research programs; competitiveness

This report contains several white papers prepared for a December 1994 White House--Construction Industry workshop organized by the Civil Engineering Research Foundation on behalf of the National Science and Technology Council's Subcommittee on Construction and Building. The National Science and Technology Council (NSTC), a cabinet-level group charged with setting Federal technology policy, coordinates R&D strategies across a broad cross-section of public and private interests. It has established nine research and development committees, including the Committee on Civilian Industrial Technology (CCIT), to collaborate with the private sector in developing a comprehensive national technology policy. The Subcommittee on Construction and Building (C&B) of CCIT coordinates and defines priorities for Federal research, development and deployment related to the industries that produce, operate and maintain constructed facilities, including buildings and infrastructure. In preparation for the workshop the steering committee asked selected industry leaders to prepare seven white papers on the industry goals, barriers to reaching those goals, and the perspective of five sectors of the industry, residential, commercial, industrial, institutional, and public works. Those white papers are presented in this document. The results of the workshop are contained in a separate report, "National Construction Goals: A Construction Industry Perspective," prepared by the Civil Engineering Research Foundation.

Fowell, A. J., Editor
American Society for Testing and Materials (ASTM). Fire and Flammability of Furnishings and Contents of Buildings. ASTM STP 1233. Sponsored by ASTM Committee E5 on Fire Standards and Its Subcommittee E05.32 on Research. December 7, 1992, Miami, FL,
ASTM, Philadelphia, PA, 247 pp, 1992.
National Institute of Standards and Technology, Gaithersburg, MD
flammability; interior furnishings; wall linings

Fuller, G. R.

Fuller, G. R.; Marshall, R. D.
Standards to Resist Hurricane Wind Forces.
Department of Housing and Urban Development, Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 871; September 1994.
Available from Government Printing Office
SN003-003-03297-2
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 26th. May 17-20, 1994, Gaithersburg, MD, Raufaste, N. J., Editor, 31-38 pp, 1994.
weather effects; wind velocity; building codes; damage; housing; residential buildings; structural engineering

On August 24, 1992, Hurricane Andrew struck the coast of south Florida, and then proceeded across the Florida Peninsula and the Gulf of Mexico before hitting Louisiana on August 26. Damages of over $30 billion, deaths exceeding 55, and over 200,000 people left homeless prompted the Department of Housing and Urban Development (HUD) to examine its wind design standards for manufactured housing and other residential construction. To review the adequacy of HUD's wind standards, the Department contracted for a study by the National Institute of Standards and Technology (NIST). Based on this study, a wind design and construction standard for manufactured housing, referencing the American Society of Civil Engineers (ASCE) Standard 7-88 was developed and published on January 14, 1994. Research is now being conducted by NIST to provide information so that HUD can further develop standards for wind and tornado resistant construction in other areas of the U.S.

G

Galambos, J.

Galambos, J.; Lechner, J.; Simiu, E.; Hagwood, C.
Extreme Value Theory and Applications: Proceedings of the Conference on Extreme Value Theory and Applications. Volume 2. Gaithersburg, Maryland. May 1993. Preface.
Temple Univ., Philadelphia, PA
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Research of the National Institute of Standards and Technology, Vol. 99, No. 4, July/August 1994.

extreme value theory; statistics; seismic risks; environment; wind; corrosion

It appears that we live in an age of disasters: the Mississippi and the Missouri rivers flood millions of acres, earthquakes hit Tokyo and California, airplanes crash due to mechanical failure, and powerful windstorms cause increasingly costly damage. While these may seem to be unexpected phenomena to the man in the street, they are actually happening according to well defined rules of science known as extreme value theory. For many phenomena records must be broken in the future, so if a design is based on the worst case of the past then we are not really prepared for the future. Materials will fail due to fatigue: even if the body of an aircraft looks fine to the naked eye, it might suddenly fail if the aircraft has been in operation over an extended period of time. Extreme value theory has by now penetrated the social sciences, the medical profession, economics and even astromony. We believe this field has come of age. To utilize and stimulate progress in the theory of extremes and promote its application, an internaitonal conference was organized in which equal weight was given to theory and practice.

Galambos, J.; Lechner, J.; Simiu, E.; Hagwood, C.
Extreme Value Theory and Applications: Proceedings of the Conference on Extreme Value Theory and Applications. Volume 3. Gaithersburg, Maryland. May 1993.
Temple Univ., Philadelphia, PA
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 866; 242 p. August 1994.
Available from the National Technical Information Service
PB95-104956

extreme value theory; statistics; seismic risks; environment; wind; corrosion

It appears that we live in an age of disasters: the Mississippi and the Missouri rivers flood millions of acres, earthquakes hit Tokyo and California, airplanes crash due to mechanical failure, and powerful windstorms cause increasingly costly damage. While these may seem to be unexpected phenomena to the man on the street, they are actually happening according to well defined rules of science known as extreme value theory. For many phenomena records must be broken in the future, so if a design is based on the worst case of the past then we are not really prepared for the future. Materials will fail due to fatigue: even if the body of an aircraft looks fine to the naked eye, it might suddenly fail if the aircraft has been in operation over an extended period of time. Extreme value theory has by now penetrated the social sciences, the medical profession, economics and even astronomy. We believe this field has come of age. To utilize and stimulate progress in the theory of extremes and promote its application, an international conference was organized in which equal weight was given to theory and practice.

Gann, R. G.

Gann, R. G.
Flame Retardants.
National Institute of Standards and Technology, Gaithersburg, MD
Kirk-Othmer Encyclopedia of Chemical Technology. 4th Edition. Volume 10, John Wiley and Sons, Inc., NY, 930-936 pp, 1994.

flame retardants; combustion toxicity; fire research

Each year, Americans report over three million fires leading to 29,000 injuries and 4,500 deaths. The direct property losses exceed $8 billion and the total annual cost to our society has been estimated at over $100 billion. Personal losses occur mostly in residences

where furniture, wall coverings, and clothes are frequently the fuel. Large financial losses occur in commercial structures such as office buildings and warehouses. Fires also occur in airplanes, buses, and trains. Fires occur when an ignition source, a match, cigarette, or stove burner, meets a flammable product such as a chair, wall, or scattered papers. The heat from the source breaks down polymer strands in the material, creating (generally endothermically) chemical fragments that vaporize. At a sufficiently high temperature, these fragments react with the oxygen in the air to release more heat. Some of this heat radiates or convects back to the product, breaking down more polymeric strands, yielding more gas-phase fuel, etc. Life- and property-threatening fires result when the rate of heat feedback to the product exceeds the sum of the heat dispersed from the combustion environments and the marginal enthalpy required to produce a steady stream of vapor-phase pyrolyzate. Understanding of fires dates to the nineteenth century. The advent of modern fire fighting techniques and equipment has meant less destruction of cities or whole buildings. Additionally, fire-resistant building design usually contains fires to parts of structures. However, a high fuel load in either a residence or a commercial building can overwhelm even the best of building construction.

Gann, R. G.
Interagency Working Group on Fire and Materials.
National Institute of Standards and Technology, Gaithersburg, MD
International Community for Composites Engineering (ICCE). Proceedings of International Conference on Composites Engineering. ICCE/1. August 28-31, 1994, New Orleans, LA, Hui, D., Editor, 149-150 pp, 1994.

composite materials; fire research; databases; thermal properties

Polymer research is producing new materials with exceptional properties, and products made with these materials may well replace conventional products where fire performance is a consideration. As this occurs, there are unique opportunities to improve the fire safety of the facilities in which they are used or to maintain a desired level of fire safety as other advantages accrue.

Gann, R. G.
Next Generation Fire Suppression Technology: A Research Strategy and Plan.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 65-66 pp, 1994.

fire research; fire suppression; halon 1301; fire protection

Halon 1301, CF3Br, has been used extensively to protect vital Department of Defense systems and facilities from unwanted fires often caused by enemy attack. The fire protection for most current weapons systems has been, in fact, designed around its excellent capabilities. Because of the chemicals high suppression efficiency, there has been minimal engineering for optimal distribution and design concentration.

Gann, R. G.
Progress Report on Smoke Toxicity Research in the U.S.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 138-140 pp, 1994.

fire safety; fire research; smoke; combustion toxicity; toxicology; exposure; toxic gases

The three years since the 11th meeting of the UJNR Panel on Fire Research and Safety have seen remarkable progress toward resolution in this field. They have also seen a major drop in research into fire toxicology. The field of smoke toxicity can be subdivided into three areas.

Gann, R. G.; Babrauskas, V.; Braun, E.; Levin, B. C.; Paabo, M.; Harris, R. H., Jr.; Peacock, R. D.; Yusa, S.
Toxicity Data for Fire Hazard Analysis.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 171-177 pp, 1994.

fire safety; fire research; hazard analysis; fire hazard; toxicity; LC-50; animals; rats

A comprehansive methodology has been developed for obtaining and using smoke toxicity data for fire hazard analysis. The methodology comprises: determination that the post-flashover fire is the propert focus of smoke inhalation deaths; criteria for a useful bench-scale toxic potency (LC50) measurement method; a method which meets these criteria, especially validation against real-scale fires; a computational procedure for correcting the results for the CO levels observed in real-scale post-flashover fires; procedures for reducing the usage of animals and broadening the applicability of data by interpreting gas measurement data using the N-Gas Model; and a procedure for identifying whether a product produces smoke within the ordinary range of toxic potency for post-flashover fires. The method is currently being developed for standardization by the National Fire Protection Association and the American Society for Testing and Materials.

Gann, R. G.; Babrauskas, V.; Peacock, R. D.; Hall, J. R., Jr.
Fire Conditions for Smoke Toxicity Measurement.
National Institute of Standards and Technology, Gaithersburg, MD
National Fire Protection Association, Quincy, MA
Fire and Materials, Vol. 18, No. 3, 193-199, May/June 1994.

smoke; toxicity; smoke inhalation; fire tests; computer simulation; fire incidence; computer models

This paper identifies those fire conditions most often present when smoke toxicity is the cause of death. It begins with a review of the evidence that smoke-inhalation deaths are in the majority in fire fatalities in the United States. Next, there is an analysis of the evidence from the national fire experience showing the connection between post-flashover fires and smoke-inhalation deaths. Third is a presentation of real-scale fire test results demonstrating that post-flashover conditions are necessary to produce enough smoke to cause smoke-inhalation deaths in the cases where they actually occur. The fourth component is a sampling of results from computer simulations of fires, affirming and broadening the results from the fire tests. It is concluded that smoke-inhalation deaths occur predominantly after fires have progressed beyond flashover. This conclusion then provides a focus for smoke toxicity measurement in particular and fire hazard mitigation in general.

Gilman, J. W.

Gilman, J. W.; Kashiwagi, T.; VanderHart, D. L.
Thermal Decomposition Chemistry of Poly(Vinyl Alcohol): Char Characterization.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 101-102 pp, 1994.

fire research; thermal decomposition; chemistry; char; inert atmosphere; experiments

Currently, due to concerns over the environmental effects of halogenated compounds, there is an international demand for the control of polymer flammability without the use of halogenated or metal based additives. Our approach to this issue is first to characterize the fundamental condensed phase processes and structures which lead to char formation during polymer combustion and then, to use this information to design new strategies, that do not use halogenated additives, which increase char formation and therefore will reduce polymer flammability.

Gmurczyk, G. W.; Cooper, L. Y.; Grosshandler, W. L.; Pitts, W. M.
Computer Simulation of the Liquid Agent Spray Motion and Evaporation.
National Institute of Standards and Technology, Gaithersburg, MD
Institute for Liquid Atomization and Spary Systems (ILASS-Europe) and CORIA. Liquid Atomization and Spray Systems, 6th International Conference Proceedings. ICLASS 94. July 18-22, 1994, Rouen, France, Begell House, Inc., NY, Yule, A. J.; Dumouchel, C., Editors, 1039-1046 pp, 1994.

sprays; evaporation; computer simulation; fire extinguishing agents; halon 1301; mathematical models; equations

The discharge of a liquid fire extinguishing agent stored in a pressurized vessel through an orifice generates a freely moving spray outside the vessel. The flow has been modeled as a two-phase, three-component, turbulent, compressible, dissipative flow. It has been assumed that the gaseous phase consists of agent vapor, nitrogen and oxygen, whereas the liquid consists of agent only. Viscosity, heat conduction, mass diffusion and turbulence have been included in the description. Interphase processes; such as Stokes forces and aerodynamic drag, forced convection and evaporation; have also been included. The spray is assumed to be a monodispersed phase described by the Sauter mean diameter. All the transport coefficients, the specific heats and the vapor pressure equation are temperature dependant. The impact of the gravitational field on the momentum exchange has also been included. The mathematical model describing the physical phenomena has been formulated with the use of the partial differential equations associated with the relevant initial-boundary conditions, expressing the balances of mass, momentum and energy. The set of time-dependant equations has been referred to the two-dimensional cylindrical geometry. The equations have been solved numerically with the use of time-marching finite-difference partially implicit scheme. The Conchas-Spray computer code of Los Alamos National Laboratory has been used to run the calculations. Sample results obtained for an extinguishing agent have been presented and the potential of the model and computer code have been discussed.

Gmurczyk, G. W.; Grosshandler, W. L.
Dynamics of Fast Flames, Detonations and Their Suppression in C2H4/Air and C3H8/Air Premixed Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 27-28 pp, 1994.

fire research; detonations; flame fronts

Experimental investigations of the effect of the fuel type, composition of the combustible mixture, geometry of the combustion system and concentration of the suppressing agent were investigated in a two-sectional 50 mm i.d. detonation tube. Depending on the initial and boundary conditions, fast flames, quasi-detonations,Chapman-Jouguet detonations, and over-driven detonations were obtainable as possible modes of combustion. Each of such combustion modes constituted a reference state for further determination of the dynamic characteristics of the suppression processes.

Gmurczyk, G. W.; Grosshandler, W. L.
Suppression Effectiveness Studies of Halon-Alternative Agents in a Detonation/Deflagration Tube.
National Institute of Standards and Technology, Gaithersburg, MD
Halon Options Technical Working Conference, Proceedings. May 3-5, 1994, Albuquerque, NM, 193-204 pp, 1994.

halons; fire suppression; halon 1301; in-flight fires; fire protection; detonation; deflagration; effectiveness; fire extinguishing agents

Experimental studies of the effect of the presence of halon-alternative agents on the suppression of premixed high-speed turbulent flames and quasi-detonations have been carried out in a 7.5 m long, 50 mm diameter tube. Lean and stoichiometric C2H4/air mixtures in the absence of any halocarbon, initially at 100 kPa and 295 K, constitute the reference states. A primary objective of

the work has been to determine the relative suppression efficiencies of different agents under highly dynamic situations, without the undue influence of either the ignition event of the mixing of the agent into the flame front. This was accomplished by generating a highly turbulent flame/quasi-detonation in the driver section, which contained no suppressant, followed by measurements of the velocity and pressure ratio as the wave front entered the test section of the tube, which contained suppressant premixed with the same fuel/air combination. A turbulence generator in the form of a spiral obstruction was used in the tube to broaden the gas dynamic conditions attainable by the flame. Flame and shock wave velocities up to 1300 m/s, pressure ratios across the shock fronts over 26:1, and shock wave/flame spacings of the order of 10 cm were measured with piezo-electric pressure transducers and fast photodiodes. The experimental facility was successfully employed to clearly discriminate among the dynamic characteristics of the five compounds, revealing behavior distinct from what was observed in companion studies using atmospheric non-premixed flames. The suppression process is strongly influenced by the concentration of an agent, the structure and composition of an agent molecule, and the composition of the combustible mixture itself. The results were compared with the situation when an agent is fully premixed with the combustible mixture in the tube.

Gmurczyk, G. W.; Grosshandler, W. L.
Suppression of High-Speed C2H4/Air Flames With C1-Halocarbons.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute, Symposium (International) on Combustion, 25th. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 1-20 pp, 1994.

fire suppression; halons; halon 1301; shock waves; turbulent flames; flame extinguishment

Experimental investigations of the effect of the presence of five C1-halocarbons (CF4, CHF3, CF3I, CHF2Cl and CF3Br) on the suppression of premixed high-speed turbulent flames and quasi-detonations have been carried out in a 7.5 m long, 50 mm diameter tube. Lean and Stoichiometric C2H4/air mixtures initially at 100 kPa and 295 K and in the absence of any halocarbon constituted the reference state. A primary objective of the work has been to determine the relative suppression efficiencies of different agents under highly dynamic situations, without the undue influence of either the ignition event or the mixing of the agent into the flame front. This was accomplished by generating a highly turbulent flame/quasi-detonation in the driver section, which contained no suppressant, followed by measurements of the velocity and pressure ratio as the wave front entered the test section of the tube, which contained suppressant premixed with the same fuel/air combination. A turbulence generator in the form of a spiral obstruction was used in the tube to broaden the gas dynamic conditions attainable by the flame. Flame and shock wave velocities up to 1300 m/s, pressure ratios across the shock fronts over 26:1, and shock wave/flame spacings of the order of 10 cm were measured with piezo-electric pressure transducers and fast photodiodes. The experimental facility was successfully employed to clearly discriminate among the dynamic characteristics of the five compounds, revealing behavior distinct from what was observed in companion studies using atmospheric non-premixed flames. The suppression process is strongly influenced by the concentration of an agent, the structure and composition of an agent molecule, and the composition of the combustible mixture itself.

Gmurczyk, G. W.; Grosshandler, W. L.
Suppression of High-Speed C2H4/Air Flames With C1-Halocarbons.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Symposium Papers. Session 06-K: Fire Suppression. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 61 pp, 1994.

combustion; fire suppression; turbulent flames; premixed flames

Experimental investigations of the effect of the presence of five C1-Halocarbons (CF4, CHF3, CF3I, CHF2Cl and CF3Br) on the suppression of premixed high-speed turbulent flames and quasi-detonations have been carried out in a 7.5 m long, 50 mm diameter tube. Lean and stoichiometric C2H4/air mixtures in the absence of any halocarbon, initially at 100 kPa and 295 K, constitute the reference states. A primary objective of the work has been to determine the relative suppression efficiencies of different agents under highly dynamic situations, without the undue influence of either the ignition event or the mixing of the agent into the flame front. This was accomplished by generating a highly turbulent flame/quasi-detonation in the driver section, which contained no suppressant, followed by measurements of the velocity nd pressure ratio as the wave front entered the test section of the tube, which contained suppressant premixed with the same fuel/air combination. A turbulence generator in the form of a spiral obstruction was used in the tube to broaden the gas dynamic conditions attainable by the flame. Flame and shock wave velocities up to 1300 m/s, pressure ratios across the shock fronts over 26:1, and shock wave/flame spacings of the order of 10 cm were measured with piezo-electric pressure tranducers and fast photodiodes. The experimental facility was successfully employed to clearly discriminate among the dynamic characteristics of the five compounds, revealing behavior distinct from what was observed in companion studies

using atmospheric non-premixed flames. The suppression process is strongly influenced by the concentration of an agent, the structure and composition of an agent molecule, and the composition of the combustible mixture itself.

Gmurczyk, G. W.; Grosshandler, W. L.; Lowe, D. L.
Suppression Effectiveness of Extinguishing Agents Under Highly Dynamic Conditions.
National Institute of Standards and Technology, Gaithersburg, MD
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 925-936 pp, 1994.

fire research; fire safety; fire science; fire suppression; fire extinguishing agents; halon 1301; fire extinguishing agents

Alternatives to halon 1301 are sought which are effective fire suppressing agents and which do not create unacceptable safety, environmental, or systems compatibility problems. Investigations of eleven chemical compounds using a deflagration/detonation tube have revealed a great potential for the technique to study the fire suppression process. The facility is used to evaluate new suppressants, establishing their dynamic characteristics as well as elucidating complex suppression mechanisms occurring in fires under highly dynamic conditions typical of fast turbulent flames, explosions and detonations. A primary feature of the set-up is that the conditions of the ignition event do not affect the suppression process itself. Also, because an agent of interest is premixed with the fuel and air in a section of the tube divorced from the ignition event, the influences of ignition and entrainment of the agent into the flame are minimized. The tube is closed to allow the increase in pressure to influence the gas dynamics and chemistry. The deflagration/detonation tube arrangement has been successfully employed to clearly discriminate among the dynamic characteristics of the eleven alternative agents, revealing new unexpected effects. The results have been used to help select among the alternatives for full-scale testing in simulated aircraft dry bay fires.

Gross, J. L.

Gross, J. L.; Heckert, N. A.; Lechner, J. A.; Simiu, E.
Extreme Winds Estimation by 'Peaks Over Threshold' and Epochal Methods.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers (ASCI). Structures Congress XII. Volume 2. April 24-28, 1994, Atlanta, GA, American Society of Civil Engineers, New York, NY, Baker, N. C.; Goodno, B. J., Editors, 1472-1477 pp, 1994.

wind velocity; wind effects; simulation; monte carlo method

With a view to applying the "peaks over threshold" method to the estimation of extreme wind speed data, we perform Monte Carlo simulations for which the parameters of the population distributions were estimated from sets of actual extreme wind speed data. We summarize results concerning (1) the relative efficiency of several estimation procedures used in such methods, (2) the optimal threshold for any given set of data, and (3) estimates based on the "peaks over threshold" method as compared to estimates based on the epochal approach. This work is part of a long-term effort conducted by NIST aimed at assessing and utilizing "peaks over threshold" methods for the estimation of extreme wind loads.

Gross, J. L.; Heckert, N. A.; Lechner, J. A.; Simiu, E.
Novel Extreme Value Estimation Procedures: Application to Extreme Wind Data.
National Institute of Standards and Technology, Gaithersburg, MD
Extreme Value Theory and Applications, Proceedings. Volume 1. 1994, Kluwer Academic Publishers, Boston, MA, Galambos, J., Editor, 139-158 pp, 1994.

wind velocity; wind effects; simulation; monte carlo method

The past two decades have seen the development of a large body of extreme value theory based on the application of the Generalized Pareto Distribution (GPD) to the excess of the extreme variate over a fixed threshold. For sufficiently large values of the extreme variates, the GPD with tail length parameters c > O and c < O is equivalent, respectively, to the Type II (Frechet) and Type III (reverse Weibull) distribution of the largest values. The Type I (Gumbel) distribution is equivalent to the limit of the GPD as c -> O. Owing to these equivalences, the GPD can be used to model extreme data obtained by either the 'peaks over threshold' approach or the epochal approach. The overall purpose of our investigation is to assess and use the potential of

GPD/extreme value theory for improving our knowledge of extreme wind speed behavior. In particular we are interested in examining the issue of the extreme distribution tail length.

Grosshandler, W. L.

Grosshandler, W. L.
Review of Measurements and Candidate Signatures for Early Fire Detection.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 137-138 pp, 1994.

fire research; fire detection; smoke detection; heat detection

The current generation of fire detection systems is designed to respond to the smoke, heat, or the elastromagnetic radiation generated during smoldering and flaming combustion. Smoke is sensed either by measuring, with a photodector, the light shich is scattered from a controlled light source, or by the change in current created by charged particles passing through an ionizing radiaiton field. Heat can be easily sensed by a number of conventional devices, such as compensated thermocouples and thermistors. Both the absolute temperature and rate of temperature rise are used to define alarm conditions. The ultraviolet and infrared portions of the electromagnetic spectrum are typically detected with vacuum tube and solid state photodiodes, photoconductive and photovoltaic cells, thermopiles and pyroelectric cells.

Grosshandler, W. L.; Braun, E.
Early Detection of Room Fires Through Acoustic Emission.
National Institute of Standards and Technology, Gaithersburg, MD
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 773-784 pp, 1993.

acoustic properties; acoustic sensors; fire detection; ionization detectors; walls; ceilings; noise (sound); room fires; compartment fires

Acoustic emission (AE) previously has been shown to be a viable concept for the early indication of an open flame impinging on various structural materials. To assess its effectiveness in a more realistic environment, experiments have been performed in a 2.5 m cubical room constructed of gypsum board and wood beams. AE transducers were mounted on top of the ceiling joists and behind the center wall panel on a vertical beam. Thermocouples were mounted at several points on the wall and ceiling, and an ionization-type smoke detector was attached to the ceiling near the door opening. Two distinct fire threats were examined: (a) a flaming fire consisting of a 0.3 m diameter pan fed with natural gas to produce a thermal load of between 12 and 125 kW; and (b) a charring condition achieved by attaching a 550 W electrical heater to a vertical wooden beam located behind the gypsum board. A signal discernable above the background was recorded from at least one AE sensor in six of nine situations. In each case, measurable acoustic emission occurred before a noticeable increase in voltage from the thermocouple mounted adjacent to the AE sensor. The conclusion is that AE emission appears to be sufficiently sensitive to detect two distinct fire situations, and that an overheated condition in a wall or ceiling can be detected if it is not more than 3 m from the transducer. Additional experiments are required to determine the type of interfering AE signals that are likely to complicate the differentiation between a false and a true fire event.

Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; 859 p. April 1994.
Available from Government Printing Office

SN003-003-03268-9
Available from National Technical Information Services
PB94-203403

halons; aircraft engines; nacelle fires; evaluation; large scale fire tests; simulation; in-flight fires; fire extinguishing agents

Grosshandler, W. L.; Hamins, A.
Flame Suppression Effectiveness of Halon Alternatives.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 3-4 pp, 1994.

fire research; halons; effectiveness; halon 1301; flame extinguishment

The elimination of new production of halon 1301 has forced the manufacturers, owners, and users of aircraft to search for an alternative. The program described here developed performance screens for candidate agents as a means to identify the best chemicals for subsequent full-scale aircraft fire extinguishment evaluation at Wright-Patterson Air Force Base. The discriminating factors could be lumped into four categories: agent dispersion characteristics, required storage volume, environmental factors, and operational issues. The results presented in this abstract are limited to the flame suppression experiments, which directly impact the storage volume of agent required. However, the dispersion of the agents in cold-flow experiments varied more extensiveley than the amount of the agent required for flame suppression. The behavior of the chemical as it leaves the storage vessel (typically pressurized with N2 at 4.1 MPa) and subsequently flashes or breaks into droplets, evaporates, and mixes with ambient air is critical, and can render an agent which requires less mass to extinguish a laboratory flame less effective in suppressing an actual aircraft fire.

Grosshandler, W. L.; Jackson, M. A.
Acoustic Emission of Structural Materials Exposed to Open Flames.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 22, 209-228, 1994.

fire detection; acoustic properties; acoustic sensors; material properties

The use of acoustic emission (AE) as an early indicator of structural materials exposed to a flame has been investigated and found to be possible. Piezoelectric transducers have been mounted directly on 0.5 m long, simply supported beams of aluminum, gypsum board, wood and plastic, and have been used to record ultrasonic events resulting from a small flame placed under the beam. The number of AE events in a minute and the cumulative energy released during the heating cycle provide a good measure of the overheated state of some of these materials even before a temperature increase is indicated. The measured signals varied in energy and number with the type of material, the thickness of the specimen and heat flux. Wood was particularly susceptible to acoustic emission, producing more than 1000 events/min in a solid fir board and 30/min in 13 mm thick plywood when the flame exceeded 1 kW. A gypsum board produced 16 events in a minute. An aluminum plate did not respond above the background level (0.3 events/min) even though it reached the highest temperature. The differences in cumulative energy were equally striking, with the plywood being four times more energetic than the gypsum board even though the heating period for the wood was half as long, and 30 times more energetic than the aluminum. Some critical issues which remain to be investigated before this technique can be adapted to practical fire detection are mentioned.

Grosshandler, W. L.; Lowe, D. L.; Notarianni, K. A.; Rinkinen, W. J.
Protection of Data Processing Equipment With Fine Water Sprays. Annual Report. September 1993-September 1994.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5514; 58 p. October 1994.
Available from National Technical Information Services
PB95-174975

water sprays; fire extinguishing agents; fire research; fire suppression; spray nozzles

The major objective of the work presented here has been to determine how a fine water spray compares to a gaseous agent in extinguishing fires in data processing equipment, an environment typically protected by halon 1301. A scaled-down, generic electronics package was designed and a chamber built to contain the water spray to emulate the physical system of interest. The mock electronics cabinet is 0.5 m wide, 0.2 m deep and 0.4 m high. The fuel is a 3 mm thick plate of poly(methyl methacrylate), placed vertically in an aluminum frame centered among a number of aluminum "circuit boards." The limitations imposed by the different transport phenomena associated with droplet versus gas dispersion have been investigated. The influence on extinguishing efficiency of the nozzle geometry, the location relative to the fire, the water application rate, and the amount of shielding surrounding the fire within the simulated cabinet are all parameters which have been examined. A gaseous agent, CF3H, is used for comparison. A phase-Doppler particle analyzer measured the droplet size distribution and velocity. The water pressure has a significant effect on the size of the region in which a fire can be effectively suppressed. The reasons for this are the greater flux of water and the increased momentum of the spray resulting from higher water pressures. With the full enclosure in place around the fuel source, extinguishment is possible only at the highest pressure (5.5 MPa), with the objection the spray centerline, and with at least 40% of the top area of the cabinet directly open to the spray. By contrast, similar fires in all geometric configurations can be successfully extinguished with CF3H as long as the concentrations in the chamber are close to those recommended in NFPA 2001.

Grosshandler, W. L.; Lowe, D. L.; Notarianni, K. A.; Rinkinen, W. J.
Suppression Within a Simulated Computer Cabinet Using an External Water Spray.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 75-76 pp, 1994.

fire research; water sprays; fire suppression; computers; halons; water mist

A total ban on halon production has created a vacuum in the fire protection industry which is likely to be filled by more than one suitable replacement. A water-based system is an attractive replacement candidate because water, in addition to being an effective fire suppressant, is non-toxic, environmentally friendly and competitively priced. The latest generation of spray systems requires much less water than traditional sprinklers, and is being considered for applications heretofore limited to non-condensing agents such as halon 1301.

H

H. J. Degenkolb Associates, Engineers

H. J. Degenkolb Associates, Engineers; Rutherford and Chekene
Evaluation and Strengthening Guidelines for Federal Buildings - Assessment of Current Federal Agency Evaluation Programs and Rehabilitation Criteria and Development of Typical Costs for Seismic Rehabilitation.
H. J. Degenkolb Associates, Engineers
Rutherford and Chekene
NIST-GCR-94-650; ICSSC TR-13; 175 p. March 1994.
Available from National Technical Information Services
PB94-181856

building technology; federal buildings; seismic evaluation; rehabilitation; costs

The National Institute of Standards and Technology (NIST), in accordance with Public Law 101-614, is developing seismic evaluation and strengthening guidelines (Guidelines for Federal Buildings) for federally owned and leased buildings. The project is overseen by the Interagency Committee on Seismic Safety in Construction (ICSSC) and funded by the Federal Emergency Management Agency (FEMA). This report develops Task 2, (see Appendix A for complete scope of work) assessment of current federal agency

evaluation programs and rehabilitation criteria and Task 3, development of typical costs for seismic rehabilitation. Part 1 of the Task 2 report includes a qualitative and quantitative comparison of six federal agency programs to the most recent versions of the NEHRP Evaluation Handbook and the NEHRP Techniques Handbook. Part 2 of the Task 2 report is an identification and assessment of rehabilitation criteria and program issues for the six federal programs, four private sector programs, RP-3, "Guidelines for Identification and Mitigation of Sesmically Hazardous Existing Federal Buildings" and the State of California program. Task 3 outlines a program to develop typical costs for seismic rehabilitation. It includes possible approaches for different levels of effort of such programs, including an outline of recommended scopes of work.

H. J. Degenkolb Associates, Engineers; Rutherford and Chekene
Evaluation and Strengthening Guidelines for Federal Buildings - Identification of Current Federal Agency Programs.
H. J. Degenkolb Associates, Engineers
Rutherford and Chekene
NIST-GCR-94-649; ICSSC TR-12; 150 p. March 1994.
Available from National Technical Information Services
PB94-176278

building technology; federal buildings; seismic evaluation; guidelines; mitigation

The National Institute of Standards and Technology (NIST), by order of the President, is developing seismic evaluation and strengthening guidelines (Guidelines for Federal Buildings) for federally owned and leased buildings. The project is overseen by the Interagency Committee on Seismic Safety in Construction (ICSSC) and funded by the Federal Emergency Management Agency (FEMA). This report develops Task 1, the identification of seismic mitigation programs. The report includes a detailed work plan and schedule for the entire project, a list of ICSSC member contacts, the results of telephone conversations with all ICSSC committee members to identify existing seismic strengthening programs, the results of detailed meetings with seven federal agencies and four private sector organizations selected for in-depth study, and summaries of the performance objectives for all agencies and organizations. In addition, a discussion of the impact and use of ATC-28, "Development of Recommended Guidelines for Seismic Strengthening of Existing Buildings, Phase 1: Issues Identification and Resolution," for this project, excerpts of rapid screening and evaluation methods from various federal agencies, and a comprehensive list of references is included.

Hamins, A.

Hamins, A.; Baghdadi, D.; Borthwick, P.; Glover, M. P.; Grosshandler, W. L.; Lowe, D. L.; Melton, L.; Presser, C.
Suppression of Simulated Engine Nacelle Fires.
National Institute of Standards and Technology, Gaithersburg, MD
University of Texas, Dallas
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 7-8 pp, 1994.

fire research; nacelle fires; extinguishment; aircraft fires

The engine nacelle encases the jet engine compressor, combustor and turbine. A nacelle fire is typically a turbulent diffusion flame stabilized behind an obstruction in a moderately high speed air flow. The most likely source for a fire in the nacelle are leaks in the fuel lines carrying jet fuel or hydraulic fluid, that can feed the fire either as a spray or as a pre-vaporized gas. Temperatures as high as 150 deg C are common in normal operating engine nacelles.

Hamins, A.; Fischer, S. J.; Kashiwagi, T.; Klassen, M. E.; Gore, J. P.
Heat Feedback to the Fuel Surface in Pool Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Purdue Univ., West Lafayette, IN

Combustion Science and Technology, Vol. 97, No. 1-3, 37-62, 1994.

pool fires; liquid fuels; burning rate; hydrocarbons; heat flux; heat balance; measuring instruments; conductive heat transfer

A series of measurements designed to investigate the heat feedback in pool fires burning liquid fuels are reported. Such measurements are essential for the development and validation of detailed models which predict the burning rate of liquid hydrocarbons and solid polymers. The radial variation of the local radiative and local net heat flux incident on the surface of 0.30 m diameter pool fires were measured. A water-cooled, nitrogen purged, narrow view-angle gauge was developed to measure the radiative flux incident on the fuel surface. Measurements of the mass burning rate in a burner composed of annular rings was used to estimate the local heat feedback. A number of different fuels were studied, yielding flames with a wide range of heat release rates and luminosities. Consideration of the heat balance for a control volume enclosing the liquid pool indicated that radiation was an important component of the heat feedback for non-luminous fires and a dominant component in luminous fires.

Hamins, A.; Gmurczyk, G. W.; Grosshandler, W. L.; Rehwoldt, R. G.; Vazquez, I.; Cleary, T. G.; Presser, C.; Seshadri, K.
Flame Suppression Effectiveness.
National Institute of Standards and Technology, Gaithersburg, MD
University of California at San Diego, La Jolla
NIST SP 861; April 1994.
Available from Government Printing Office
SN003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 4, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 345-465 pp, 1994.

halons; fire suppression; effectiveness; diffusion flames; turbulent flames; premixed flames; detonation

A flame will be extinguished when the time required for the chain reaction which sustains combustion exceeds the time it takes to replenish the necessary heat and reactants. A characteristic time for reaction can be estimated from the inverse of a global kinetic rate coefficient expressed in Arrhenius form as [equation] where B is a molecular collision frequency factor, Eo is a global activation energy, R is the ideal gas constant, and T is the gas temperature. Assuming reactant species and heat are transported at about the same rate (i.e., unity Lewis number), a characteristic time for replenishing both can be estimated from a convective flow velocity and a length scale by [equation].

Hamins, A.; Trees, D.; Seshadri, K.; Chelliah, H. K.
Extinction of Nonpremixed Flames With Halogenated Fire Suppressants.
National Institute of Standards and Technology, Gaithersburg, MD
University of California San Diego, La Jolla
University of Virginia, Charlottesville, VA
Combustion and Flame, Vol. 99, No. 2, 221-230, 1994.
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Symposium. Session 06-K: Fire Suppression. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 62 pp, 1994.

extinction; fire extinguishing agents; flame extinguishment; flame retardants; flame structure; halon 1301; halogenated compounds

An experimental, analytical, and numerical study was performed to elucidate the influence of eleven gaseous agents, considered to be substitutes for CF3Br, on the structure and critical conditions of extinction of diffusion flames burning liquid hydrocarbon fuels. The effectiveness of these agents in quenching flames was compared to those of CF3Br and an inert diluent such as nitrogen. Experiments were performed on diffusion flames stabilized in the counterflowing as well as in the coflowing configuration. The fuels tested were heptane in the counterflowing configuration, and heptane, the jet fuels JP-8, and JP-5, and hydraulic fluids (military specifications 5606 and 83282) in the coflowing configuration. The oxidizing gas was a mixture of air and the agent. On a mass and mole basis CF3Br was found to be most effective in quenching the flames and the mass-based effectiveness of the other eleven

agents was found to be nearly the same as that of nitrogen. Experimental results were interpreted using one-step, activation-energy asymptotic theories and the results were used to provide a rough indication of the thermal and chemical influence of these agents on the flame structure. To understand in some detail the influence of CF3Br on the structure and mechanisms of extinction of the flame, numerical calculations using detailed chemistry were performed. The calculated structure of counterflow heptane-air diffusion flames inhibited with CF3Br was found to consist of three distinct zones including a CF3Br consumption zone which appears to act as a sink for radicals. The calculated values of the critical conditions of extinction of counterflow heptane-air diffusion flames inhibited with CF3Br were found to agree fairly well with measurements. The study suggests the need for refinement of the inhibition chemistry.

Harrington, J. E.

Harrington, J. E.; Shaddix, C. R.; Smyth, K. C.

Laser Imaging of Chemistry-Flowfield Interactions: Enhanced Soot Formation in Time-Varying Diffusion Flames.

National Institute of Standards and Technology, Gaithersburg, MD

Society of Photo-Optical Instrumentation Engineers (SPIE). Laser Techniques for State-Selected and State-to-State Chemistry II. Session 5. Laser Diagnostics for Combustion. Volume 2124. January 27-29, 1994, Los Angeles, CA, SPIE, Bellingham, WA, Editor, 1-14 pp, 1994.

lasers; flow fields; soot formation; diffusion flames; extinction; incandescence; flame luminosity; polycyclic aromatic hydrocarbons; methane

Models of detailed flame chemistry and soot formation are based upon experimental results obtained in steady, laminar flames. For successful application of these descriptions to turbulent combustion, it is instructive to test predictions against measurements in time-varying flowfields. This paper reports the use of optical methods to examine soot production and oxidation processes in a co-flowing, axisymmetric CH4/air diffusion flame in which the fuel flow rate is acoustically forced to create a time-varying flowfield. For a particular forcing condition in which tip clipping occurs (0.75 V loudspeaker excitation), elastic scattering of vertically polarized light from the soot particles increases by nearly an order of magnitude with respect to that observed for a steady flame with the same mean fuel flow rate. The visible flame luminosity and laser-induced fluorescence attributed to polycyclic aromatic hydrocarbons (PAH) are also enhanced. Peak soot volume fractions, as measured by time-resolved laser extinction/tomography at 632.8 and 454.5 nm and calibrated laser-induced incandescene (LII), show a factor of 4-5 enhancement in this flickering flame. The LII method is found to track the soot volume fraction closely and to give better signal-to-noise than the extinction measurements in both the steady and time-varying flowfields. A Mie analysis suggests that most of the enhanced soot production results from the formation of larger particles in the time-varying flowfield.

Hasemi, Y.

Hasemi, Y.; Yoshida, M.; Yasui, N.; Parker, W. J.

Upward Flame Spread Along a Vertical Solid for Transient Local Heat Release Rate.

Building Research Inst., Ibaraki, Japan

Science University of Tokyo, Chiba, Japan

National Institute of Standards and Technology, Gaithersburg, MD

International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 385-396 pp, 1994.

fire research; fire safety; fire science; heat release rate; flame spread; burnout; charring; equations; flame spread test; material properties; heat flux; experiments

Theoretical and experimental analysis of turbulent upward flame spread along a vertical solid is presented. A conventional flame spread model based on a linearized flame height approximation is generalized to incorporate burnout effects. The model is verified against full-scale flame spread tests using material heat release data obtained from intermediate-scale tests in which the time history of surface heat flux during the flame spread tests was reproduced.

Hill, J. E.

Hill, J. E.
NIST Green Building Program.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 863; June 1994.
Available from Government Printing Office
National Institute of Standards and Technology and the U.S. Green Building Council (USGBC). U.S. Green Building Conference, 1994. February 16-17, 1994, Gaithersburg, MD, Fanney, A. H.; Whitter, K. M.; Traugott, A. E.; Simon, L. N., Editors, 42-54 pp, 1994.

building technology; construction; environment

For over 2 decades, NIST has been involved in energy conservation programs. NIST's current programs broadly span the areas from waste minimization to air, soil, water, indoor air quality, ozone depletion, and global warming. The latest endeavor NIST is undertaking is the "Green Building Program" in which NIST is at the forefront of designing buildings using environmentally safe materials. NIST's program has two components. The laboratory based activities involve NIST staff working directly with manufacturers and designers to develop technologies conducive to energy efficiency. The second component, demonstration buildings, includes environmentally safe buildings which are monuments to green technologies. These buildings not only demonstrate cost effectiveness and evaluate green technologies, they also identify new technologies needed to develop an effective green building.

Hochgreb, S.

Hochgreb, S.; Hsin, Y. E.; Linteris, G. T.
Laminar Flame Speeds of CF3H-Propane-Air Mixtures at Elevated Pressures.
Massachusetts Institute of Technology, Cambridge
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 19-20 pp, 1994.

fire research; laminar flames; flame speed; propane; pressure

A fundamental property of interest in characterizing the effectiveness of fire suppressants is the effect of addition of inhibitors on the laminar flame speed of a fuel as a function of pressure and temperature of the unburned mixture. The effects of CF3H and C2F6 on the laminar flame speed of mixtures of gaseous fuels and air are currently being investigated in a laminar combustion bomb (a constant volume combustion device amenable to flame speed measurements at elevated and reduced pressures). Preliminary results for CF3H-propane-air mixtures are reported here. The data show little reduction in the burning rate at elevated pressures for addition of 1% CF3H but about 25% reduction in the burning rate for 2% CF3H.

J

Jason, N. H.

Jason, N. H., Editor
National Institute of Standards and Technology and Minerals Management Service. In Situ Burning Oil Spill. Proceedings. January 26-28, 1994, Orlando, FL, Jason, N. H., Editor, 101 pp, 1994.
NIST SP 867; August 1994.
Available from Government Printing Office
SN003-003-03290-5
Available from National Technical Information Services

PB95-104907

in situ burning; oil spills; fire research; environmental effects; operational hazards; human beings

The goal of the workshop was: To present the state of knowledge to the user community, representatives from local, state, and federal agencies, oil industry, manufacturers, and researchers; to reach consensus on the present status of decision making to allow the use of in situ burning and to prioritize research and information needs to support decisions on the use of in situ burning of spilled oil. To facilitate the discussions, preprints of technical papers were distributed at registration. Participants were divided into two breakout panels: Environmental and human health; Operational implications. The panels examined the information presented, determined a consensus and developed a list of priority needs. The results of the workshop will be used by MMS to refine future research efforts to address the most important issues developed by the participants.

Jason, N. H.
BFRL Fire Publications, 1993.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5397; 36 p. April 1994.
Available from National Technical Information Services
PB94-164191

fire research; evacuation; information transfer; room fires; databases; smoke control; fire models; elderly persons; oil spills; fire tests; water mist; carbon monoxide; halons

Building and Fire Research Publications, 1993 contains references to the publications prepared by the members of the Building and Fire Research Laboratory (BFRL) research 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 1993. Building program staff citations will appear in a combined publication entitled "Building and Fire Research Laboratory Publications, 1993"; it will be published later. 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 800/553-6847 or 703/487-4650.

Jason, N. H.
NIST Building and Fire Research Laboratory Publications, 1993.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-6; 112 p. September 1994.
Available from Government Printing Office
SN003-003-03295-6
Available from National Technical Information Services
PB95-143202

fire research; building technology; earthquakes; large fires; refrigerants; fire suppression; fire models; evacuation; fire extinguishing agents; water mist

Building and Fire Research Publications, 1993 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 1993. 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. 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 800/553-6847 or (703)487-4650.

Jason, N. H.
Summaries of BFRL Fire Research In-House Projects and Grants, 1994.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5504; 245 p. October 1994.
Available from National Technical Information Services
PB95-130845

charring; combustion; fire models; fire research; flame spread; blowout fires; hazards; ignition; polymers; egress; soot; smoke; sprinklers; halons

This report describes the research projects performed in the Building and Fire Research Laboraotry (BFRL) Fire Research Program and under its grants program from October 1, 1993 through September 30, 1994.

Johnsson, E. L.

Johnsson, E. L.; Bryner, N. P.; Pitts, W. M.
Fire-Induced Mass Flow Into a Reduced-Scale Enclosure.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 87-88 pp, 1994.

fire research; mass flow; enclosures; fluid dynamics

Enclosure fires are of great interest because of the resulting loss of life and property, yet the fluid dynamic and chemical behaviors of fires within enclosures are still not well understood. In recent decades, it has become clear that burning rates, fire growth and spread, production of toxic gases, and depletion of oxygen in room fires are very dependent on air supply and entrainment rates.

Jones, W. W.

Jones, W. W.
Modeling Smoke Movement Through Compartmented Structures.
National Institute of Standards and Technology, Gaithersburg, MD
U.S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, Fire Research Inst., Tokyo, Japan, 34-41 pp, 1994.

smoke; compartment fires; fire growth; mathematical models; numerical models; room fires; toxicity

This paper describes a model of fire growth and smoke transport for compartmented structures, with emphasis on those aspects which are important to making correct predictions of smoke movement in multicompartment structures. In particular, we are interested in the ability to model the movement of toxic gases from the room of origin of a fire to a distant compartment. The newest phenomena in the model are vertical flow and mechanical ventilation. Finally, we have improved the radiation transport scheme which affects energy distribution, and therefore the buoyancy forces. These are very important in a actual situations relevant to fire growth and smoke propagation, as is demonstrated.

Jones, W. W.; Baum, H. R.
Modeling Fire Growth and Smoke Transport in the United States.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 4-7 pp, 1994.

fire safety; fire research; fire growth; smoke transport; zone models; fire models; field models

In the United States, modeling of fire phenomena is done with both zone and field models. The applications are significantly different but there is overlap in the understanding and in most respects they are complementary.

Jones, W. W.; Matsushita, T.; Baum, H. R.
Smoke Movement in Corridors: Adding the Horizontal Momentum Equation to a Zone Model.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 42-54 pp, 1994.

fire safety; fire research; corridors; smoke movement; equations; zone models; heat transfer; experiments; computer models

The most common type of models utilized to study building fires are referred to as zone models. The motivation for using such models in preference to a complete implementation of the Navier Stokes equation is the great difficulty in obtaining solutions of the latter in realistic fire scenarios. One uses only a few elements, or zones, per compartment, and thus can apply the technique to many compartments. A more complete description of zone models is given elsewhere. This type of model works well in many cases. However, for long rooms or tall shafts, the basic tenet of the finite element concept as applied to fires is violated. The idea is that within an element, or zone, the gases are uniformly mixed, and there is no bulk velocity of the gas. To simulate smoke movement in large buildings, it is important to predict movement of the smoke front (nose) in the corridor or shaft. Although the ideas which we will discuss are also applicable to tall shafts, there will be differences in both the equations, and their implementation. This paper concentrates on the flow along a horizontal corridor.

Joshi, A. A.

Joshi, A. A.; Pagni, P. J.
Fire Induced Thermal Fields in Window Glass I - Theory.
California Univ., Berkeley
Fire Safety Journal, Vol. 22, No. 1, 25-43, 1994.

glass; windows; computer models; fire models; mathematical models; radiation; thermal stresses; vents; equations; temperature profiles; heat flux

Window glass breaking plays an important role in compartment fire dynamics as the window acts as a wall before breaking and as a vent after breaking. Previous work suggested a model for the time to breakage of a window glass exposed to a particular fire. In this paper, the glass thermal fields obtained using that model are examined in detail. The temperature field dependence on heat transfer coefficients, radiative decay length and flame radiation is explored. The results show that the glass surface temperature increases with a decrease in the decay length and increases with an increase in flame radiation heat flux. Early in the fire, the glass temperature may be higher than the hot layer temperature due to direct impingement of flame radiation. Later the glass temperature lags the hot layer temperature. The variation of the time to breakage as a function of the shading width and decay length is also presented and the results indicate that the breaking time decreases with an increase in the shading width and decreases with a decrease in decay length. Heat flux maps for typical conditions indicate that most of the heat influx is stored in the glass, increasing its temperature.

Joshi, A. A.; Pagni, P. J.
Fire Induced Thermal Fields in Window Glass II - Experiments.
California Univ., Berkeley
Fire Safety Journal, Vol. 22, No. 1, 45-65, 1994.

glass; windows; computer models; fire models; mathematical models; radiation; thermal stresses; vents; equations; temperature profiles; heat flux

The authors' previously presented model determines the time to breakage of window glass exposed to a compartment fire. The physical and mechanical properties of glass and the history of the compartment fire are required. Among the mechanical properties of glass, the breaking stress is the least well known. Here, experiments on 59 plate glass samples using the four-point flexure method are described to determine the breaking stress distribution. This distribution is by a three-parameter cumulative Weibull

function with parameters. A breaking stress of 40 M Pa (5800 psi) was determined to be a reasonable value to use in breaking calculations for ordinary window glass. The breaking patterns of the test specimens suggest that fractures initiate at edge imperfections rather than at surface flaws. Some experiments to estimate the heat transfer coefficient inside the compartment and the emissivity of the hot layer are also described and values are suggested for use in the model.

K

Kao, J. Y.

Kao, J. Y.
Evaluation of GSA Maintenance Practices of Large Centrifugal Chillers and Review of GSA Refrigerant Management Practices.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5336; 51 p. January 1994.
Available from National Technical Information Services
PB94-143344

refrigerants; evaluation; maintenance; chillers

This study contains two major subjects involving maintenance of large centrifugal chillers in the General Services Administration (GSA) facilities. The first part is to use nondestructive testing (NDT) techniques for chiller testing and maintenance. NDT techniques investigated are visual inspection, leak testing, vibration analysis, infrared thermal testing, eddy current testing, oil analysis, and acoustic emission testing. With the expection of acoustic emission testing, all other techniques are recommended for GSA chiller maintenance. The second part of this study is about refrigerant management. It reviews the Clean Air Act, Environmental Protection Agency regulations, a recently issued Executive Order, and Standards from the American Society of Heating, Refrigerating, Air Conditioning Engineers on subjects associated with ozone depleting refrigerants. Also reviewed are GSA refrigerant handling practices and certain GSA retrofit specifications involving these refrigerants. Recommendations are made for refrigerant management including chiller retrofit/conversion.

Kaplan, C. R.

Kaplan, C. R.; Shaddix, C. R.; Smyth, K. C.
Experimental and Computed Profiles of Soot Volume Fraction and Temperature in Laminar Methane/Air Diffusion Flame.
Naval Research Laboratory, Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Work-in-Progress Poster Session Presentations. Work-in-Poster Session 2. Paper 36. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 128 pp, 1994.

combustion; soot; volume; temperature; laminar flames; diffusion flames; methane

Comparisons are presented between experimental and computed profiles of soot volume fraction and temperature for a laminar, co-flowing, axisymmetric CH4/air diffusion flame at atmospheric pressure. Local soot volume fractions have been measured using tomographic reconstruction of extinction data obtained at 632.8 nm as well as laser-induced incandescence images (LII), with the LII method providing superior results. Temperatures have been obtained from radiation-corrected thermocouple data. The numerical model solves the time-dependent reactive-flow Navier-Stokes equations coupled with sub-models for soot formation and radiation trnasport. Fluid convection is solved with a high-order implicit algorithm, Barely Implicit Correction to flux-corrected Transport, while thermal conduction, molecular diffusion and viscosity are evaluated with two-dimensional finite differencing. The CH4 consumption rate is computed as a function of the local mixture fraction using Bilger's formulation, and the resulting production and consumption rates of O2, CO2 and H2O are then evaluated from their respective stoichiometric coefficients. The soot volume fraction is computed as a function of the local gas properties (temperature, density, fuel mole fraction), based upon the simplified rate expressions of Syed et al. developed from measurements in steady CH4/air flames. These expressions consider the effects of nucleation, surface growth, coagulation, and oxidation. The radiative heat flux is found by solving the radiation transfer equation using the Discrete Ordinated Method and includes radiative effects from soot, CO2, and H2O.

Kaplan, C. R.; Shaddix, C. R.; Smyth, K. C.
Prediction of Enhanced Soot Production Observed in Flickering Methane/Air Diffusion Flames.
Naval Research Laboratory, Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Work-in-Progress Poster Session Presentations. Work-in-Poster Session 2. Paper 35. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 127 pp, 1994.

combustion; soot; diffusion flames; methane; air; atmospheric pressure

Recent quantitative experimental measurements of the local soot volume fraction have been obtained in a co-flowing, flickering CH4/air diffusion flame burning at atmospheric pressure. Acoustic forcing of the fuel flow rate was used to phase lock the periodic flame flicker to the 10 Hz repetition rate of a pulsed laser system, permitting phase-specific measurements to be performed at a frequency close to the natural flame flicker rate. The experimental results show that for a forcing condition in which the tip of the flame is clipped, soot production is four times greater than that measured for a steady flame burning with the same mean fuel flow velocity. These results should provide demanding tests of recently formulated integrated soot models, which have been derived from experiments carried out exclusively in steady flames. In order to test how accurately such a model can predict soot production and oxidation rates in a complex combusting flowfield, time-dependent computations of sooting CH4/air diffusion flames have been conducted for both the steady and flickering flames.

Kashiwagi, T.

Kashiwagi, T., Editor
Fire Safety Science. Proceedings. 4th International Symposium, July 13-17, 1994, Ottawa, Ontario, Canada, International Association for Fire Safety Science (Society for Fire Protection Engineers), Boston, MA, 1341 pp, 1994.

fire research; fire safety; fire science; physics; chemistry; smoke hazards; toxic hazards; human behavior; egress; fire detection; fire risk; hazard analysis; fire suppression; structures; structural behavior;; industrial fires

Kashiwagi, T.
Topical Review: Polymer Combustion and Flammability - Role of the Condensed Phase.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Symposium Papers. Session 07-B: Fire Hazards. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 69 pp, 1994.

combustion; fire hazards; flammability; burning rate

The combustion process of polymers is a complex coupling of energy feedback from a flame to the polymer surface with gasification of the polymer to generate combustible degradation products. Although there are extensive studies of the effects of wind velocity, gas phase oxygen concentration, external thermal radiation, and gravity on the combustion of polymers, the effects of polymer characteristics on combustion and flammability are not nearly as well understood as those in the gas phase. At present, detailed governing equations for continuity, momentum, energy, and chemical species concentration in the gas phase can readily be written with appropriate boundary conditions and the solutions can be derived for various cases. However, even those governing equations cannot be derived for the condensed phase without understanding of the governing chemical and physical processes which control the gasification of polymers. This paper concentrates on describing various observed phenomena in polymers (which have been often ignored or neglected) during their combustion some or all of which might have significant effects on the burning rate and flammability properties. Due to a lack of understanding of the basic combustion mechanisms of polymers, theoretical models able to predict combustion phenomena and flammability properties are not available. In order to overcome this problem, global material characteristics are currently measured by well-defined test methods and the results are used as inputs to fire growth models intended to predict behavior of the materials in specific fire scenarios. To improve the fire performance of polymers, a non-halogenated char-forming flame retardant approach is suggested and its benefits are discussed.

Kashiwagi, T.; Babrauskas, V.
Progress Report on U.S. Research on Materials and Test Methods.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 242-254 pp, 1994.

fire safety; fire research; test methods; heat release rate; ignition; flame spread; smoke; toxic products

Two important recent trends which have started to affect the materials aspects of fire are non-halogenated flame retardant treatments and polymer recycling. Brominated flame retardants have gained a major position in the worldwide plastics industry. To meet today's requirements in the electronic and electrical equipment industries, virtually every plastic requires flame retardancy. Due to negative publicly about dioxin and furan as possible degradation products, these retardants have received a negative public perception in Europe. Some regulations on the use of certain types of these flame retardants will be introduced within the next several years. Although the use of halogenated flame retardants is still showing an upward trend, some concerns have been raised and there is a definite trend to seek alternatives for halogenated flame retardants. The possible introduction of future test methods on corrosivity of combustion products, as discussed in the Test Method Section, might further affect the use of halogenated flame retardants.

Kashiwagi, T.; Cleary, T. G.
New Generation of Fire Resistant Polymers. Part 2. Silicon-Containing Polycarbonate.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 267-279 pp, 1994.

fire safety; fire research; silicones; polycarbonates; cone calorimeters; flame spread; furniture calorimeters

Various flammability properties of a silicone-containing polycarbonate sample were measured and compared with those of a pure polycarbonate sample. The results show that peak heat release rate for the silicone-containing polycarbonate sample is significantly reduced (less than half) compared to that for the pure polycarbonate sample with two different sizes of sample, 10cmx10cm and 40cmx40cm. However, the ignition delay time for the silicone-containing sample is shorter than that for the pure polycarbonate sample. Also, the flame spread rate with external radiant fluxes for the silicone-containing sample becomes faster than that for the pure polycarbonate sample. The observed char behavior, such as char depth, physical nature and apparent combustibility, and its impact on flammability properties are discussed.

Kedzierski, M. A.

Kedzierski, M. A.; Crowder, J. M.; Jacobi, A. M.; Zhang, L.
Visual Measurement Technique for Analysis of Nucleate Flow Boiling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5519; 96 p. October 1994.
Available from National Technical Information Services
PB95-143301

bubbles; boiling; visualization technique; digital image analysis; alternative refrigerants

This report records a visual measurement technique for analyzing bubbles formed by nucleate flow boiling. The purpose of measuring these bubbles is to expand understanding the boiling process. By studying the behavior of these vapor bubbles, a better understanding of the physics controlling boiling heat transfer will be gained. The boiling of refrigerants is simultaneously filmed with a high speed 16 mm camera while heat transfer measurements are taken. These tests are performed over a range of heat fluxes and flow velocities to study the effect of these conditions on the bubble dynamics. Analysis of the 16 mm films evolved from a manual to a computer-assisted system, and finally to a digital image analysis system. The following is an overview of the filming apparatus and the bubble measurement schemes.

Kedzierski, M. A.; Kim, M. S.
Single-Phase Heat Transfer and Pressure Drop Characteristics of an Integral-Spine-Fin With an Annulus.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Enhanced Heat Transfer, June 1994.
NISTIR 5454; 33 p. June 1994.
Available from National Technical Information Services
PB94-194073

annulus; enhanced heat transfer; heat transfer; spine-fin; friction; water; ethylene glycol

The laminar, single-phase heat transfer and friction characteristics of a porcupine-like surface (integral-spine-fin) within an annulus are presented. The heat-transfer coefficient was determined using a modified version of the Wilson Plot method on a 3 m test section. Three fluids were investigated: (1) water, (2) 34% ethylene glycol/water mixture, and (3) 40% ethylene glycol/water mixture. These fluids produced a significant variation in the Prandtl number so that its exponential dependence could be determined. The annulus Reynolds numbers were varied from 100 to 1400 to obtain the Reynolds number exponent. An empirical correlation for the Nusselt number that accounts for the development of the thermal boundary layer is presented. An empirical correlation for the fanning friction factor is also provided. It is shown that the spines enhance the heat transfer through additional surface area and fluid mixing.

Kelly, G. E.

Kelly, G. E.; May, W. B.; Kao, J. Y.; Park, C.
Using Emulators to Evaluate the Performance of Building Energy Management Systems.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 100, No. 1, [pages unknown], January 1994.

emulator; algorithms; building/HVAC/plant system; building energy management system; energy management; control system; performance evaluation; simulation; test and rating methodology

The performance of Building Energy Management System (BEMS) is directly related to the amount of energy consumed in a building and the comfort of the building's occupants. One approach with which to evaluate the performance of a BEMS is through the use of an emulator - a special computer/data acquisition system that is connected to the sensor inputs and command outputs of the BEMS. It replaces the building and its heating, ventilating, and air-conditioning (HVAC) systems and uses a computer program to simulate their response to BEMS commands. The BEMS, through its supervisory and/or direct digital control algorithms, then controls the simulated building/HVAC system as if it were an actual one. At the same time, the emulator evaluates the performance of the BEMS in terms of the energy consumed by the simulated building, the degree of comfort maintained in the simulated space, response time, accuracy, etc. This paper describes using emulators to evaluate a BEMS. Major topics include setting up a BEMS and an emulator, evaluating system/command and DDC software, and methodlogies for testing BEMS application algorithms. Considerations are presented for evaluating the programming capabilities of a BEMS, DDC control loop performance, and rating different aspects of BEMS's performance. A brief discussion of BEMS software is also included.

Kim, M. S.

Kim, M. S.; Mulroy, W. J.; Didion, D. A.
Performance Evaluation of Two Azeotropic Refrigerant Mixtures of HFC-134a With R-290 (Propane) and R-600a (Isobutane).
National Institute of Standards and Technology, Gaithersburg, MD
ASME Journal of Energy Resources Technology, Vol. 116, 148-154, June 1994.

refrigerants; evaluation; flammability measurements; heat pump; evaluation; thermodynamic properties; high temperature; cooling; heating; simulation; heat transfer

The reduction in chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) production and the scheduled phase-out of these ozone-depleting refrigerants require the development and determination of environmentally safe refrigerants for use in heat pumps, water chillers, air conditioners, and refrigerators. This paper presents a performance evaluation of a generic heat pump with two

azeotropic refrigerant mixtures of HFC-134a (1,1,1,2-tetrafluoroethane) with R-290 (propane) and R-600a (isobutane); R-290/134a (45/55 by mass percentage) and R-134a/600a (80/20 by mass percentage). The performance characteristics of the azeotropes were compared with pure CFC-12, HFC-134a, HCFC-22, and R-290 at the high temperature cooling and heating conditions including those using liquid-line/suction-line heat exchange. The coefficient of performance of R-290/134a is lower than that of HCFC-22 and R-290, and R-134a/600a shows higher coefficient of performance than CFC-12 and HFC-134a. The capacity for R-290/134a is higher than that for HCFC-22 and R-290, and R-134a/600a exhibits higher system capacity than CFC-12 and HFC-134a. Experimental results show that the discharge temperatures of the studied azeotropic mixtures are lower than those of the pure refrigerants, CFC-12 and HCFC-22.

Klassen, M. E.

Klassen, M. E.; Gore, J. P.
Structure and Radiation Properties of Pool Fires. Final Report.
Purdue Univ., West Lafayette, IN
NIST-GCR-94-651; 153 p. June 1994.
Available from National Technical Information Services
PB94-193802

pool fires; burning rate; flame height; heat loss; heat transfer; measurement; radiation; soot; temperature distribution

An experimental and theoretical study of radiative feedback, burning rates, radiative heat loss fractions, and flame heights for pool fires with diameters ranging from 4.6 cm to 100 cm was completed. Transient measurements of soot and temperature distributions were obtained in 7.1 cm and 30 cm heptane and toluene fires using a three-wavelength emission/absorption probe. The heat release rates of the fires varied from 0.6 kW to 2166 kW allowing a study over a wide range. A variety of fuels were tried but most of the measurements were restricted to methanol, heptane, and toluene as representatives of the alcohols, paraffins and aromatics. Radiative feedback was measured using a new in situ purged optical probe inserted at the level of the fuel surface. Measurements of reflection of energy from the fuel surface were also obtained. A multi-ray radiation calculation procedure utilizing simultaneous single-point measurements of soot volume fractions and temperatures was used to estimate the heat transfer to the surroundings and that to the fuel surface. Importance of turbulent fluctuations of different frequencies on the radiation heat flux was studied using filtered simulations.

Klote, J. H.

Klote, J. H.
Fire and Smoke Control: An Historical Perspective.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Journal, Vol. 36, No. 7, 46-50, July 1994.

smoke control; heating; ventilation; air conditioning; research facilities; office buildings; education

At the 1968 ASHRAE Annual Meeting in Lake Placid, New York, the symposium 'Fire Hazards in Buildings and Air-Handling Systems' was held. This symposium marked the start of a period of ASHRAE fire-related activity that is still ongoing. The symposium was jointly chaired by Alastair Simmonds and Clint Phillips. The eight papers presented included such topics as principles of fire protection, fire problems with HVAC systems, protection of duct openings and penetrations, and smoke problems in buildings. The main focus of most of the papers was identification of fire problems that were relevant to ASHRAE. In commemoration of the ASHRAE Centennial, the following brief history of ASHRAE's activities in fire and smoke control is presented. Some events that lead up to ASHRAE's activity in this area are also discussed as background information.

Klote, J. H.
Method of Predicting Smoke Movement in Atria With Application to Smoke Management.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5516; 94 p. November 1994.
Available from National Technical Information Services
PB95-154746

smoke movement; atriums; building fires; fire models; fire plumes; fire research; plumes; scale models; smoke control

In recent years, building with atria has become commonplace. Other spaces involving enclosed shopping malls, arcades, sports arenas and airplane hangers also have large volumes, and the methods of this paper are also applicable to these spaces. This paper presents information that can be used for predicting smoke movement for design of atrium smoke management systems. The basic approach used in many codes consists of a collection of algebraic equations for design analysis. This approach and the physical concepts behind it are discussed including atrium smoke management system limitations. For applications for which the basic approach is inappropriate, computational fluid dynamics (CFD) and physical modeling can be applied. Research is needed concerning (1) the depth of smoke layer required to prevent atrium exhaust from pulling air from the lower layer and (2) the use of airflow for smoke control between the atrium and spaces opening onto the atrium.

Klote, J. H.; Levin, B. M.; Groner, N. E.
Feasibility of Fire Evacuation by Elevators at FAA Control Towers.
National Institute of Standards and Technology, Gaithersburg, MD
George Mason Univ., Fairfax, VA
NISTIR 5445; 110 p. May 1994.
Available from National Technical Information Services
PB94-213857

evacuation; elevators (lifts); air traffic control; building fires; emergencies; handicapped; life safety; smoke control

Throughout most of the world, warning signs next to elevators indicated they should not be used in fire situations. Because these elevators have not been designed for fire evacuation, they should not be used for fire evacuation. However, the idea of using elevators for fire evacuation has gained considerable attention. The Federal Aviation Administration (FAA) has sponsored a project to study the feasibility of elevator emergency evacuation at air traffic control towers. This paper describes this project including (1) a general discussion of elevator evacuation, (2) presentation of conceptual criteria for such elevator evacuation systems, and (3) application of that criteria to several ATCTs. It is concluded that elevator emergency evacuation is not feasible for existing ATCTs. This could change for some standard designs if water resistant elevator components are developed that make water protection of elevators feasible. However, elevator emergency evacuation is feasible for new ATCTs, and this would involve significant challenges concerning engineering and human factors.

Kostreva, M. M.

Kostreva, M. M.
Mathematical Modeling of Human Egress From Fires in Residential Buildings.
Clemson Univ., SC
Fire Technology, Vol. 30, No. 3, 338-340, Third Quarter 1994.
NIST-GCR-94-643; 96 p. June 1994.
Available from National Technical Information Services
PB94-193778

residential buildings; mathematical models; egress; computer models; fire models; fire research; hazard assessment; human behavior

Models for predicting human egress in fires have been developed in parallel with those that predict environmental conditions which occur as a fire develops and spreads. Mathematical models which find optimal and/or Pareto optimal (non-dominated) paths for human egress in fires are presented. These optimal paths may serve as multiple functions. In addition to gaining insight into expected and desired actions in fires, such predictions can serve as the basis for directing egress during building evacuation. Optimal paths may serve as a standard against with other heuistically generated paths may be evaluated.

Koylu, U. O.

Koylu, U. O.; Faeth, G. M.
Optical Properties of Overfire Soot in Buoyant Turbulent Diffusion Flames at Long Residence Times.
Michigan Univ., Ann Arbor
Journal of Heat Transfer, Vol. 116, No. 1, 152-159, Feburary 1994.

soot; turbulent flames; diffusion flames; flame radiation; scattering coefficient; extinction

The optical properties of soot were studied for the fuel-lean (overfire) region of buoyant turbulent diffusion flames in still air. Results were limited to the long residence time regime where soot structure is indpendent of position in the overfire region and residence time for a particular fuel. Measurements included scattering, absorption, and extinction cross sections at 514.5 nm and extinction cross sections at 632.8 and 1152 nm for flames fueled with acetylene, propylene, ethylene, and propane. The measurements were used to evaluate scattering predictions based on the Rayleigh-Debye-Gans (RDG) approximation for randomly oriented polydisperse fractal aggregates of spherical primary soot particles having constant diameters. The present soot aggregates exhibited significant departures from Rayleigh-scattering behavior at 514.5 nm, with forward scattering roughly 100 times larger than wide-angle scattering and ratios of scattering to absorption cross sections in the range 0.22-0.41, increasing with increasing propensity of the fuel to soot. The approximate RDG theory generally provided an acceptable basis to treat the optical properties of the present overfire soot aggregates, although additional measurements in the Guinier (small angle) regime are needed for a definitive evaluation of model performance.

Koylu, U. O.; Faeth, G. M.; Farias, T. L.; Carvalho, M. G.
Computational Evaluation of an Approximate Theory for the Optical Properties of Soot.
University of Michigan, Ann Arbor
Instituto Superior Tecnico, Lisbon, Portugal
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 127-128 pp, 1994.

fire research; soot; optical properties; evaluation

The absorption and scattering (optical) properties of soot are needed both to predict the continuum radiation properties of soot and to interpret nonintrusive optical measurements to find soot concentrations and structure. This is a challenging problem, however, because soot consists of small primary particles that combine into branched aggregates that exhibit neither simple Rayleigh nor Mie scattering behavior.

Kulkarni, A. K.

Kulkarni, A. K.; Brehob, E.; Manohar, S.; Nair, R.
Turbulent Upward Flame Spread on a Vertical Wall Under External Radiation. Annual Report. September 30, 1991-January 15, 1993.
Pennsylvania State Univ., University Park
NIST-GCR-94-638; 90 p. June 1994.
Available from National Technical Information Services
PB94-207388

building fires; fire research; flame spread; linings; mathematical models; transportation; wall coverings; walls

Progress made on NIST grant number 60NANB8D0849 for the period September 30, 1991 to January 15, 1993 is reported. The overall objective is to understand the upward flame spread phenomenon under simulated surrounding fire conditions by establishing a data base for upward flame spread under external radiation, developing a mathematical model, measuring the relevant basic material properties needed, and checking the validity of the model by comparing its results with data. Emphasis is placed on studying and predicting the behavior of practical wall materials used in building and vehicle interiors, and textiles. In the past year, we measured flame spread on several different materials under a range of external radiant fluxes of up to 15 kW/m2. A model for describing the upward flame spread process was developed and numerical results were compared with data. The model needed

input of certain properties, such as the burning rate characteristics and surface radiation properties. A series of supporting studies were undertaken which provided the needed input properties to the model and other useful material property data. These studies included transient mass loss rate experiments, in-depth radiation absorption analysis and experiments, and reflectance measurements using a specially designed heated cavity reflectometer. Experimental data, appropriately validated model, and radiative properties of materials obtained here should be very useful in fire hazard codes for single or multiple enclosures, as well as for assessing material flammability in a relevant orientation.

L

LaBelle, R. P.

LaBelle, R. P.; Galt, J. A.; Tennyson, E. J.; McGrattan, K. B.
1993 Spill Off Tampa Bay, a Candidate for Burning?
Minerals Management Service, Herndon, VA
National Oceanic and Atmospheric Administration, Seattle, WA
National Institute of Standards and Technology, Gaithersburg, MD
Environment Canada. Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, 17th Proceedings. Volume 1. June 8-10, 1994, Vancouver, British Columbia, Environment Canada, Ottawa, Ontario, 635-649 pp, 1994.

oil spills; in situ combustion; fire plumes

On August 10, 1993, the Tank Barge Ocean 255 and the Tank Barge Bouchard B-155 collided with the freighter Balsa 37 near the entrance of Tampa Bay, Florida. Jet fuel from the Ocean 255 caught fire and burned for approximately 18 hours. Barge B-155, carrying 5 million gallons of No. 6 fuel oil, ruptured a port tank and spilled an estimated 328,000 gallons. Much of the discharged oil was initially carried offshore by winds and tidal currents and moved northward, parallel to the adjacent barrier island beaches. By August 14 and 15, a storm system bringing winds from the west pushed oil onshore onto several beaches and into and through tidal inlets. Subsequent oiling of sand beaches, shallow embayments, and fringing wetlands occurred during the second week of the spill event. Estimates are that about 14.5 miles of sand beaches were oiled, along with approximately 6 acres of mangrove wetlands, 2.5 acres of seagrass beds, and 1.5 acres of saltmarshes. Areas of submerged oil were also present in bays and bay passes. This paper outlines the general behavior and movements of the spilled oil and the sea and weather conditions prevalent before the oil moved ashore. The possibility of removing portions of the spill by ignition and combustion is discussed, and results of smoke plume model runs are presented. Given the highly successful in-situ test burning of spills off Newfoundland in August 1993, this response measure deserves serious evaluation in future emergencies. Presently, spill responders must consider both actual and publicly perceived hazards associated with the at-sea burning of oil.

Lattimer, B. Y.

Lattimer, B. Y.; Ewens, D. S.; Vandsburger, U.; Roby, R. J.
Transport and Oxidation of Compartment Fire Exhaust Gases in an Adjacent Corridor.
Virginia Polytechnic Institute and State Univ., Blacksburg
Hughes Associates, Inc., Columbia, MD
Journal of Fire Protection Engineering, Vol. 6, No. 4, 163-181, 1994.

corridors; compartment fires; exhaust gases; oxidation; flame length; carbon monoxide; hydrocarbons

The oxidation of underventilated compartment fire exhaust gases during their transport down a corridor adjacent to the compartment was experimentally investigated. External burning from a compartment has been reported to decrease the toxic exhaust gas levels downstream of the compartment. The focus of the investigation was to identify the phenomena controlling the oxidation of the combustion gases external of the compartment as they traveled down a corridor during external burning. Variables in the research included the fire size, the hallway inlet and exit soffit heights, and the vent area from which the exhaust gases exit the compartment. Through gas sampling both in the hallway and in the exhaust duct downstream of the hallway, the oxidation of carbon monoxide (CO) and total unburned hydrocarbons (UHC) was studied. The concentrations of CO and UHC were reduced from the entrance to the exit of the hallway by 65 percent and 98 percent, respectively, with no soffit at either end of the hallway. The addition of a 20 cm soffit at the hallway entrance dramatically improved the oxidation and dilution of CO and UHC, resulting

in a reduction of 80 percent and 94 percent in CO and UHC concentrations; respectively, from the entrance to the exit of the hallway. A soffit at the hallway exit was found to inhibit the species oxidation and resulted in only a 51 percent and 94 percent reduction in CO and UHC concentrations, respectively, from the exit to the entrance of the hallway. Descriptions of the types of external burning which occurred for different soffit geometries are given and then related to how it affected the oxidation of the exhaust gases within the hallway. The global equivalence ratio (GER) in the compartment could not predict the post-hallway species yields, so correlations were developed to predict the CO and UHC yields downstream of the hallway using dimensionless groups derived from dimensional analysis.

Lawson, J. R.

Lawson, J. R.; Mulholland, G. W.; Koseki, H.
Airborne Smoke Sampling Package for Field Measurements of Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Research Institute, Tokyo, Japan
Fire Technology, Vol. 30, No. 1, 155-172, First Quarter 1994.

smoke; sampling; fire research; measuring instruments; oils; pool fires; smoke yield; experiments

A unique airborne smoke sample package (ASSP) for determining the smoke yield of large fires has been developed. The uncertainty in the average smoke yield at the 95% confidence interval is about +7% of the average of three repeat measurements. The ASSP, which weighs less than 4 kg, is light enough to be flown suspended below a tethered helium-filled balloon or attached to a small radio-controlled aircraft. Measurements are made by flying the sampling equipment into a fire's smoke plume. Additional smoke plume measurements that can be made with the ASSP include particle size distribution using a cascade impactor, smoke agglomerate structure using transmission electron microscope (TEM) grids, and polycyclic aromatic hydrocarbons (PAHs) analysis using various sorbent tubes. The application of the ASSP in measuring laboratory and large outdoors petroleum pool fires is discussed. Smoke yield values measured in field burns of Louisiana crude oil range from 0.080 to 0.137, and the primary sphere diameter of the agglomerates is as large as 0.15 mum.

Lee, K. Y.

Lee, K. Y.; Cha, D. J.; Puri, I. K.; Hamins, A.
Heat Release Mechanisms in Inhibited Laminar Counterflow Flames.
University of Illinois, Chicago
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers. Fire, Combustion, and Hazardous Waste Processing. HTD-Vol. 296. November 6-11, 1994, Chicago, IL, American Society of Mechanical Engineers, NY, Acharya, S.; Annamalai, K.; Presser, C.; Skocypec, R. D., Editors, 25-36 pp, 1994.

combustion; hazardous materials; waste disposal; laminar flames; heat release; methodology; inhibitors; flame stability; radiative heat loss

Both the chemical kinetic and thermal channels of inhibition must be simultaneously characterized in order to understand the effectiveness of chemical agents on flame stability. However, due to the participation of inhibitors in flame chemistry, it is difficult to concurrently characterize the complex interaction between their cooling action, and the chemical kinetic effects due to them. Investigations involving chemical inhibitors have to contend with three interacting phenomena, i.e., (Chang et al., 1987) the cooling action due to the specific heat of the species: (Karra et al., 1988) the heat release due to their burning; and (Pitz and Westbrook, 1990) inhibition associated with scavenging of critical radical species. This study investigated the effect of chloromethane (a chemical inhibitor) on the heat release in methane-air nonpremixed flames. For comparison, the effect on the heat release due to the purely thermal action of nitrogen was also investigated. The flames were experimentally and numerically studied in a counterflow configuration, and the heat release was calculated from simulations involving detailed chemistry. When inert suppressants were added to the oxidizer stream of a nonpremixed flame, the global heat release decreased. Chloromethane addition to the fuel stream, however, increased the heat release. Whereas addition of nitrogen narrowed the heat release region, chloromethane addition to the oxidizer altered the flame stoichiometry, such that the heat release profiles were markedly different. A thorough investigation of flame stability must consider the importance of heat losses through radiative emission. Halogenated compounds can influence flame emission through changes in flame structure including increases in temperature and soot concentration. For these reasons, a small Schmidt-Boelter type gauge was used to measure the radiative flux through a cylindrical control volume surrounding the flame, and the total radiation emitted from the flame was calculated by integrating the emitted flux. The results

show that as nitrogen was added to the methane-air base flame, the radiative heat loss fraction decreased slightly. When chloromethane was added to the oxidizer stream, the radiative heat loss fraction increased substantially (=40%). Values of the radiative heat loss fraction remained relatively unchanged (=2.3%) for all of the flames studied.

Leonard, S.

Leonard, S.; Mulholland, G. W.; Puri, R.; Santoro, R. J.
Generation of CO and Smoke During Underventilated Combustion.
Pennsylvania State Univ., University Park
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 98, 20-34, 1994.

combustion; carbon monoxide; smoke; ethene; flame research; laminar flames; methane; smoke yield

The CO and smoke yields observed for underventilated laminar diffusion flames are presented for methane and ethene for global equivalence ratio phi over the range 0.5 to 4.0. A Burke-Schumann type burner with fuel in the center tube and air in the annular region was used. The peak CO yields for methane and ethene, 0.37 and 0.47 respectively, are at least a factor of 100 greater than for overventilated burning. The ratio of CO/CO2 versus phi for the methane flame is compared with local measurements of this ratio for both overventilated and underventilated laminar diffusion flames and with the results for turbulent natural gas flames quenched in an upper layer. The peak smoke yields for methane at a flow rate of 10 cm3/s and for ethene at a fuel flow rate of 6.4 cm3/s are 0.01 and 0.05, and ethene are 0.01 and 0.05, respectively, compared with yields of 0 and 0.028 for the overventilated case. The proportionality between smoke yield and CO yield observed for overventilated burning for a wide range of fuels is found not to be valid for the underventilated case. The chemical makeup and structure of the smoke produced at high equivalence ratio is qualitatively different from smoke produced under overventilated conditions; the smoke is mainly organic rather than graphitic and it has an agglutinated structure rather than an agglomerate structure with distinct primary spheres usually observed in overventilated burning.

Levin, B. M.

Levin, B. M.; Groner, N. E.
Human Factors Considerations for the Potential Use of Elevators for Fire Evacuation of FAA Air Traffic Control Towers.
George Mason Univ., Fairfax, VA
NIST-GCR-94-656; 23 p. August 1994.
Available from National Technical Information Services
PB94-217163

air traffic control; building fires; elevators (lifts); emergencies; evacuation; fire research; handicapped; human behavior; life safety

The Federal Aviation Administration (FAA) is interested in the possibility of using elevators for evacuation of air traffic control towers during fire emergencies. Assuming that the FAA could design, install, and maintain elevators that could safely be used by tower occupants during fire evacuations, it would be important to study a number of human factor considerations. This report, which is partly based on interviews of occupants in thirteen FAA towers, discusses these issues. Given the fact that there has been a 20 year campaign to discourage elevator use during fire emergencies, most interviewees indicated a willingness to use such elevators as a backup mode of escape with some reluctance. The controls in the elevator would not need any major modification but a special communication system would be needed. Fire emergency plans and training are important to assure proper use of the proposed system and confidence in the safety it provides.

Levine, R. S.

Levine, R. S.
Safety and Environmental Aspects of Navy Firefighter Trainers.
National Institute of Standards and Technology, Gaithersburg, MD

U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 334-342 pp, 1994.

fire safety; fire research; fire fighters; fire fighting training; safety; environmental effects

A new generation of devices to train Navy firefighters combines a degree of realism with established safety, so that trainees can be allowed to make mistakes and learn from them. Propane gas is used as fuel, with an agent to produce artificial smoke. Pollutants in the exhaust gases have been measured and found to be environmentally acceptable, far superior to training devices these replace. Two companies are using the Navy technology to build trainers for civilian firefighters.

Lew, H. S.

Lew, H. S.; Cooper, J. D.; Hacopian, S.; Hays, W.; Mahoney, M.
January 17, 1994, Northridge Earthquake, California.
National Institute of Standards and Technology, Gaithersburg, MD
Federal Highway Administraiton, Washington, DC
Department of Housing and Urban Development, Washington, DC
U.S. Geological Survey, Washington, DC
Federal Emergency Management Agency, Washington, DC
NIST SP 871; September 1994.
Available from Government Printing Office
SN003-003-03297-2
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 26th. May 17-20, 1994, Gaithersburg, MD, Raufaste, N. J., Editor, 375-426 pp, 1994.

earthquakes; bridges (structures); lifelines; design performance; evaluation

The magnitude 6.8 earthquake occurred during the pre-dawn hours of January 17, 1994 provided a crucial test for assessing our progress in earthquake resistant design and construction over the past two decades, following a similar magnitude event, the San Fernando earthquake in 1971. A reconnaissance team was organized by NIST through the auspices of the National Earthquake Hazards Reduction Program and the Interagency Committee on Seismic Safety in Construction, to observe the damage, assess the performance of various types of engineering structures, and document the effects of the earthquake on the built environment: buildings, bridges, and lifeline systems. This paper summarizes what we learned from the reconnaissance effort. More detailed documentation has been presented in an NIST Special Publication 862, "1994 Northridge Earthquake: Performance of Structures, Lifelines, and Fire Protection Systems."

Linteris, G. T.

Linteris, G. T.
Experimental and Numerical Burning Rates of Premixed Methane-Air Flames Inhibited by Fluoromethanes.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern State Section. Proceedings. December 5-7, 1994, Clearwater Beach, FL, 1-4 pp, 1994.

premixed flames; methane; air; burning rate; experiments; inhibitors; hydrocarbons; fire extinguishing agents

The agents which are currently being considered as replacements for fire suppressant agent CF3Br are mostly fluorinated hydrocarbons and perfluorinated alkanes. This abstract describes measurements of the reduction in burning rate of premixed methane-air flames by the single carbon inhibitors CF4, CF3H, and CF2H2. Early studies of the inhibitory effects of halogenated hydrocarbons on flames were conducted in premixed systems. The premixed laminar burning rate is a fundamental parameter describing the overall reaction rate, heat release, and heat and mass transport in a flame. In addition, the reduction in the premixed flame burning rate is useful for understanding the mechanism of chemical inhibition of fires since diffusion flames often have a stabilization region which is premixed, and good correlation has been found between the reduction in burning rate and the concentration of inhibitors found to extinguish diffusion flames. Premixed flame burners have flow fields which are relatively easily

characterized, making interpretation of the inhibitor's effect on the overall reaction rate straightforward. The present burning rate measurements allow an early assessment of the performance of the NIST fluorinated species chemical kinetic mechanism in premixed flames and are considered to be an initial step in the validation and refinement of the mechanism. The mechanism is being used to gain insight into the possible modes of inhibition of these agents in premixed-methane air flames.

Linteris, G. T.; King, M. D.; Liu, A.
Acid Gas Production in Inhibited Premixed Flames.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 21-22 pp, 1994.

fire research; premixed flames; fire extinguishing agents

Halogenated fire extinguishing agents such as CF3Br decompose in flames to form hydrogen halides such as HF and HBr and other toxic and corrosive products. Possible replacements for halon 1301 are required in significantly higher concentrations to extinguish fires; consequently, the post combustion gases in the inhibited flames may have higher concentrations of these undesirable species. Previous experiments and analyses have been preformed to understand the phenomena important for HF production in inhibited propane-air diffusion flames. These tests have suggested that, for diffusion flames, both the rate of agent transport to the reaction zone and the chemical kinetic rates influence the formation of HF. In order to more clearly separate the importance of these processes and study HF formation in a more tractable configuration, the methods previously applied to diffusion flames are now extended in the present work to premixed flames.

Linteris, G. T.; King, M. D.; Liu, A.; Womeldorf, C. A.; Hsin, Y. E.
Acid Gas Production in Inhibited Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
Halon Options Technical Working Conference, Proceedings. May 3-5, 1994, Albuquerque, NM, 177-191 pp, 1994.

halons; diffusion flames; halon 1301; experiments

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 the 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 have been performed with several types of laboratory-scale burners, varying agent type and concentration, and fuel type. A wet-chemistry analysis of the final products of the flames using ion-selective electrodes for F and Cl provided an experimental basis for quantitative understanding of the HF and HCl production. Production rates were measured for co-flow laminar and turbulent diffusion flames. Systematic selection of the agent concentrations, burner type, and air flow rates allowed an assessment of the relative importance of agent transport and chemical kinetics on the acid gas production rates. These experimental results were then compared to a model which estimates the maximum HF and HCl production rates based on stoichiometric reaction to the most stable products. The results demonstrate the relative significance of F, Cl, and H in the inhibitor and fuel, as well as the effect of different burner configurations.

Linteris, G. T.; Truett, L.
Burning Rate of Premixed Methane-Air Flames Inhibited by Fluorinated Hydrocarbons.
National Institute of Standards and Technology, Gaithersburg, MD
Halon Options Technical Working Conference, Proceedings. May 3-5, 1994, Albuquerque, NM, 1-12 pp, 1994.

halons; hydrocarbons; burning rate; premixed flames; methane; air; oxidation

This paper presents the first measurements of the burning rate of premixed flames inhibited by three fluorinated hydrocarbons that have oxidation chemistry which is similar to agents which may be used as replacements for CF3Br. The burning rate of premixed methane-air flames stabilized on a Mache-Hebra nozzle burner was determined using the total area method from schlieren images

of the flame. The inhibitors were tested over a range of concentrations and fuel-air equivalence ratios. The measured burning rate reductions are compared with those predicted by numerical solution of the species and energy conservation equations employing a detailed chemical kinetic mechanism recently developed at the National Institute of Standards and Technology (NIST). This paper presents initial efforts at testing and validation of the mechanism using burning rate data. The mode of inhibition of these chemicals is inferred through interpretation of the numerical results.

Linteris, G. T.; Truett, L.
Burning Rate of Premixed Methane-Air Flames Inhibited by Fluorinated Hydrocarbons. [Abstract Only]
National Institute of Standards and Technology, Gaithersburg, MD
Wright-Patterson AFB, Dayton, OH
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, NISTIR 5499, Gaithersburg, MD, 17-18 pp, 1994 AND
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Work-in-Progress Poster Session Presentations. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 148 pp, 1994.

fire research; hydrocarbons; burning rate; premixed flames; methane

The agents which are currently being considered as replacements for fire suppressant agent CF3Br are mostly fluorinated hydrocarbons and perfluorinated alkanes. This abstract describes measurements of the reduction in burning rate of premixed methane-air flames with the addition of the single carbon inhibitors CF4, CF3H, CF2H2, and CF3I. Early studies of the inhibitory effects of halogenated hydrocarbons on flames were conducted in premixed systems. The premixed laminar burning rate is a fundamental parameter describing the overall reaction rate, heat release, and heat and mass transport in a flame. In addition, the reduction in the premixed flame burning rate is useful for understanding the mechanism of chemical inhibition of fires since diffusion flames often have a stabilization region which is premixed, and good correlation has been found between the reduction in burning rate and the concentration of inhibitors found to extinguish diffusion flames. Premixed flame burners have flow fields which are relatively easily characterized, making interpretation of the inhibitor's effect on the overall reaction rate straightforward.

M

Madrzykowski, D.

Madrzykowski, D.; Evans, D. D.
Large Fires: Kuwait.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 357-364 pp, 1994.

fire safety; fire research; well fires; heat release rate; flame height; thermal radiation; radiation measurements

A series of measurements were made in the Al Mawqa/Al Ahmadi oil field region of Kuwait to explore the feasibility of assessing the heat release rate of individual well fires through flame height and thermal radiation measurements. The 12 fires measured ranged in calculated heat release rate from 90 to 2000 MW which correspond to flow rates of 240 m3 day (15000 bbl/day) to 4800 m3/day (30000 bbl/day). Based on these twelve burning well measurements, the estimated total flow from the 651 damaged wells, both burning and leaking in March, 1991, was 7,400,000 barrels/day which is only 20 percent greater than published NOAA estimates based on information from the Kuwait Oil Company.

Marshall, R. D.
Gust Speeds in Hurricanes.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers (ASCI). Structures Congress XII. Volume 2. April 24-28, 1994, Atlanta, GA, American Society of Civil Engineers, New York, NY, Baker, N. C.; Goodno, B. J., Editors, 1457-1462 pp, 1994.

hurricanes; wind velocity; gust factors; dynamic pressure; data analysis; wind effects

Based on strip-chart records of wind speeds representing 11 recording stations and four hurricanes, it is concluded that gust factors for hurricanes generally exceed the gust factors proposed by Durst more than 30 years ago for well-developed extratropical storms. When put in terms of dynamic pressure, these higher gust factors suggest increases in qust loads of as much as 20 percent. More data will be needed to establish the probability distribution of hurricane gust factors and to discern any significant differences for locations within and outside of the hurricane eyewall.

Marshall, R. D.
Manufactured Homes - Probability of Failure and the Need for Better Windstorm Protection Through Improved Anchoring Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5370; 54 p. November 1994.
Available from National Technical Information Services
PB95-143129

building technology; codes; standards; hurricanes; manufactured homes; mobile homes; natural disasters; soil anchors; structural engineering; wind damage; wind engineering; wind loads; windstorm protection

Probabilities of failure are estimated for structures designed in accordance with the wind load provisions of the Manufactured Home Construction and Safety Standards (MHCSS) that were in effect at the time of Hurricane Andrew (1992) and for structures designed in accordance with the wind load provisions of ASCE 7-88 (Minimum Design Loads for Buildings and Other Structures). It is concluded that for a 10-yr exposure the probability of structural failure in a hurricane-prone area such as Dade County, Florida, using the MHCSS wind load criteria is approximately 10 times that determined using the wind load requirements of ASCE 7-88. This same ratio holds for an extra-tropical wind climate such as that of Omaha, Nebraska. For Tucson, Arizona, this ratio is approximately 5. Test data for various components of traditional manufactured home anchoring systems are examined and it is concluded that the load capacity of these systems is substantially less than the load capacities implied by the MHCSS and by current standards covering the installation of manufactured homes. It is recommended that traditional anchoring systems that utilize allow soil anchors be designed on the basis of factored loads and that preloading be made an integral part of the installation process. A new approach to providing windstorm protection for manufactured homes located in hurricane-prone regions needs to be developed.

Marshall, R. D.
Sensors and Techniques for Structural Monitoring.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers (ASCI). Structures Congress XII. Volume 2. April 24-28, 1994, Atlanta, GA, American Society of Civil Engineers, New York, NY, Baker, N. C.; Goodno, B. J., Editors, 1379-1384 pp, 1994.

sensors; monitors; seismic effects; wind effects

This paper summarizes measurement requirements for the monitoring of engineering structures and describes new sensor-system configurations that are finding useful application in field studies. To meet the special needs of structural monitoring, specific areas in need of additional research and development are identified.

Marshall, R. D.; Phan, L. T.; Celebi, M.
Full-Scale Measurement of Building Response to Ambient Vibration and the Loma Prieta Earthquake.
National Institute of Standards and Technology, Gaithersburg, MD
U.S. Geological Survey, Menlo Park, CA
U.S. National Conference on Earthquake Engineering, Fifth (5th). Earthquake Awareness and Mitigation Across the Nation Proceedings. Volume 2. July 10-14, 1994, Chicago, IL, 661-670 pp, 1994.

earthquakes; vibration; data analysis; high rise buildings; office buildings; commercial buildings

This paper describes the collection and analysis of ambient vibration data from five buildings in the San Francisco Bay area that experienced strong shaking during the Loma Prieta earthquake of October 17, 1989. Results of data analyses show that, while the lower modes of vibration can be reliably identified from ambient vibration records, the frequencies of these modes are in each case higher than the frequencies derived from strong-motion response records. When soil-structure interaction is involved, the strong-motion modal frequencies may range from 70 to 80 percent of the corresponding values extracted from ambient vibration records. Estimates of structural damping derived from ambient vibration data are substantially smaller than those derived from strong-motion data and are consistent with predictions of a damping model based on forced vibration tests. Where soil-structure interaction is a significant factor, the overall damping for strong-motion response may be 3 to 4 times the indicated lower bound.

Martin, J. W.

Martin, J. W.; Guenther, F. R.; Nguyen, T.; Liggett, W. S., Jr.; Byrd, E.; Oakley, L.
Source of Phenol Emissions Affecting the Indoor Air of an Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5353; 49 p. February 1994.
Available from National Technical Information Services
PB94-154382

phenols; emissions; indoor air quality; office buildings; floor-leveling material; gas chromatography; mass spectrometry; liquid chromatography; sampling plan; thermogravimetric analysis; UV-spectrophotometry; volatile organic compound

For several years, National Oceanic and Atmospheric Administration (NOAA) employees occupying Floors 3 through 5 of the Silver Spring Metro Center Building One (SSMC-1) in Silver Spring, MD have complained about ailments which they have associated with poor indoor air quality. NOAA and the General Services Administration (GSA) commissioned at least six indoor air quality surveys to seek the causes of these complaints. In one of the later surveys, it was concluded that phenol emissions from an epoxy floor-leveling material used in leveling the floor slabs were causing the indoor air quality complaints from Floors 3 through 5. To obtain an independent analysis and assessment, NOAA and GSA asked the National Institute of Standards and Technology (NIST) to ascertain whether phenol (or any other volatile organic compound) was being emitted from the epoxy floor-leveling material and, if so, to recommend remedial actions for mitigating or eliminating the emissions. Prior to investigating the epoxy floor-leveling material, a review was made of the construction and occupancy history of SSMC-1, the installation of the floor-leveling material, occupant complaints about the poor indoor air quality, and the indoor air quality surveys.

Martin, J. W.; Saunders, S. C.; Floyd, F. L.; Wineburg, J. P.
Methodologies for Predicting the Service Lives of Coating Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Washington State Univ., Pullman, WA
Duron Paints and Wallcoverings, Beltsville, MD
E. I. du Pont de Nemours and Co. (Inc.), Philadelphia, PA
NIST BSS 172; 73 p. October 1994.
Available from Government Printing Office
SN003-003-03291-3
Available from National Technical Information Services

PB95-146387

computerized materials databases; fault tree; fundamental mechanistic experiments; in-service exposures; performance characteristic; reliability theory; reliability-based methodology; service life; time series; UV-radiation

Over the last two decades, the organic coatings industry has undergone rapid technological and structural changes. These changes have been induced by legislative actions such as restrictions pertaining to hazardous chemicals, toxic effluents, and volatile organic compounds. The consequence of these changes has been the displacement of almost all commercially-important, well-established coatings (largely high-solvent coatings) by newer systems, the formulation and application of which are based on different chemistries and technologies. Unlike the displaced coatings, however, the new coatings do not have performance histories and the only accepted method for generating performance data is through an extensive outdoor exposure program. Since outdoor exposure results typically take five years to obtain, a desperate need exists for a methodology which is capable of generating timely, accurate, and reliable service life estimates of a coating system. This report reviews the attributes of the service life prediction problem which are common to all materials, components, and systems in an effort to establish a set of criteria for assessing the adequacy of existing or proposed service life prediction methodology for coating systems. The current durability methodology and the reliability-based methodology are then evaluated against these criteria.

Martin, P. M.

Martin, P. M.; Jason, N. H., Editors
Fire Research Publications, 1993.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 878; October 1994.

fire research

This CD-ROM contains the full text of 1993 publications by the NIST/BFRL fire research staff and publications prepared on grant or contract to the fire research staff.

Martys, N. S.

Martys, N. S.
Fractal Growth in Hydrodynamic Dispersion Through Random Porous Media.
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review E, Vol. 50, No. 1, 335-342, July 1994.

dispersions; tracers; dyes; fluid flow; diffusion; scaling

Results from the numerical simulation of hydrodynamic dispersion in model random porous media are presented. The morphology of a spreading dye (or tracer), as a function of Peclet number, is studied. In the limit of infinite Peclet number, the dye pattern formed is fractal with fractal dimension close to that observed in diffusion-limited aggregation (DLA) in both two and three dimensions. Also, as in DLA, multifractal behavior is exhibited. At moderately high Peclet numbers the pattern formed by the dispersing dye in a two-dimensional porous medium is fractal over the concentration are self-affine with an anomalously large roughness exponent. By comparison, we show that the pattern formed by a dilute ion concentration driven by an electric field, rather than a flow field, is also self-affine but with the usual roughness exponent of 0.5.

Martys, N. S.
Universal Scaling of Fluid Permeability for Sphere Packings.
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review E, Vol. 50, No. 1, 403-402, July 1994.

permeability; scaling; simulation; fluid flow; porous media

Results from the numerical simulation of Stokes flow through random packings of nonoverlapping or overlapping spheres and a scaling ansatz are used to obtain universal curves for the fluid permeability. The scaling ansatz is motivated by previous analysis of rigorous bounds on the permeability. Excellent agreement was found for a variety of model microstructures of porous media in the low and high porosity regimes. Experimentally obtained permeabilities of several sandstones were found to agree well with our universal curve.

Martys, N. S.; Bentz, D. P.; Garboczi, E. J.
Computer Simulation Study of the Effective Viscosity in Brinkman's Equation.
National Institute of Standards and Technology, Gaithersburg, MD
Physics Fluids, Vol. 6, No. 4, 1434-1439, April 1994.
viscosity; equations; computer simulation

Brinkman's equation is often used to match solutions of Stokes' equation to solutions of Darcy's law at free-fluid:porous medium interfaces by the introduction of an effective viscosity parameter, me. Theoretical predictions of the dependence of me on the porosity of the porous medium have given conflicting results. A finite difference solution of Stokes' equation in three dimensions was used to study fluid flow near the interface between a free fluid and a porous medium. It was found that in order to match solutions of Brinkman's equation to the numerical solutions, the value of me had to be grater than the free fluid viscosity. Within numerical precision, the effective viscosity me was monotonically increasing with decreasing porosity. Good fits to the numerical fluid velocity profiles were obtained for porosities ranging from 50% to 80%.

McDonough, J. M.

McDonough, J. M.; Saito, K.
Local, Small-Scale Interaction of Turbulence With Chemical Reactions in H2-O2 Combustion.
Kentucky Univ., Lexington
Fire Science and Technology, Vol. 14, No. 1/2, 1-18, 1994.
combustion; turbulence; chemical reactions; turbulent combustion; equations

A brief survey of commonly used techniques for simulating turbulent combustion is presented, and it is noted that, except for direct numerical simulation (which is too computationally intensive even on foreseeable supercomputers), none of the current methods is able to predict details of chemical kinetics/turbulence interactions. A new approach, based on an extension of earlier work with one-dimensional mathematical models of turbulence by McDonough and co-workers (1984a, b, 1986, 1989), is applied to study a simple, single-step forward reaction H2-O2 combustion problem. The method requires no averaging, or modeling, at any level due to an additive multi-scale decomposition of governing equations. Thus, like direct numerical simulation, it is completely consistent with the original, unaveraged equations; but required arithermic is significantly reduced via consistent linking of large-scale and small-scale phenomena, resulting in the ability to focus on local regions and consistently (with respect to the full equations) simulate phenomena within these regions to a high degree of accuracy. In addition, the method is naturally parallelizable at several algorithmic levels. This technique, termed additive turbulent decomposition, is treated theoretically, and then applied to the one-dimensional, viscous, compressible Navier-Stokes and species equations. Preliminary computational results showing detailed chemical kinetics/turbulence interactions at the tip of an H2-O2 diffusion flame are presented and discussed for a flow with Reynolds number 6000, and thermal and mass diffusion Peclet numbers of 1000 and 3000, respectively. Computed results show a relatively long period of increase in negative amplitude of H2 and O2 concentrations followed by onset of chaotic oscillations simultaneously in velocity and temperature. Corresponding fluctuations then begin to appear in the concentrations via feedback from advective and species production terms.

McGrath, J. E.

McGrath, J. E.; Yoon, T. H.; Knauss, D.; Yuan, I. W.
Synthesis, Characterization, and Systematic Fire Safety Evaluation of High Volume and Specialty Hydrolytically Stable Phosphine Oxide Containing Polymeric Materials.
Virginia Polytechnic Institute and State Univ., Blacksburg
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 115-116 pp, 1994.
fire research; phosphorus; fire safety; safety evaluation; phosphine oxides; fire behavior

The research is attempting to determine whether or not chemically incorporated hydrolytically stable phosphorus systems can produce major improvements in fundamental fire resistant behavior. This chemically incorporated approach contrasts with the normal industrial method of physically adding fire retardants to the material systems. The disadvantage of the current approach includes the ideas that mechanical properties are impaired by the physical additives. Secondly, the additives may be extractable

under conditions of use, possibly even producing unattractive, toxic byproducts. In contract, the chemically incorporated systems will not be extracted by detergents or subjected to environmental degradation by normal humidity in the air. Preliminary small scale burning tests and dynamic thermogravimetric analysis methods have been very encouraging. The NIST project is the first effort achieving a more fundamental understanding through the use of cone calorimetry methodologies, which permit determination of heat release rate, heats of combustion, smoke generation, and carbon monoxide generation.

McGrattan, K. B.

McGrattan, K. B.; Baum, H. R.; Rehm, R. G.
Smoke Plume Trajectory From In Situ Burning of Crude Oil in Alaska.
National Institute of Standards and Technology, Gaithersburg, MD
Environment Canada. Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, 17th Proceedings. Volume 1. June 8-10, 1994, Vancouver, British Columbia, 725-733 pp, 1994.

oil spills; in situ combustion; crude oil; smoke; fire plumes; smoke measurement

Experimentation, analysis, and modeling have been performed to predict the downwind dispersion of smoke resulting from in situ burning of oil spills in Alaska. Laboratory burns of North Slope and Cook Inlet crude oils as well as mesoscale experiments performed at the U.S. Coast Guard Fire and Safety Test Detachment in Mobile, Alabama have provided input data for the LES (Large Eddy Simulation) plume trajectory model. A number of different fire sizes and weather conditions were considered with the aim of predicting the extent to which concentrations of smoke particulate matter would exceed ambient air quality standards. The model was also applied to the Newfoundland Offshore Burn Experiment (NOBE), where a comparison has been made between the model prediction and measurements of the smoke plume taken from an aircraft.

McKenna, G. B.

McKenna, G. B.; Waldron, W. K., Jr.; Horkay, F.
Elastomer Seal Compatibility.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; April 1994.
Available from Government Printing Office
SN003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 8, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 729-763 pp, 1994.

halons; elastomers; compatibility; seals; thermodynamics; durability; lubricants

Excessive swelling or deterioration of the elastomer seal (o-ring and its lubricant) in the fire suppressant storage container could lead to leakage of the agent leaving the system unready to respond in case of fire. Short term exposure experiments have been conducted and data have been generated on the proclivity of the eleven fluid agents to alter the properties of various elastomers and greases. The compatibilities of the fire suppressant agents with commonly used elastomers and greases have been characterized using two types of measurements.

Milke, J. A.

Milke, J. A.; Hagen, B. C.; McAvoy, T. J.; Pan, D.
Large-Scale Experiments of Fire Signatures to Develop a Discriminating Fire Detector.
Maryland Univ., College Park
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 145-146 pp, 1994.

fire research; fire detectors; experiments

Incorporating intelligence into a fire detector can provide the capability to promptly react to smoke while discriminating between smoke from fire and non-fire sources. The primary purpose of this study was to investigate the patterns of signatures associated with fire and environmental signatures via experiments.

Milosavljevic, I.

Milosavljevic, I.; Suuberg, E. M.
Behavior of Charring Solids Under Fire-Level Heat Fluxes.
Brown Univ., Providence, RI
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 107-108 pp, 1994.

fire research; solids; charring; heat flux; fire behavior

It has recently been argued in the fire research community that the ability to quantitatively describe flame spread over combustible solids has reached the point at which our understanding of the complexity of the solid phase processes is limiting. Often the processes occurring in the solid are modeled by simple thermal diffusion in a solid (with ill-defined thermal properties) together with a crude empirical decomposition rate law. A critically important parameter-release rate of combustibles into the vapor phase-often becomes little more than an adjustable parameter, as decomposition rates, products of pyrolysis and solids thermal properties under relevant conditions are only approximately known. This is particularly so in the practically important case of charring solids such as wood and other cellulosics. As a result, it is difficult to claim that a truly critical testing of combustion models for bulk, charring solids has ever been possible. This communication addresses some issues related to this problem.

Mitler, H. E.

Mitler, H. E.
Algorithm to Describe the Spread of a Wall Fire Under a Ceiling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5547; 53 p. November 1994.
Available from National Technical Information Services
PB95-182259

algorithms; ceilings; ceiling fires; computer models; fire growth; fire spread; wall fires

After some discussion of wall fires, the effects that a ceiling has on a wall fire are analyzed and discussed qualitatively. There are two kinds of effects: first, when the upper sill of the ventilating opening lies below the ceiling (as is usual), a layer of hot gas is trapped, which heats the walls by convection and radiation; the heated ceiling also radiates to the walls. A calculation which uses the wall-fire computer model SPREAD is carried out to demonstrate how these effects can be calculated now. Second, when the flame impinges on the ceiling, it bifurcates and spreads horizontally, rather than vertically. A simple algorithm is presented which calculates the spread rate of these horizontal flame extensions, as well as the modified pyrolysis rate, due to the modified radiation feedbacks.

Mitler, H. E.; Tu, K. M.
Effect of Ignition Location on Heat Release Rate of Burning Upholstered Furniture.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 121-122 pp, 1994.

fire research; furniture; upholstered furniture; ignition; heat release rate

Upholstered furniture has long been identified as the consumer product most frequently involved in home fires which result in personal injury or death. Hence an understanding of the way upholstered furniture performs when ignited, is desirable.

Morris, F. B.

Morris, F. B.; Braun, J. E.; Treado, S. J.
Experimental and Simulated Performance of Optimal Control of Building Thermal Storage.
Rohm and Haas Co., Bristol, PA
Purdue Univ., West Lafayette, IN
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 100, No. 1, 402-414, January 1994.

storage; building control; experiments; test facilities; simulation; optimal control strategies; energy savings; peak demand reductions

Dynamic building control involves utilizing the thermal storage potential of building mass to reduce cooling costs. Previous simulation studies have shown that both energy use and peak electrical demand can be significantly reduced using dynamic building control instead of conventional night setback control for many applications. In this study, optimal dynamic building control strategies were compared with night setback control through experiments at a test facility representative of a room in a large office building. Two optimal dynamic building control strategies were considered: minimum total energy costs and minimum peak electrical demand. These control strategies were determined through simulation of the test facility. The experiments showed that up to 51% of the total cooling load could be shifted to off-peak hours through optimal control. The reduction in the peak cooling load was found to be as much as 40%. For the test conditions, estimates of electrical energy and demand savings were determined through simulations and found to be 10% and 38%, respectively. Occupant thermal comfort was also measured during the experiments and maintained within acceptable limits for all control strategies tested. Measured cooling loads compare well with those predicted by the simulation and validate the simulation method. Additional simulations were conducted to study the effect of ambient conditions, utility rate structure, and the coupling between the zone and the ambient through exterior walls on the savings potential of dynamic building control. The results of this research demonstrate the tremendous potential associated with optimal control of building thermal storage.

Mowrer, F. W.

Mowrer, F. W.
Development of the Fire Data Management System.
Maryland Univ., College Park
NIST-GCR-94-639; 35 p. June 1994.
Available from National Technical Information Services
PB94-206091

cone calorimeters; corner tests; databases; fire safety; flame spread; furniture calorimeters; heat release; numeric databases; room tests; small scale fire tests

The Fire Data Management System (FDMS) is being developed under international collaboration to provide uniform means for storing fire test data. The purpose of the present work has been to aid the development of the FDMS for practical use by fire safety design professionals with respect to the following three tasks: (*) Recovery of existing data at BFRL/NIST for implementation into the FDMS; (*) Generation of additional data not already available; (*) Development of engineering guidelines for use of the FDMS. To be of practical use by fire safety design professionals, the FDMS must contain relevant data and these data must be readily accessible. Currently, the data fields in the FDMS are too general and too restricted to be of practical design use. Additional data fields are needed in the FDMS to assist the design professional find flammability test data relevant to the design of different combustible objects in buildings. To help identify the types of additional data fields that are needed, a series of morphological charts have been developed to describe the types, elements and attributes of combustible objects in buildings. These morphological charts represent a first effort to describe a common syntax for identifying appropriate objects and their attributes for flammability analyses. Further refinement of the morphological charts is needed.

Mulholland, G. W.

Mulholland, G. W.; Babrauskas, V.; Parker, W. J.; Twilley, W. H.
PHI-Meter: A Fuel-Independent Instrument for Monitoring Combustion Equivalence Ratio.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 159-160 pp, 1994.

fire research; combustion; carbon monoxide; equations; instruments

Gaseous carbon monoxide is mainly responsible for deaths due to unwanted fires. This has been a major difficulty to specialists in fire protection engineering, since quantitative methods for predicting CO yields from building fires have not been available.

Mulholland, G. W.; Bohren, C. F.; Fuller, K. A.
Light Scattering by Agglomerates: Coupled Electric and Magnetic Dipole Method.
National Institute of Standards and Technology, Gaithersburg, MD
Pennsylvania State Univ., University Park
Colorado State Univ., Fort Collins
Langmuir, Vol. 10, No. 8, 2533-2546, 1994.

light scattering; agglomerates; Rayleigh-Debye light scattering

The coupled electric dipole method (CED) for treating light scattering by an agglomerate particle is extended to include both the electric and magnetic dipole terms (CEMD). The accuracy of these two methods along with the Rayleigh-Debye (RD) method is obtained by comparing with the exact solution for two spheres in contact. It is found that the additional term extends the range of the coupled dipole method from a primary sphere diameter of about 0.06 mm to about 0.12 mm for soot-like particles at visible wavelengths. The scattering and extinction cross sections, the differential scattering, and the polarization ratio are computed for agglomerates with 17, 52, and 165 primary spheres for soot-like and silica-like agglomerates. The agglomerates are generated by Brownian dynamics computer simulation of in-flame growth. A comparison is made among RD, CED, and CEMD. The effects of primary sphere diameter and agglomerate size on the validity of the RD approximation is discussed. It is shown that the polarization ratio computed by CEMD is sensitive to the primary sphere size independent of agglomerate size.

Mulholland, G. W.; Bryner, N. P.
Radiometric Model of the Transmission Cell-Reciprocal Nephelometer.
National Institute of Standards and Technology, Gaithersburg, MD
Atmospheric Environment, Vol. 28, No. 5, 873-887, 1994.

absorption; aerosols; agglomerates; extinction; scattering coefficient; smoke

A radiometric model has been developed to assess the effects of angular truncation, finite size of the detector, and angle response characteristics of the cosine sensor on the measurement of the total scattering coefficient by a transmission cell-reciprocal nephelometer. These effects are computed for monodisperse polystyrene spheres over the size range 0.02-8 mum based on Mie theory and for smoke agglomerates ranging from 10 to 10(7) primary units based on the Fisher-Burford approximation. The accuracy of the model calculations is determined by comparison with exact solutions for the case of a detector with an infinitesimal area and for a finite area detector with a diffuse scattering function. The predicted results are compared with measured results for six different sizes of monodisperse polystyrene sphere aerosols with particle diameters in the range 0.1-2.35 mum. The measurements were carried out as a function of the distance between the laser beam and detector for 1.3 and 2.7 cm diameter cosine sensors. A table of design parameters for making accurate total scattering measurements is obtained for both spheres and agglomerates. An accuracy of +5% was obtained for spherical particles with diameters <1.1 mum with our TCRN, and we estimate that similar performance would be obtained for smoke agglomerates with up to 3 x 10(3) primary spheres per agglomerate.

Mulroy, W. J.

Mulroy, W. J.; Domanski, P. A.; Didion, D. A.

Glide Matching With Binary and Ternary Zeotropic Refrigerant Mixtures. Part 1. An Experimental Study.

National Institute of Standards and Technology, Gaithersburg, MD

International Journal of Refrigeration, Vol. 17, No. 4, 220-225, 1994.

refrigerants; temperature profile; heat transfer; enthalpy; tests; simulation

An improvement of the coefficient of performance (COP) of the refrigeration cycle can be realized when temperature profiles of the refrigerant mixture and the heat transfer fluid (HTF) are matched. For the same temperature lift, the benefit of glide matching increases as the application glide increases. High-glide binary mixtures composed of components far apart in boiling points tend to have a non-linear relationship between temperature and enthalpy in the two-phase region. The introduction of an intermediate boiler as a third component can linearize this relationship and, theoretically, increase the cycle COP when heat-source and heat-sink fluids are substantially linear (e.g., water, brines, dry air). The research described in this paper was directed at exemplifying this characteristic of ternary mixtures by experimental evaluation of the performance of a R23/142b binary mixture and an R23/22/142b ternary mixture in a generic laboratory breadboard refrigeration system.

N

Nabinger, S. J.

Nabinger, S. J.; Persily, A. K.; Dols, W. S.

Study of Ventilation and Carbon Dioxide in an Office Building.

National Institute of Standards and Technology, Gaithersburg, MD

ASHRAE Transactions, Vol. 100, No. 2, 1994.

office buildings; ventilation; carbon dioxide; indoor air quality; monitoring; tracer gas; ventilation rates

Ventilation rates and indoor carbon dioxide levels were monitored for two years in a new office building near St. Louis, Missouri. These measurements were made to assess the operation and performance of the ventilation system in this building and to investigate the relationship between indoor carbon dioxide levels and air change rates. Ventilation rates were measured with the tracer gas decay technique using an automated measuring system. Indoor carbon dioxide concentrations were also measured with an automated system. The ventilation rates exhibited a dependence on outdoor temperature that was expected based on the heating, ventilating, and air-conditioning (HVAC) system's controls. The air change rates under conditions of minimum outdoor air intake were about 0.5 air changes per hour (ach), which is lower than both the air change rate corresponding to the building design value for minimum outdoor air intake and the rate that corresponds to the recommended minimum outdoor airflow per person in ASHRAE Standard 62-1989. The indoor carbon dioxide concentrations were generally lower than the 1,000-ppm guideline in Standard 62. The relationship between the indoor carbon dioxide levels and the building air change rates was similar to that seen in other office buildings. These results are presented as part of a discussion on the use of equilibrium analysis of carbon dioxide concentrations to determine building air change rates. This discussion points out limitations in the use of equilibrium analysis of carbon dioxide concentrations in office buildings.

Nakabe, K.

Nakabe, K.; McGrattan, K. B.; Kashiwagi, T.; Baum, H. R.; Yamashita, H.; Kushida, G.

Ignition and Transition to Flame Spread Over a Thermally Thin Cellulosic Sheet in a Microgravity Environment.

National Institute of Standards and Technology, Gaithersburg, MD

Combustion and Flame, Vol. 93, 361-374, 1994.

microgravity; ignition; flame spread; oxygen; autoignition; cellulose

An axisymmetric, time-dependent model is developed describing auto-ignition and subsequent transition to flame spread over a thermally-thin cellulosic sheet heated by external radiation in a quiescent microgravity environment. Due to the unique combination of a microgravity environment and low Reynolds number associated with the slow, thermally induced flow, the resulting velocity

is taken as a potential flow. A one-step global gas phase oxidation reaction and three global degradation reactions for the condensed phase are used in the model. A maximum external radiant flux of 5 W/cm2 (Gaussian distribution) with 21%, 30%, and 50% oxygen concentrations is used in the calculations. The results indicate that autoignition is observed for 30% oxygen concentrations but the transition to the flame spread does not occur. For 50% oxygen the transition is achieved. A detailed discussion of the transition from ignition to flame spread is given as an aid to understanding this process. Also, a comparison is made between the axisymmetric configuration and a two-dimensional (line source) configuration.

Nelson, H. E.

Nelson, H. E.
Fire Growth Analysis of the Fire of March 20, 1990, Pulaski Building, 20 Massachusetts Avenue, N.W., Washington, DC.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4489; 51 p. June 1994.
Available from National Technical Information Services
PB94-205952

office buildings; fire investigation; fire models; fire spread; flashover; fire spread

An analysis of an office building fire was made using fire modeling techniques. The data to conduct the analysis was obtained through on-site inspection and interviews. The analysis describes a rapid fire developing in easily ignited boxing materials that flashed over in about six minutes from flame initiation, causing failure of the ceiling system, venting of fire products in the plenum system above the ceiling, and rapid filling of the entire flow area with smoke. The report suggests a likely source of ignition and provides analysis of the impact that several fire protection systems would have had were they present at the time of this fire.

Notarianni, K. A.

Notarianni, K. A.
Water Mist Fire Suppression Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Society of Fire Protection Engineers and PLC Education Foundation. Technical Symposium on Halon Alternatives, Proceedings. June 27-28, 1994, Knoxville, TN, 57-64 pp, 1994.

fire suppression; water fog; water mist; water sprays; fire research; droplets; drop size; fire extinguishment; sprinklers; commercial aircraft

The imminent lack of availability of halon fire suppressants has sparked worldwide efforts in developing alternative fire fighting agents and delivery systems. Water mist fire suppression systems are potential replacements in many industrial applications as well as in new markets such as commercial passenger aircraft. Interest in water mist technology has heightened over the past two years. There are several manufacturers with developed products on the market, and more entering the market. Two major conferences were held in 1993 on the topic, and the National Fire Protection Association (NFPA) has formed a committee to write an installation standard for water mist systems. The NFPA 750 Committee "Standard for the Installation of Water Mist Fire Suppression Systems," has formed a task group to summarize the data on water mist fire suppression. An international literature search was conducted, and based on the results of the search and input from the main committee, eight topic areas were identified. Each member of the task group assumed responsibility for compiling an executive summary in one topic area. Each summary contains a description of the hazard, a review of the scenarios tested in the literature, a synopsis of what is known and what further research should be conducted in that topic area, as well as an annotated bibliography of key references. This paper presents an overview of the various types of water mist systems and an introduction to the work of the NFPA task group.

Notarianni, K. A.; Jackson, M. A.
Comparison of Fire Sprinkler Piping Materials: Steel, Copper, Chlorinated Polyvinyl Chloride and Polybutylene, in Residential and Light Hazard Installations.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5339; 40 p. June 1994.
Available from National Technical Information Services
PB95-182267

sprinkler systems; pipes; building technology; copper; chlorinated polyvinyl chloride; fire research; polybutylene; plastic pipes; steels

A literature-based study was conducted at the Building and Fire Research Laboratory of the National Institute of Standards and Technology, to compare characteristics and usage of steel, copper, chlorinated polyvinyl chloride, and polybutylene fire sprinkler pipe primarily related to residential and light hazard installations. This report addresses key variables such as material properties, usage criteria and limitations, system design, installation requirements, economics, and maintenance. Information is presented which is useful for the selection of a sprinkler pipe material. This study was sponsored by the United States Fire Administration.

Nyden, M. R.

Nyden, M. R.; Brown, J. E.
Investigation Into the Flammability Properties of Honeycomb Composites.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5509; 22 p. October 1994.
Available from National Technical Information Services
PB95-143293

flammability; FTIR; phenol formaldehyde; composite materials

The study which is the subject of this record was carried out in two stages. The objective of the first phase was to investigate the effect of electron beam irradiation and grafting on polymer flammability. The time to ignition and the rate-of-heat-release were measured for the combustion of a series of samples in which a fire resistant polymer was used to protect the surface of a more flammable polymer. The flammability properties of honeycomb composite materials, which are currently used in the interior cabin compartments of commercial aircraft, were examined in the second phase of this project. Analyses of the gases evolved during the thermal degradation of the components indicated that the phenol-formaldehyde resin makes a significant contribution to 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.

Nyden, M. R.; Brown, J. E.
New Generation of Fire Resistant Polymers. Part 1. Computer-Aided Molecular Design.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 257-266 pp, 1994.

fire safety; fire research; polymers; computers; degradation; equations; crosslinking

Molecular dynamics modeling and experimental measurements are used to identify factors which reduce flammability by promoting the formation of heat resistant chars during the thermal degradation of polymers. Computer movies of the calculated trajectories reveal that cross-linked model polymers tend to undergo further cross-linking when burned. The presence of strong potential energy interactions with a surface or filler further facilitates the formation of high molecular weight, thermally stable chars.

Nyden, M. R.; Linteris, G. T.; Burgess, D. R. F., Jr.; Westemoreland, P. R.; Tsang, W.; Zachariah, M. R.
Flame Inhibition Chemistry and the Search for Additional Fire Fighting Chemicals.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; April 1994.
Available from Government Printing Office
SN003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 5, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 467-641 pp, 1994.

halons; flame extinguishment; flame chemistry; chemical fire fighting; kinetics; hydrocarbons; fire suppression; effectiveness; ozone; reaction rate

Replacements for the current commercial halons should posses a diverse set of properties which are rarely found together in the same molecule. Thus, the ideal candidate for the replacement of halon 1301 would be a nontoxic gas which is reactive in flames and in the troposphere, yet at the same time, inert in the stratosphere and in its storage environment. The present generation of replacements, as typified by the core candidates listed in Section 1, were selected on the basis of a compromise, whereby fire suppression efficiency was sacrificed to ensure acceptable environmental properties. The research reported in this section was directed at developing the capability to predict the fire suppression effectiveness, propensity to generate corrosive combustion products, and environmental impact of a molecule on the basis of its structure. This is essential to the development of a rational approach to the search for new and more effective fire fighting chemicals.

O

Ohlemiller, T. J.

Ohlemiller, T. J.; Cleary, T. G.
Upward Flame Spread on Composite Materials.
National Institute of Standards and Technology, Gaithersburg, MD
International Community for Composites Engineering (ICCE). Proceedings of International Conference on Composites Engineering. ICCE/1. August 28-31, 1994, New Orleans, LA, Hui, D., Editor, 375-376 pp, 1994.

composite materials; flame spread; compartments

The composite materials of interest in this work contain several piles of long, high strength fibers, typically woven in some fixed pattern; the layered multi-ply structure is embedded with an organic polymer resin. Such composites offer a high strength-to-weight ratio and other advantages, such as corrosion resistance, which make them attractive for a wide variety of structural uses. In particular, the U.S. Navy is investigating the use of such composites for both ship and submarine compartment construction; load-bearing compartment walls would consist of flat (or possibly more complex) panels of composite material.

Ohlemiller, T. J.; Corley, D. M.
Heat Release Rate and Induced Wind Field in a Large Scale Fire.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Science and Technology, Vol. 97, 315-330, 1994.

large scale fire tests; forest fires; heat release rate; wind effects

Logging slash on a 486 hectare site in Ontario was burned as part of a Forestry Canada forest management program. A 100 hectare portion of this site was instrumented by several groups interested in large scale fires. NIST utilized Forestry Canada data on mass loading before and after the fire, total burning area as a function of time and burning duration to estimate the spatial and temporal pattern of heat release during the burning of the instrumented section of the fire. The heat release rate was estimated to reach 2-4 x 10(7)kW during the time of interest. This information was utilized in the context of a flow model due to Baum and McCaffrey to calculate the near-ground flow field induced by this heat release pattern; the results compared moderately well with point measurements made in the field.

Ohlemiller, T. J.; Shields, J. R.
Furniture Mock-Up Performance Under California Technical Bulletin 133 Test Conditions.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 119-120 pp, 1994.

fire research; furniture; upholstered furniture; chairs; mattresses; public buildings; fire tests; codes; California Technical Bulletin 133

Fires involving soft furnishings such as upholstered chairs and mattresses continue to play a prominent role in U.S. fire losses. This is a multi-faceted problem that has been addressed, over the years, from several directions with some significant success. Fire deaths and injuries involving these products show a substantial decline over the past 15 years. One of the more recent developments in this area is the increasing acceptance of a test protocol (CB 133) developed at the California Bureau of Home Furnishings, intended for upholstered chairs utilized in public occupancies (hotels, hospitals, etc.). The protocol imposes quite restrictive limits on the response of a char (or equivalent mock-up) to an arson-like ignition source (an 18 kW gas burner). Of particular interest here is the rate of heat release response to burner exposure since this effectively measures the size and threat of the resulting fire.

P

Palm, S.

Palm, S.; Zukoski, E. E.
Measurements of the Transient Development of a Ceiling Layer.
California Institute of Technology, Pasadena, CA
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 325-333 pp, 1994.

fire research; fire safety; fire science; diffusion flames; carbon monoxide; heat balance; ceilings

The results of a study of the transient production of CO and other species in a ceiling layer during the development of the layer are presented. The aim of this work is to produce a set of data that can be used as a check on models for species production, particularly of carbon monoxide production, in strongly vitiated ceiling layers under transient conditions.

Parmelee, H. J.

Parmelee, H. J.; DiTomas, E. E.
National Construction and Building Goals Bring Tomorrow Into Today's Commercial Buildings.
Turner Construction Co.
NISTIR 5610; 1994.
Available from National Technical Information Services
White Papers Prepared for the White House--Construction Industry Workshop on National Construction Goals. December 14-16, 1994, Fowell, A. J., Editor, D1-D18 pp, 1994.

construction; industries; research programs; competitiveness

Peacock, R. D.

Peacock, R. D.; Bukowski, R. W.; Jones, W. W.; Reneke, P. A.
New Concepts for Fire Protection of Passenger Rail Transportation Vehicles.
National Institute of Standards and Technology, Gaithersburg, MD
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, International Association for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 1007-1016 pp, 1994.

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

Recent advances in guided ground transportation, fire test methods, and hazard analysis necessitate re-examination of requirements for fire safety. Several studies have indicated nearly random ability of current tests to predict actual fire behavior. A comparison of the approaches used in the United States, Germany, and France is presented. With the strengths and weaknesses of current

methods for measuring the fire performance of materials used in rail transit systems reviewed, a direction is suggested in which most fire science-oriented organizations in the world are clearly headed - fire hazard and fire risk assessment methods supported by measurement methods based on heat release rate.

Peacock, R. D.; Bukowski, R. W.; Jones, W. W.; Reneke, P. A.; Babrauskas, V.; Brown, J. E.
Fire Safety of Passenger Trains: A Review of Current Approaches and of New Concepts.
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1406; DOT/FRA/ORD-93/23; DOT-VNTSC-FRA-93-26; 170 p.
January 1994.
Available from Government Printing Office
SN003-003-03246-8
Available from National Technical Information Services
PB94-152006

passenger vehicles; railroads; fire research; heat release rate; large scale fire tests; smoke; small scale fire tests; standards; systems approach; test methods

Recent advances in passenger guided transportation, fire test methods, and hazard analysis necessitate re-examination of requirements for fire safety. Several studies have indicated nearly random ability of current 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 are all considered. All of the technologies being considered for U.S. operation have evolved under different types of regulations and standards. This report presents a detailed comparison of the fire safety approaches used in the United States, France, and Germany. The strengths and weaknesses of current methods for measuring the fire performance of rail transportation systems are evaluated. An optimum systems approach to fire safety which addresses 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 (HRR).

Peacock, R. D.; Cleary, T. G.; Harris, R. H., Jr.
Agent Stability Under Storage and Discharge Residue.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; April 1994.
Available from Government Printing Office
SN003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 6, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 643-668 pp, 1994.

halons; residues; stability; storage; metals; experiments; halon 1301; infrared spectroscopy

Halon 1301 is known to be stable in metal containers for many years. Any by-products do not affect its fire suppression effectiveness or result in an unacceptable residue. For candidate replacement chemicals, comparable data are needed, reflecting the storage conditions of elevated temperature and pressure. Significant losses in fire suppression effectiveness and increases in toxicity are possible if the extinguishing agent degrades during storage. Thus, stability during the multi-year storage environment is an important concern. In this project, samples of each of the 12 candidate agents were evaluated in pressurized cylinders. It was presumed that NaHCO3 is stable under the likely storage temperatures and pressures. In order to allow for potential interactions analogous to actual storage conditions, a measured amount of metal (with separate tests for each candidate cylinder metal) was introduced into the containers prior to the experiments. The vessel and its contents were stored in an oven at elevated temperature for 28 days. After cooling to ambient conditions, an infrared spectrum of the aged sample was compared to a spectrum of the original sample. Degradation of the sample would be indicated by a systematic decrease in the absorbance of peaks attributable to the agent and/or the appearance of new peaks in the IR spectrum of the aged agent.

Peacock, R. D.; Jones, W. W.; Forney, G. P.; Portier, R. W.; Reneke, P. A.; Bukowski, R. W.; Klote, J. H.
Update Guide for HAZARD I Version 1.2.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5410; 159 p. May 1994.
Available from National Technical Information Services, Springfield, VA
PB94-501996GEI
Available from National Fire Protection Association, Quincy, MA
Available from International Conference of Building Officials, Whittier, CA
Available from Australian Fire Protection Assoc., Ltd., Victoria, Australia

computer models; computer programs; evacuation; fire models; fire research; hazard assessment; human behavior; toxicity

A method for quantifying the hazards to occupants of buildings from fires, and the relative contribution of specific products (e.g., furniture, wire insulation) to those hazards is presented. This method called HAZARD I, combines expert judgment and calculations to estimate the consequences of a specified fire. These procedures involve four steps: 1) defining the context, 2) defining the scenario, 3) calculating the hazard, and 4) evaluating the consequences. Steps 1, 2, and 4 are largely judgmental and depend on the expertise of the user. Step 3, which involves use of the extensive computer software, requires considerable expertise in fire safety practice. The heart of HAZARD I is a sequence of computer software procedures which calculate the development of hazardous conditions over time, calculate the time needed by building occupants to escape under those conditions, and estimate the resulting loss of life based on assumed occupant behavior and tenability criteria. This report describes the theory and use of the latest update to the software implementing the hazard methodology. It is intended to supplement an existing Technical Reference Guide and Software User's Guide for Version 1.1 of the methodology, NIST Handbook 146. As such, it does not replace the existing documents.

Peitsman, H. C.

Peitsman, H. C.; Wang, S.; Karki, S. H.; Park, C.; Haves, P.
Reproducibility of Tests on Energy Management and Control Systems Using Building Emulators.
TNO Building and Construction Research, Delft, The Netherlands
University of Liege, Belgium
Technical Resarch Center of Finland, Espoo, Finland
National Institute of Standards and Technology, Gaithersburg, MD
University of Technology, Loughborough, UK
ASHRAE Transactions, Vol. 100, No. 1, 1455-1464, January 1994.

emulator; reproducibility; tests; energy management; control systems; heating; ventilation; air conditioning; building systems

An emulator consists of a real-time simulation of a building and its HVAC system and a hardware interface that allows the simulation to be connected to a real control system. Recent studies have shown that emulation can provide a flexible and low-cost method of testing real energy management and control systems (EMCS). As part of a research project, an experiment involving four different emulators with two different EMCS was performed to study the reproducibility of the emulation method. This paper presents the results of this experiment in the form of a comparison of the predictions of energy consumption, thermal comfort, and control activity obtained from tests of the EMCS using emulators based on different design and different simulation programs.

Persily, A. K.

Persily, A. K.
Few Caveats on Carbon Dioxide Monitoring.
National Institute of Standards and Technology, Gaithersburg, MD
IAQ Journal, Vol. 4, No. 1, 22-25, Summer 1994.

carbon dioxide; indoor air quality; tracer gas; ventilation

While techniques exist to relate indoor carbon dioxide concentrations to building ventilation and indoor air quality, they are not as simple as sometimes suggested. Some of the techniques can yield reliable results when used correctly, while others can result in

serious errors. Using any of these approaches requires that one understands the technique and the following factors are considered: the outdoor carbon dioxide concentration; the number of people in the building and the rate at which they generate carbon dioxide; variations in the number of occupants within the building and over time; variations in the carbon dioxide concentration within the building; the measurement uncertainty of the carbon dioxide monitor being used; ventilation system operation prior to and during the measurements; and, indoor sources of carbon dioxide other than the occupants.

Persily, A. K.
Manual for Ventilation Assessment in Mechanically Ventilated Commercial Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5329; 129 p. January 1994.
Available from National Technical Information Services
PB94-145653

commercial buildings; ventilation; building diagnostics; indoor air quality; measurement; mechanical ventilation; office buildings

This manual describes procedures for assessing ventilation system performance and other aspects of building ventilation in mechanically ventilate commercial buildings. These procedures are intended to provide basic information on building ventilation for comparing ventilation performance to standards, guidelines and building design values and for investigating indoor air quality problems. The procedures in the manual are based on established measurement techniques and available instrumentation and provide practical means for obtaining reliable information on ventilation performance. The manual does not describe complete system evaluations that are performed during testing and balancing efforts or sophisticated measurement techniques that are used in ventilation research. The manual is written for technically competent indoor air quality investigators, building operators and others who need to perform ventilation assessments in order to address existing problems or as part of preventive maintenance programs. The manual provides background information on building ventilation, discusses instrumentation used in ventilation assessments, describes measurement techniques for determining the values of key ventilation performance parameters, and presents procedures to evaluate building ventilation using these techniques.

Persily, A. K.; Dols, W. S.; Nabinger, S. J.
Air Change Effectiveness Measurements in Two Modern Office Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
Indoor Air, Vol. 4, 40-55, 1994.

office buildings; air change effectiveness; building performance; commercial buildings; indoor air quality; mechanical ventilation; tracer gas; ventilation; ventilation effectiveness

Local age of air and air change effectiveness were determined in two office buildings using tracer gas techniques to study the applicability of the associated measurement procedures in mechanically ventilated office buildings. Measurement issues examined include the establishment of a uniform tracer gas concentration at the start of the test and the relationship of ventilation system configuration and system operation to the test procedure. Air change effectiveness was determined at locations in the occupied space based on the local age of air at that location and the age of air in the corresponding ventilation system return duct. Values of the air change effectiveness in the occupied space were generally close to one, which is consistent with good mixing of the ventilation air within the occupied space. Deviations from 1.0, on the order of 10%, did occur, but given the limited experience with these measurement procedures in the field it is not clear whether these deviations are significant. These tests provide data on air change effectiveness to supplement the limited database on mechanically ventilated office buildings in the U.S. In addition, the experience obtained with the measurement procedures will assist in the development of a standardized approach to measuring air change effectiveness in the field.

Phan, L. T.

Phan, L. T.; Hendrickson, E. M.; Marshall, R. D.; Celebi, M.
Analytical Modeling for Soil-Structure Interaction of a 6-Story Commercial Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
U.S. Geological Survey, Menlo Park, CA

U.S. National Conference on Earthquake Engineering, Fifth (5th). Earthquake Awareness and Mitigation Across the Nation Proceedings. Volume 1. July 10-14, 1994, Chicago, IL, 199-208 pp, 1994.

office buildings; commercial buildings; earthquakes; computer models; vibration; structural response; instruments

Strong-motion and ambient vibration data obtained from a 6-story commercial office building in San Bruno, California, were analyzed. Comparison of dynamic characteristics revealed that the first-mode response frequency deduced from the Loma Prieta earthquake records is significantly lower than that deduced from ambient vibration data, and the damping ratio for strong motion is higher than that obtained from ambient vibration. A computer model of the building was developed and analyzed using two boundary conditions. The fixed-base condition was used to simulate the building response to ambient vibration, and the spring-supported condition was used to incorporate soil-structure interaction and thus simulate realistic building response to the Loma Prieta earthquake. Results of analyses showed that the first-mode response frequencies for the two cases differ by essentially the same factor observed from measurements. This suggests that the difference in first-mode response frequencies between ambient vibration and strong motion in this building was due largely to soil-structure interaction.

Phan, L. T.; Todd, D. R.; Lew, H. S.
Strengthening Methodology for Lightly Reinforced Concrete Frames-II. Recommended Calculation Techniques for the Design of Infill Walls.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5421; 44 p. May 1994.
Available from National Technical Information Services
PB94-187648

building technology; reinforced concretes; empirical equation; experimental; frames; infilled walls

Empirical equations were developed for estimations of ultimate lateral shear strength, story drift ratio at ultimate load, and ductility factor of existing lightly reinforced concrete frames (bare frames), existing monolithic shear walls, and reinforced concrete frames strengthened either by cast-in-place infilled walls or by single or multiple precast concrete panels. These equations were derived based on experimental results of many independently conducted test programs. Estimations of the ultimate shear stress, ultimate story drift ratio (story drift at ultimate load divided by story height), and ductility factor using the empirical equations compared favorably with the experimental results. The estimations confirm many observations made independently in individual test programs. The empirical expressions also provide "benchmark" values or ranges for these important parameters and thus provide a useful means for quick estimations of seismic capacity of bare, monolithic, and strengthened lightly reinforced concrete frames.

Pitts, W. M.

Pitts, W. M.
Engineering Algorithm for the Estimation of Carbon Monoxide Generation in Enclosure Fires.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 51-52 pp, 1994.

fire research; carbon monoxide; generation; enclosures; algorithms

Roughly two thirds of all deaths resulting from enclosure fires can be attributed to the presence of carbon monoxide (CO) which is the dominant toxicant in fire deaths. A long-term program (Carbon Monoxide production and Prediction Project) at the Building and Fire Research Laboratory is seeking to develop an understanding of and predictive capability for the generation of CO in enclosure fires.

Pitts, W. M.
Global Equivalence Ratio Concept and the Prediction of Carbon Monoxide Formation in Enclosure Fires.
National Institute of Standards and Technology, Gaithersburg, MD
NIST Monograph 179; 171 p. June 1994.
Available from Government Printing Office
SN003-003-03271-9
Available from National Technical Information Services
PB94-207511

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 the first complete review and 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 modeling studies have shown 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 which 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.
Limitations of the Global Equivalence Ratio Concept for Predicting CO Formation in Room Fires.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 152-159 pp, 1994.

fire safety; fire research; carbon monoxide; room fires; enclosures; reaction kinetics; compartment fires

Recent experimental and modeling efforts designed to characterize the formation of carbon monoxide (CO) in enclosure fires which were funded by or performed at the Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST) are summarized. The findings are used to assess the conditions for which the Global Equivalence Ratio Concept can be used to predict the generation of CO and other combustion gases by enclosure fires.

Pitts, W. M.; Johnsson, E. L.; Bryner, N. P.
Carbon Monoxide Formation in Fires by High-Temperature Anaerobic Wood Pyrolysis.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Symposium Papers. Session 07-B: Fire Hazards. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 69-70 pp, 1994.

combustion; fire hazards; carbon monoxide; high temperature; wood; pyrolysis

Building fire fatalities often occur at locations remote from the room where the fire is actually burning. The majority of these fire deaths are the result of smoke inhalation, primarily due to exposure to carbon monoxide (CO). Although causing nearly 2500 deaths per year in the United States, the mechanisms for the formation of CO in building or enclosure fires remain poorly characterized. In order to test the hypothesis that high concentrations of CO can be generated by pyrolysis of wood in high temperature, vitiated environment, a series of natural-gas fires, ranging rom 40-600 kW in heat release rate, were burned inside a reduced-scale enclosure (RSE). The ceiling and upper walls of the RSE were lined with 6.4 mm thick plywood. During each

burn, the concentrations of CO CO2, and O2 were monitored at two locations within the upper layer. Oxygen calorimetry was used to monitor the total heat release rate for each fire. Verticle temperature profiles for two positions within the enclosure were also recorded. Much higher levels of CO were generated with the wood-lined upper layer than with comparable fires fueled only by natural gas. Volume concentrations as high as 14% were observed. The fires with wood in the upper layer had higher heat release rates and deparessed upper-layer temperatures. The major conclusions of this work based on the experimental findings are: 1) the pyrolysis of wood in a highly vitiated, high temperature environment can lead to the generation of very high concentrations of CO in enclosure fires; 2) the overall wood pyrolysis is endothermic for the experimental conditions studies; and 3) the maximum mass loss rate of wood under the experimental conditions is on the order of 10 gs-1m-2 with the majority of released carbon being converted to a roughly 1:1 mixture of CO and CO2.

Pitts, W. M.; Yang, J. C.; Gmurczyk, G. W.; Cooper, L. Y.; Grosshandler, W. L.; Cleveland, W. G.; Presser, C.
Fluid Dynamics of Agent Discharge.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; April 1994.
Available from Government Printing Office
SN003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 3, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 37-343 pp, 1994.

halons; fluid dynamics; discharge rate; dispersions; equations; sprays

The extinguishment of a fire using gaseous agents is a very complicated process which is not completely understood. Current fire-fighting agents such as halon 1301 and halon 1211 are believed to function by a combination of chemical (catalytic removal of hydrogen atoms at the flame front due to the presence of bromine atoms) and physical (cooling and dilution of flame gases) actions. All of the proposed alternative agents are known to be less effective (i.e., considerably higher molar concentrations of the agent are required) than halon 1301. This reduction in effectiveness is attributed to the absence of bromine atoms in these chemicals and thus the absence of a highly effective chemical means of fire extinguishment.

Portier, R. W.

Portier, R. W.
Fire Data Management System, FDMS 2.0, Technical Documentation.
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1407; 81 p. February 1994.
Available from Government Printing Office
SN003-03251-4
Available from National Technical Information Services
PB94-164019

bench scale fire tests; computer database; export; fire research; import; large scale fire tests; numeric databases; real scale fire tests; scalar data; fire tests; vector data

Fire Data Management System, FDMS, is a computer database specifically designed to store and retrieve fire tests results. A version, FDMS 1.0, of the database is currently available. This guide provides detailed descriptions of the physical fire implementations planned for the next generation of the database, FDMS 2.0.

Portier, R. W.
Fire Data Management System, FDMS 2.0.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964

National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 39-40 pp, 1994.

bench scale fire tests; computer database; export; fire research; import; large scale fire tests; numeric databases; real scale fire tests; scalar data; fire tests; vector data

A unified method of accessing data is crucial to both experimental and modeling efforts in the development of the science of fire. The FDMS concept is well founded, and very important to experimentalists acquiring data, as well as modelers and others using data related to fires and material properties. A standalone, PC version of the database, FDMS 1.0, currently exists which supports a limited number of fire test method types. This version is not portable across computer platforms and is dependent upon third-party software libraries which are no longer supported. A second generation of the database, FDMS 2.0, is in development which will remedy these problems and provide flexibility for future data needs. As an extension to FDMS 1.0, version 2.0 will play an important part in model verification. The design of FDMS 2.0 allows fire test data and model output data to be stored in the same database. Storage design provides for replicate data for standard test methods as well as compressed data for extensive real-scale tests.

Priestly, M. J. N.

Priestly, M. J. N.; Lew, H. S.
Status of the U.S. Precast Seismic Structural Systems (PRESSS) Program.
University of California, San diego, La Jolla
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 871; September 1994.
Available from Government Printing Office
SN003-003-03297-2
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 26th. May 17-20, 1994, Gaithersburg, MD, Raufaste, N. J., Editor, 365-368 pp, 1994.

structures; concretes; earthquakes; precast; buildings; PRESS; seismic; structures

The paper provides a brief overview of the recently completed Phase I U.S. PRESSS program, and the current Phase II program, which emphasizes theoretical and experimental studies of ductile connection systems for precast frame and panel structures.

Puri, R.

Puri, R.; Santoro, R. J.; Smyth, K. C.
Oxidation of Soot and Carbon Monoxide in Hydrocarbon Diffusion Flames.
Pennsylvania State Univ., University Park
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 97, 125-144, 1994.

soot; carbon monoxide; diffusion flames; oxidation; particle size; concentration measurement

Quantitative OH concentrations and primary soot particle sizes have been determined in the soot oxidation regions of axisymmetric diffusion flames burning methane, methane/butane, and methane/1-butene in air at atmospheric pressure. The total carbon flow rate was held constant in these flames while the maximum amount of soot varied by a factor of seven along the centerline. Laser-induced fluorescence measurements of OH were placed on an absolute basis by calibration against earlier absorption results. The primary size measurements of the soot particles were made using thermophoretic sampling and transmission electron microscopy. OH concentrations are greatly reduced in the presence of soot particles. Whereas large super-equilibrium ratios are observed in the high-temperature reaction zones in the absence of soot, the OH concentrations approach equilibrium values when the soot loading is high. The diminished OH concentrations are found to arise from reactions with the soot particles and only to a minor degree from lower temperatures due to soot radiation losses. Analysis of the soot oxidation rates computed from the primary particle size profiles as a function of time along the flame centerlines shows that OH is the dominant oxidizer of soot, with O2 making only a small contribution. Higher collision efficiencies of OH reactions with soot particles are found for the flames containing larger soot concentrations at lower temperatures. A comparison of the soot and CO oxidation rates shows that although CO is inherently more reactive than soot, the soot successfully competes with CO for OH and hence suppresses CO oxidation for large soot concentrations.

Putorti, A. D., Jr.

Putorti, A. D., Jr.; Evans, D. D.; Tennyson, E. J.
Ignition of Weathered and Emulsified Oils.
National Institute of Standards and Technology, Gaithersburg, MD
Environment Canada. Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, 17th Proceedings. Volume 1. June 8-10, 1994, Vancouver, British Columbia, Environment Canada, Ottawa, Ontario, 657-667 pp, 1994.

oil spills; in situ combustion; oils; emulsions; experiments; ignition time; thermal radiation; diesel fuels; pool fires

In situ burning of oil spills has been shown to be a rapid means of removing oil from the water surface. Although fresh oil is usually easily ignited, the ability to ignite weathered oils and water-in-oil emulsions is less certain. This paper presents results from laboratory experiments that measure the ignition times for oils and emulsions when heated by thermal radiation. Measurements of thermal radiation for diesel fuel pool fires of various sizes likely to be used for oil spill ignition are combined with the laboratory measurements of ignition times to provide a guide for ignition of weathered and emulsified oils under no wind conditions.

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
FR 3995; 21 p. August 31, 1994.
Available from National Technical Information Services
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.; Ishida, H.; Saito, K.
Upward Flame Spread Along the Vertical Corner Walls. Final Report.
Kentucky Univ., Lexington
NIST-GCR-94-648; 45 p. June 1994.
Available from National Technical Information Services
PB94-206299

corners; flame spread; heat flux; polymethylmethacrylate; pyrolysis; walls

Flame spread behavior and the pyrolysis region spread characteristics along vertical corner walls were studied in detail with an automated infrared imaging temperature measurement technique (IR technique). The technique was recently developed for the measurement of transient pyrolysis temperature on both charring and non-charring materials. Temporal isotherms on PMMA samples were successfully obtained, from which the progress rate of the pyrolysis front was automatically deduced. It was found that the pyrolysis front shape was always M-shaped, i.e., no spread along the corner, and the maximum spread is in a few centimeters away from the corner. Understanding of the mechanism of the M-shape formation is important in developing a prediction model of the spread rate. Four possible mechanisms were identified and flame displacement effects are found to be the principal mechanism. Transient total heat flux distributions above the M-shape pyrolysis peak for a spreading fire were measured. Using these values, it was shown that the upward spread rate is predictable from a simple, one-dimensional, thermal model.

Quintiere, J. G.

Quintiere, J. G.; Cleary, T. G.
Heat Flux From Flames to Vertical Surfaces.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Technology, Vol. 30, No. 2, 209-231, 2nd Quarter 1994.

heat flux; data analysis; heat transfer

Dimensional analysis is used to examine heat transfer from flames to vertical surfaces. Configurations include a line fire against a wall, a square burner flame against a wall and in a corner, and window flames impinging on a wall. Dimensionless parameters that affect flame heat flux include [equation] where x is vertical distance, y is horizontal distance, l is flame length, D is burner dimension, and k is the flame absorption coefficient. Only the effect of these variables is shown. No general correlation is developed, and more data are needed before these results can be applied with confidence.

Quintiere, J. G.; Rhodes, B.
Fire Growth Models for Materials. Final Report. June 1992-December 1993.
Maryland Univ., College Park
NIST-GCR-94-647; 49 p. June 1994.
Available from National Technical Information Services
PB94-195856

fire growth; burning rate; cone calorimeters; fire models; heat flux; ignition; pigments; polymethylmethacrylate; small scale fire tests

Ignition and burning rate data have been developed for thick (25 mm.) black Polycast PMMA in a Cone Calorimeter heating assembly. The objective was to establish a testing protocol that would lead to the prediction of ignition and burning rate from Cone data. This has been done for a thermoplastic like PMMA. For black PMMA we measured ignition temperatures of 250 to 350 C and vaporization temperatures of approximately 325 to 380 C over irradiance levels of 15 to 60 kW/m2. The incident flame heat flux, for irradiation levels of 0 to 75 kW/m2, was found to be approximately 37 kW/m2 for black PMMA. Its constancy has been show due to the geometry of the Cone flame. Also, this flame can be shown to be nearly transparent for Cone irradiance (greater than 90 percent). The heat of gasification of the black PMMA used was found to be approximately 2.8 kJ/g: higher than other values reported for PMMA. This is believed to be due to differences in molecular structure or pigmentation effects and the types of PMMA tested. A burning rate model was demonstrated to yield good accuracy (greater than 80 percent) in comparison to measured transient values.

R

Raufaste, N. J.

Raufaste, N. J.
NIST Building and Fire Research Laboratory Projects Summaries, 1994.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-5; 158 p. June 1994.
Available from Government Printing Office
SN003-003-03273-5
Available from National Technical Information Services
PB94-207495

building technology; building controls; 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 1993, new construction put in place amounted to about $470 billion (7.9% of GDP) and provided about 6 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, during the 12 month period July 1993 through June 1994, the United States experienced significant property losses from natural disasters such as: The Mid-West Floods; the January 1994 Northridge Earthquake; and wind damage to the built environment. These are only three examples; many other natural phenomena 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 1994. The report is arranged by its research programs: structural engineering, materials engineering, mechanical and environmental systems, fire safety and engineering, and fire science. 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.

Raufaste, N. J., Editor
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 26th. May 17-20, 1994, Gaithersburg, MD, 731 pp, 1994.
NIST SP 871; September 1994.
Available from Government Printing Office
SN003-003-03297-2
Available from National Technical Information Services
PB95-147385

accelerograph; bridges (structures); building technology; disaster reduction; earthquakes; geotechnical engineering; ground failures; lifelines; liquefaction; masonry; repair and retrofit; risk assessment; seismic; soils; standards; storm surge; structural engineering; tsunamis; wind loads

This publication is the proceedings of the 26th Joint Meeting of the U. S.-Japan Panel on Wind and Seismic Effects. The meeting was held at the National Institute of Standards and Technology, Gaithersburg, Maryland during May 17-20, 1994. The proceedings include the program, list of members, panel resolutions, task committee reports, and 45 technical papers. The papers were presented under six themes: (I) Wind Engineering, (II) Earthquake Engineering, (III) Storm Surge and Tsunamis, (IV) Joint Cooperative Research Program, (V) Northridge Southern California and Hokkaido Nansei-Oki Earthquakes and (VI) Summaries of Task Committee Workshop Reports (oral presentations only).

Rehm, R. G.

Rehm, R. G.; Forney, G. P.
Pressure Equations in Zone-Fire Modeling.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology, Vol. 14, No. 1/2, 61-73, 1994.

zone models; fire models; pressure; equations

The nonadiabatic nature of low-speed combustion and fire, in which strongly exothermic reactions produce large temperature variations but only mild pressure variations, can cause difficulty when integrating zone models of enclosure fires. Examples of simple zone fire models are examined to illustrate the analytical nature of the problems encountered. These difficulties arise in the solution of the equations for the pressure in general enclosures because the pressure equilibrates much more rapidly than other dynamical variables. Singular perturbation methods and phase plane analyses, together with numerical integration of the nondimensionalized equations, are employed to study the stiff nature of the equations. We conclude that many of the difficulties associated with numerical integration of zone fire models may be circumvented by appropriate analysis of the zone fire model equations.

Rhodes, B. T.

Rhodes, B. T.
Burning Rate and Flame Heat Flux for PMMA in the Cone Calorimeter.
Maryland Univ., College Park

NIST-GCR-95-664; 125 p. December 1994.
Available from National Technical Information Services

cone calorimeters; burning rate; heat flux; polymethylmethacrylate; ignition; experiments; mass loss; heating; thermoplastics; small scale fire tests

Ignition and burning rate data are developed for thick (25 mm.) black Polycast PMMA in a Cone Calorimeter heating assembly. The objective is to establish a testing protocol that will lead to the prediction of ignition and burning rate from Cone data. This is done for a thermoplastic like PMMA. For black PMMA, ignition temperatures of 250 to 350 deg C and vaporization temperatures of approximately 325 to 380 deg C were measured over irradiance levels of 15 to 65 kW/m(2). The incident flame heat flux, for irradiation levels of 0 to 75 kW/m(2), is found to be approximately 37 kW/m(2) for black PMMA. Its constancy is shown due to the geometry of the Cone flame. Also, this flame is shown to be nearly transparent for Cone irradiance (>90%). The heat of gasification of the black PMMA used is found to be approximately 2.8 kJ/g; higher than other values reported for PMMA. This is believed to be due to differences in molecular structure or pigmentation effects and the types of PMMA tested. A burning rate model is demonstrated to yield good accuracy (>80%) in comparison to measured transient values.

Ricker, R. E.

Ricker, R. E.; Stoudt, M. R.; Dante, J. F.; Fink, J. L.; Beauchamp, C. R.; Moffat, T. P.
Corrosion of Metals.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; April 1994.
Available from Government Printing Office
SN003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 7, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 669-728 pp, 1994.

halons; metals; corrosion; experiments; storage; exposure; stress (mechanics); combustion products; alloys

Since a fire suppressant which is corrosive to either the materials used for storage and distribution of the agent or to aircraft materials after deployment would be undersirable, experiments were conducted to assess the relative corrosivity of the potential fire suppressants to different metallic alloys used on aircraft. These experiments were designed to evaluate the propensity of the different agents to cause failure by any of the possible corrosion failure modes during service or after deployment. In addition to these experiments, experiments were conducted to develop an electrochemical technique that would rapidly, and less expensively, evaluate the corrosivity of an agent and the influence of changes in composition, temperature and contaminant levels on the corrosivity of an agent.

S

Sanders, R. E.

Sanders, R. E.; Madrzykowski, D.
Fire Service and Fire Science: A Winning Combination.
Louisville Fire Dept., KY
National Institute of Standards and Technology, Gaithersburg, MD
NFPA Journal, Vol. 88, No. 2, 55-60, March/April 1994.

fire departments; fire science; high rise buildings; fire fighting training; simulation

To test their ability to fight high-rise fires, the Louisville Fire Department had to simulate one. And to do that, they needed the help of the National Institute of Standards and Technology.

Santoro, R. J.

Santoro, R. J.
Fundamental Mechanisms for CO and Soot Formation. Final Report.
Pennsylvania State Univ., University Park
NIST-GCR-94-661; 167 p. November 1994.
Available from National Technical Information Services
PB95-143160

carbon monoxide; diffusion flames; fire research; oxidation; soot

Studies investigating the oxidation of soot and carbon monoxide (CO) have been conducted in a series of laminar diffusion flames. Both overventilated and underventilated conditions have been examined. For the overventilated studies, the production and destruction of CO has been found to be influenced by the amount of soot present in the flame. Measurements of the hydroxyl radical (OHDT) have demonstrated that soot can compete for OHDT when undergoing oxidation and, thus, impede the oxidation of CO to CO2. Absolute concentration measurements for OHDT have shown that superequilibrium values of OHDT are achieved in the upper region of these diffusion flames. In these situations, equilibrium estimates for OHDT are in error, underestimating the OHDT concentration significantly. However, as soot concentration increases to a point where soot is emitted from the flame, rapid reactions between soot particle and OHDT result in concentration levels close to equilibrium values. These results clearly demonstrate that soot particles are far from passive species in flames and can directly affect the chemical pathways involved in the oxidation process through radiative effects on temperature and soot particle reactivity effects on radical concentrations. The CO and smoke yields were observed for underventilated laminar diffusion flames burning methane and ethene for global equivalence ratio over the range 0.5 to 4.0. A Burke-Schumann type burner with fuel in the center tube and air in the annular region was used. The peak CO yields for methane and ethene, 0.37 and 0.47 respectively, are at least a factor of 100 greater than for overventilated burning. The ratio of CO/CO2 versus for the methane flame is compared with local measurements of this ratio for both overventilated and underventilated laminar diffusion flames and with the results for turbulent natural gas flames quenched in an upper layer. The peak smoke yields for methane at a flow rate of 10 cm3/s and for ethene at a fuel flow rate of 6.4 cm3/s are 0.01 and 0.05, respectively, compared to yields of 0. and 0.028 for the overventilated case. The proportionality between smoke yield and CO yield observed for overventilated burning for a wide range of fuels is found not to be valid for the underventilated case. The chemical makeup and structure of the smoke produced at high equivalence ratio is qualitatively different from smoke produced under overventilated conditions; the smoke is mainly organic rather than graphitic and it has an agglutinated structure rather than an agglomerate structure with distinct primary spheres usually observed in overventilated burning.

Schultz, A. E.

Schultz, A. E.
NIST Research Program on the Seismic Resistance of Partially-Grouted Masonry Shear Walls.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5481; 110 p. June 1994.
Available from National Technical Information Services
PB94-219052

masonry; shear walls; bond beam; building technology; cyclic load tests; finite element; horizontal reinforcement; partial grouting; seismic loading

A review of the current status of research on masonry structures at the Building and Fire Research Laboratory of the National Institute of Standards and Technology (NIST) is presented, and an ongoing project on partially-grouted masonry shear walls is summarized. This report draws from previous work conducted at NIST, including a comprehensive literature review (Yancey et al., 1991), simulated seismic load tests of unreinforced masonry walls (Woodward and Rankin, 1983; 1984a; 1984b; 1985a; 1985b) and reinforced masonry walls (Yancey and Scribner, 1989), and numerical analyses employing empirical formulations (Fattal and Todd, 1991; Fattal, 1993a, Fattal, 1993c) and finite element models (Yancey). The previous NIST research culminates with a preliminary draft outlining a research program on partially-grouted masonry shear walls (Fattal, 1993b). This program calls for simulated seismic load experiments of partially-grouted masonry walls, and numerical analyses, both empirical and finite element modeling of shear wall behavior. The existing preliminary draft of the research plan on partially-grouted masonry shear walls is revised in response to recent findings on the cyclic load response of masonry shear walls and to better reflect laboratory requirements for simulated seismic load tests at the NIST tri-directional testing facility (TTF). Specimen configuration, test setup, instrumentation, testing procedure, and numerical modeling are presented, along with a discussion of the shear strength of the specimens calculated using expressions available in the technical literature. The issue of minimum horizontal reinforcement in masonry shear walls is addressed in an appendix, and expressions are derived to serve as a guideline for the experimental program. Potential directions for future research are discussed in a second appendix.

Schultz, A. E.; Magana, R. A.; Tadros, M. K.; Huo, X. M.
Experimental Study of Joint Connections in Precast Concrete Walls.
National Institute of Standards and Technology, Gaithersburg, MD
LEAP Associates International, Inc., Tampa, FL
University of Nebraska-Lincoln, Omaha
Earthquake Engineering Research Institute. U.S. National Conference on Earthquake Engineering, Fifth (5th). Earthquake Awareness and Mitigation Across the Nation Proceedings. Volume 2. July 10-14, 1994, Chicago, IL, 579-587 pp, 1994.

earthquakes; walls; precast concretes; office buildings; connections

A research project is in progress, under the auspices of the U.S.-Japan coordinated PREcast Seismic Structural Systems (PRESSS) program, to investigate the seismic performance of joints between panels in precast concrete shear walls. This study is a component of a larger PRESSS research project at the University of Nebraska-Lincoln which seeks to study the behavior of a six-story precast concrete office building exposed to moderate seismic risk (Tadros et al., 1993; Tadros et. al 1994). Although the focus of the larger study is on structural systems for regions of moderate seismicity, precast shear wall connections for a wider range of seismic applications are targeted here.

Schultz, A. E.; Tadros, M. K.; Huo, X. M.; Magana, R. A.
Seismic Resistance of Vertical Joints in Precast Shear Walls.
National Institute of Standards and Technology, Gaithersburg, MD
University of Nebraska-Lincoln, Omaha
LEAP Associates International, Inc., Tampa, FL
Federation Internationale de la Precontrainte (FIP). Proceedings of the 12th Congress. Volume 1. FIP'94. May 29-June 2, 1994, Washington, DC, E25-E27 pp, 1994.

walls; joints; concretes; connections; seismic resistance; PRESSS; structures; precast; office buildings

A research project is underway, under the auspices of the USA-Japan coordinated PREcast Seismic Structural Systems (PRESSS) program, to investigate the seismic performance of joints between panels in precast concrete shear walls. This study is a component of a larger PRESSS research project at the University of Nebraska-Lincoln which seeks to study the behavior of a six-storey precast concrete office building exposed to moderate seismic risk. Although the focus of the larger study is on structural systems for regions of moderate seismicity, precast shear wall connections for a wider range of seismic applications are targeted here. The objective of the present study is to develop, by means of carefully calibrated experiments, accurate behavioral models and design rules for connections in precast shear walls.

Schultz, A. E.; Welton, S. S.; Rey, L. E.
Sustained Load Effects on the Seismic Performance of Concrete Columns.
National Institute of Standards and Technology, Gaithersburg, MD
Stroud Pence Associates, Virginia Beach, VA
Brown and Root Inc., Houston, TX
Earthquake Engineering Research Institute. U.S. National Conference on Earthquake Engineering, Fifth (5th). Earthquake Awareness and Mitigation Across the Nation Proceedings. Volume 2. July 10-14, 1994, Chiago, IL, 589-597 pp, 1994.

earthquakes; columns; concretes; load effects; beams; shrinkage; cracking (fracturing); reinforced concretes

An integrated experimental and analytical research program is undertaken to define the effects of sustained axial load on the seismic performance of reinforced concrete columns. Thirteen beam-column specimens are subjected to simulated seismic lateral loads after the columns sustain axial load for a predefined duration. The experiments are supplemented by computer analyses that simulate 1) redistribution of compression stress during sustained axial load periods, and 2) nonlinear flexural response to short-term lateral loads. Columns which sustained load for longer durations are observed to develop inclined cracks at earlier stages of the lateral load tests, and this damage led to 1) large decreases in lateral stiffness prior to column hinging, 2) modest decreases in peak strength, and 3) marked reductions in energy absorption.

Serio, M. A.

Serio, M. A.; Bonanno, A. S.; Knight, K. S.; Newman, J. S.
FT-IR Based System for Fire Detection.
Advanced Fuel Research Inc., East Hartford, CT
Factory Mutual Research Corp., Norwood, MA
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 139-140 pp, 1994.

fire research; FT-IR; fire safety

A major advance in fire safety technology during the past two decades is the availability of low cost smoke detectors based on either ionization or photoelectric detectors. However, these detectors have some drawbacks because of the high frequency of false alarms and maintenance problems. Other types of detector technologies have been developed for specific gases, such as CO2, CO, or O2, based on metal oxide semiconductors, electrochemical sensors, or optical sensors.

Shaddix, C. R.

Shaddix, C. R.; Harrington, J. E.; Smyth, K. C.
Enhanced Soot Formation in Flickering CH4/Air Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society (ACS). Reprints of the Fuel Chemistry Division, 1-8 pp, 1994.

soot formation; laminar flames; diffusion flames; extinction; methane; soot

Optical methods are used to examine soot production in a co-flowing, axisymmetric CH4/air diffusion flame in which the fuel flow rate is acoustically forced to create a time-varying flowfield. For a particular forcing condition in which tip clipping occurs (0.75 V loudspeaker excitation), elastic scattering of vertically polarized light from the soot particles increases by nearly an order of magnitude with respect to the observed for a steady flame with the same mean fuel flow rate. Peak soot volume fractions, as measured by time-resolved laser extinction/tomography at 632.8 and 454.4 nm and calibrated laser-induced incandescence (LII), show a factor of 4-5 enhancement in this flickering flame. A Mie analysis suggests that most of the enhanced soot production results from the formation of larger particles in the time-varying flowfield.

Shaddix, C. R.; Harrington, J. E.; Smyth, K. C.
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. 99, 723-732, 1994.
Combustion Institute. Symposium (International) on Combustion, 25th. Proceedings. Abstracts of Symposium Papers. Session 09-F: Soot Formation. July 31-August 5, 1994, Irvine, CA, Combustion Institute, Pittsburgh, PA, 93 pp, 1994.

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

Integrated models of soot production and oxidation are based upon experimental results obtained in steady, laminar flames. For successful application of these descriptions to turbulent combustion, it is instructive to test predictions of soot concentrations against experimental measurements obtained in time-varying flowfields. This paper reports quantitative measurements of the local soot volume fraction in a co-flowing, flickering CH4/air diffusion flame burning at atmospheric pressure. Acoustic forcing of the fuel flow rate is used to phase lock the periodic flame flicker close to the natural flicker frequency. Our measurements show that soot production is four times greater for a forcing condition in which flame tip clipping occurs, compared with a steady flame burning with the same mean fuel flow velocity. The soot field in the flickering flame has been characterized using tomographic reconstruction of extinction data obtained at 632.8 nm, laser-induced incandescence (LII) images calibrated against steady CH4/air extinction results, and vertically polarized scattering data. The LII method is found to track the soot volume fraction closely and to give better signal-to-noise than the extinction measurements in both the steady and time-varying flowfields. A Mie analysis of

these results suggests that the flickering flame exhibits similar number densities but large particle sizes than the corresponding steady flame.

Shaddix, C. R.; Smyth, K. C.
Soot Production in Flickering Methane, Propane, and Ethylene Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 133-134 pp, 1994.

fire research; diffusion flames; soot; methane; propane; ethylene

Diffusion flames originating from gaseous jets, liquid pools, or even solid materials frequently exhibit a periodic flickering behavior, whose effect on the chemical fields within the flame is not understood. In particular, the slow rates of soot particle inception chemistry and of carbon monoxide oxidation might be expected to result in strong sensitivity of soot and CO production to the complex, time-varying flowfields present in flickering flames; this would have important consequences for flame radiation and the emission of smoke and CO.

Shenton, H. W., III

Shenton, H. W., III
Draft Guidelines for Pre-Qualification and Prototype Testing of Seismic Isolation Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5359; 105 p. March 1994.
Available from National Technical Information Services
PB94-161940

base isolation; building technology; seismic isolation; standards; testing

At the present time, at least in the United States, seismic isolation systems are custom designed and built on a per project basis. As a result, testing has become an essential element in the design and construction of isolated structures. Prototype and quality control tests are required by the 1991 Uniform Building Code and the American Association of State Highway and Transportation Officials, 1991 Guide Specifications for Seismic Isolation Design. Currently, however, standards do not exist for conducting these tests. The Building and Fire Research Laboratory of the National Institute of Standards and Technology has developed draft guidelines for testing and evaluation of seismic isolation systems. Presented in the report are guidelines for conducting pre-qualification and prototype tests. Pre-qualification tests are currently not required by the codes but are generally conducted during development of a new system and are aimed at evaluating fundamental properties and characteristics of the isolation system. The guidelines include general requirements of the test facility, instrumentation, calibration, data acquisition, data analysis and reporting of result. A total of twenty three tests are included in the guidelines. Performance criteria have been established for all tests, systems that do not meet or exceed these criteria may not function adequately in service. The guidelines are to serve as a resource document for voluntary standard/specification writing organizations, and for practitioners and researchers involved in the design, manufacture and testing of seismic isolation systems.

Shenton, H. W., III
Draft Guidelines for Quality Control Testing of Elastomeric Seismic Isolation Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5345; 33 p. February 1944.
Available from National Technical Information Services
PB94-161734

quality control; base isolation; building technology; elastomeric; experiments; seismic isolation; standards; tests

Seismic isolation systems designed according to the 1991 "Uniform Building Code", or the 1991 AASHTO "Guide Specification for Seismic Isolation Design" are required to undergo a series of prototype and quality control tests before being installed in the structure. At the present time standards do not exist for conducting these tests and results are subject to unknown variability. The document represents the initiation of the process to develop standards for quality control testing of seismic isolation systems built in the U.S. The guidelines are devoted specifically to quality control testing of elastomeric systems. The guidelines address material and component tests to be conducted during production, and tests on completed isolation units. Nine production tests are specified in the guidelines. Three completed isolation unit tests are outlined: sustained compression, compression stiffness, and effective stiffness and energy dissipation. Complete details of the test set-up, test procedure, data acquisition, analysis and reporting of results are given in the guidelines. Performance criteria are established for all tests, systems that do not meet these criteria may not perform satisfactorily in service and should be set aside for disposition by the engineer of record.

Shenton, H. W., III
Draft Guidelines for Quality Control Testing of Sliding Seismic Isolation Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5371; 33 p. March 1994.
Available from National Technical Information Services
PB94-161957

base isolation; building technology; experiments; seismic isolation; sliding; standards; testing; quality control

Seismic isolation systems designed according to the 1991 Uniform Building Code, or the 1991 AASHTO Guide Specifications for Seismic Isolation Design are required to undergo a series of prototype and quality control tests before being installed in the structure. At the present time, however, standards do not exist for conducting these tests, consequently, results are subject to unknown variability. The document represents the initiation of the process to develop standards for quality control testing of seismic isolation systems built in the U.S. The guidelines are devoted specifically to quality control testing of sliding systems (another report is devoted to quality control testing of elastomeric isolation systems). The guidelines address component part and material tests to be conducted during production, and tests on completed isolation units or components. Production tests are outlined in broad terms for a generic pure sliding device. Two completed isolation unit tests are outlines: sustained compression, and effective stiffness and energy dissipation. Complete details of the test set-up, test procedure, data acquisition, analysis and reporting of results are given in the guidelines. Performance criteria are established for all tests, systems that do not meet these criteria may not perform satisfactorily in service should be set aside for disposition by the engineer or record.

Shenton, H. W., III
Standard Test Procedures for Seismic Isolation Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 871; September 1994.
Available from Government Printing Office
SN003-003-03297-2
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 26th. May 17-20, 1994, Gaithersburg, MD, Raufaste, N. J., Editor, 97-107 pp, 1994.

building codes; tests; standards; base isolation; guidelines; seismic isolation

The Building and Fire Research Laboratory of the National Institute of Standards and Technology is currently engaged in an effort to develop guidelines for testing of seismic isolation systems. A comprehensive set of draft guidelines for testing has been developed and are available for use. The guidelines were developed to be independent of the type of superstructure, and generally independent of the type of isolation system. Three classes of tests are addressed in the guidelines: pre-qualification, prototype and quality control testing. The final guidelines for testing will be developed from the draft guidelines, based on industry feedback of the draft guidelines, and a test program to assess and evaluate the draft guidelines.

Shenton, H. W., III; Cassidy, M. M.; Spellerberg, P. A.; Savage, D. A.
System for Calibration of the Marshall Compaction Hammer.
National Institute of Standards and Technology, Gaithersburg, MD
AASHTO Materials Reference Laboratory, Gaithersburg, MD
NISTIR 5338; FHWA-RD-94-002; 149 p. January 1994.
Available from National Technical Information Services
PB94-145661

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

The Marshall method is used by many state and local highway agencies for the design of hot-mix asphalt pavement. Although the procedure is specified by several industry standards, round-robin programs have confirmed wide variability in Marshall test results. Much of the scatter in the data is attributed to compaction hammer variables, such as: variation in drop weight, drop height, friction, hammer alignment, pedestal support and foundation. With the objective of reducing the variability of Marshall test results, a robust, easy to use and relatively inexpensive test apparatus has been developed for calibration of mechanical Marshall compaction hammers. The system consists of a spring-mass device with force transducer, power supply and data acquisition system. The device replaces the standard specimen mold during calibration. Force time histories from multiple hammer blows are recorded and analyzed to determine average peak force, energy and cumulative impulse. The proposed calibration procedure requires adjusting the number of blows to achieve a "standard" cumulative impulse. A limited laboratory evaluation program has been undertaken to demonstrate the system. The variability of test results for specimens prepared in calibrated machines was reduced by as much as 60%, as measured by the reduction in standard deviation and range of data for 15 specimens. A draft calibration standard has been developed and formatted according to AASHTO standards.

Simiu, E.

Simiu, E.
Chaotic Behavior of Coastal Currents Due to Random Wind Forcing.
National Institute of Standards and Technology, Gaithersburg, MD
Oceanic Engineering Society of the Institute of Electrical and Electronics Engineers, Inc. by the Societe des Electriciens et Electroniciens de France, and by la Communaute Urbaine de Brest. OCEANS 94. Oceans Engineering for Today's Technology and Tomorrow' Preservation. Proceedings. Volume 3. 1994, III/11-16 pp, 1994.

chaotic behavior; wind velocity; coastal currents; wind forcing; analytical models; equations; melnikov approach

Recent analyses revealed that chaotic behavior is possible in a model of currents induced by wind over topography that slopes offshore and varies approximately periodically alongshore. These analyses were based on the assumption that the forcing by wind is harmonic. We examine the more realistic case where the wind field, and therefore the wind forcing, is random. Given a wind field with specified spectral density, and any specified parameters of the bottom topography, we use a generalized Melnikov transform technique to estimate upper bounds for probabilities that chaotic excursions will occur during a specified time interval.

Simiu, E.; Frey, M.
Transitions to Chaos Induced by Additive and Multiplicative Noise.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
Towards the Harnessing of Chaos, Elsevier Science B.V., NY, Yamaguti, M., Editor, 405-408 pp, 1994.

noise (sound); equations; chaos

For a class of multistable systems, deterministic and stochastic chaos are closely related mathematically; a necessary condition for the occurrence of noise-induced chaos with sensitive dependence on initial conditions can be derived from the generalized Melnikov function. Proof that this condition is applicable requires the approximate representation of the noise in the form of a modified Shinozuka process or other uniformly continuous and uniformly bounded processes. Additive and/or multiplicative Gaussian noise with any spectral density can be accommodated, as can other types of noises, including shot noise and non-Gaussian noise. We

review recent results, including a successful verification of our Melnikov-based approach against results based on a solution of the Fokker-Planck equation. We conclude by briefly describing ongoing research.

Sivathanu, Y. R.

Sivathanu, Y. R.; Gore, J. P.
Soot Kinetics/Radiation Interactions in Methane/Air Diffusion Flames.
Purdue Univ., West Lafayette, IN
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 125-126 pp, 1994.

fire research; diffusion flames; soot; kinetics; methane; radiative heat transfer

Radiation heat transfer from flames depends on the instantaneous soot volume fractions and temperatures. The major obstacle to obtaining accurate soot volume fraction predictions in flames is the strong coupling between the finite rate kinetics of soot processes and radiation. Detailed models of soot kinetics cannot be incorporated in turbulent flame studies due to the limitations of computer resources. Therefore, many studies have concentrated on simplified global kinetics models incorporating soot nucleation, growth and oxidation mechanisms. The local temperatures needed for the soot kinetics calculations were obtained using simplified global radiation models. However, in strongly radiating flames it has been shown that the radiation and soot kinetics calculations need to be coupled to accurately predict observed soot volume fractions. The degree of this coupling in weakly radiating flames, where radiation is predominantly from gas species molecules rather than soot, has not been studied. The objective of the present work is evaluate this coupling of radiation and soot kinetics in weakly radiating flames by using the simplified soot kinetics model of Ref. 4 along with a narrow-band radiation model.

Smith, R. L.

Smith, R. L.
Performance Parameters of Fire Detection Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Technology, Vol. 30, No. 3, 326-337, Third Quarter 1994.
NISTIR 5439; 14 p. June 1994.
Available from National Technical Information Services
PB94-194339

fire detection systems; fire research; probability

This report is a formal, functional analysis of fire detection systems' requirements. The performance parameters of fire detection systems are given as conditional probabilities. These parameters are identified by the objective analysis of the functions of a fire detection system. It is demonstrated that using the false alarm rate to specify the malfunctioning of a threshold detection system is inadequate. The principal function of fire detection systems is identified as the notification of anti-fire agents of the probability of an unwanted fire. The evaluation of the information provided by a detector system is central to its worth.

Smith, R. L.
Risk Analysis for the Fire Safety of Airline Passengers.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5441; 37 p. June 1994.
Available from National Technical Information Services
PB94-194065

risk analysis; risk management; probability; decision analysis; artificial intelligence; fire research

The purpose of this report is to describe the National Institute of Standards and Technology's work to date relating to the general methodology being developed for the project Risk Analysis for the Fire Safety of Airline Passengers and the software being used to facilitate this methodology. The approach selected involved the use of influence diagrams. Therefore, a brief discussion of

influence diagrams is given. The status of their application to the water mist system for passenger planes is given and the overall approach to carrying out the project is described. An example is included that shows how the process works, but the case is fictional, not intended to be realistic.

Smith, S. B.

Smith, S. B., Editor
Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994. Gaithersburg, MD.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; 180 p. September 1994.
Available from National Technical Information Services
PB95-104964

fire research; fire suppression; halocarbons; fire hazard; fire risk; fire data; water; pool fires; fire chemistry; combustion physics; combustion; soot; flame spread; fire plumes

The NIST Annual Conference on Fire Research has long been the prime forum for presentation and discussion of the latest advances in the science of fire and the engineering of fire safety. Hundreds of billions of dollars of products and services are involved in fire safety decisions each year. New technology is changing the way those products are developed, manufactured, evaluated, and used. This conference enables all interested parties to hear of and discuss advances in fire science, with the intent of stimulating (a) new products that are more fire-safe and (b) new ways to capture that value in the ways products are tested and approved for use. The conference scope includes all fire research performed within Federal laboratories or sponsored by Federal agencies, as well as work from laboratories around the world.

Smyth, K. C.

Smyth, K. C.
Combustion Metrology: A Manifesto.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Science and Technology, Vol. 98, 341-347, 1994.

combustion; turbulence; decomposition

In the fall of 1985 Jene Golovchenko from Bell Laboratories presented a staff colloquium at the National Bureau of Standards (now NIST) on scanning tunnelling microscopy. This was an exciting time in surface science, since the tunnelling microscope was yielding such fundamentally new insights that the Nobel Prize would soon be awarded for its invention and application. In his seminar Golovchenko made a key point that has stuck with me ever since. His argument went something like this: Investigations of surface processes had been largely empirical and had made little headway before the advent of scanning tunneling microscopy. The field simply could not progress beyond a certain point without a detailed knowledge at the scale of atomic dimensions. Tunnelling microscopy was unleashing a flood of information which was forming the basis of a new surface science.

Snyder, K. A.

Snyder, K. A.; Clifton, J. R.
Measures of Air Void Spacing.
National Institute of Standards and Technology, Gaithersburg, MD
International Conference on Building Materials. Proceedings. September 22-24, 1994, Weimar, Germany, 155-157 pp, 1994.

building technology; air void systems; Attiogbe spacing factor; concretes; freeze-thaw; Philleo spacing factor; Powers spacing factor

Currently in the United States, the standard measure by which to characterize the air void system in hardened concrete is the Powers spacing factor. This parameter attempts to estimate the maximum distance water can travel to reach the nearest air-void before freeze-thaw damage occurs. However, there has been no definitive means to ascertain the accuracy of the spacing factor prediction of any statistical property of the distance water must travel to reach the nearest air void. A computer porgram was written which randomly places non-overlapping spheres, representing air voids, in a cubic cell of cement paste. Points in the paste are chosen at random and the distance to the nearest air void surface is tabulated for each point. Additionally, spheres are chosen

at random and the mimimum distance to the nearest neighbor air void surface is tabulated. Various statistical properties of these spacing distribution functions are compared to the spacing factors of Powers, Philleo, and Attiogbe.

Snyder, K. A.; Clifton, J. R.; Knob, L. I.
Freeze-Thaw Susceptibility of High Performance Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
International Conference on Building Materials. Proceedings. September 22-24, 1994, Weimar, Germany, 139-142 pp, 1994.

building technology; concretes; freeze-thaw; high performance concrete; hydraulic pressure theory; spacing factor

Based upon the physical arguments used by Powers to develop the hydraulic pressure theory for the air-entrainment requirement of concrete, it is reasonable to expect that low water-cement ratio concretes, under certain conditions, may not require air entrainment. Powers' critical spacing of the air voids is proportional to permeability and tensile strength, and inversely proportional to capillary porosity. At early ages the permeability of the paste is large and at later ages the tensile strength is large and the capillary porosity is small. Therefore, the critical spacing should become a minimum at intermediate ages. Results from freeze-thaw tests performed on concretes with water-cement (w/c) ratios of 0.28 and 0.38 with no air-entrainment dindicate an intermediate age when the concrete was most susceptible to freeze-thaw damage. An experiment has been performed in which samples were subjected to freeze-thaw cycling after 3, 7, 14, 28, 56, and 91 days of curing. The specimens of the w/c=0,38 concrete that were cured for 3, 7, 14, and 28 days failed the ASTM C 666 freeze-thaw procedure. Except for the 3-day specimens performing as well as the 56-day specimens. The existence of a pessimum hydration time for the 0.28-w/c concretes can be estimated qualitatively using a simple analysis based upon Powers' hydraulic pressure theory.

Sorensen, C. M.

Sorensen, C. M.
Light Scattering Studies of Fractal Soot Aggregates in Flames.
Kansas State Univ., Manhattan
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 129-130 pp, 1994.

fire research; soot; light scattering; morphology

This paper presents an overview of our work concerning light scattering studies of soot in flames. We have developed static light scattering (SLS) to an ability where a complete in situ characterization of soot cluster morphology can be obtained. The morphological parameters we can measure are soot cluster radius of gyration, fractal dimension, number of monomers per cluster, and monomer radius. We have also developed an SLS technique to measure the width of the size distribution.

Spring, C. B.

Spring, C. B.; Pielert, J. H.; Leigh, S.; Heckert, N. A.
Graphical Analysis of the CCRL Portland Cement Proficiency Sample Database (Samples 1-72).
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5387; 123 p. March 1994.
Available from National Technical Information Services
PB94-196557

cements; construction; standards; test methods; databases; graphics

A large database of Portland cement and Portland cement concrete interlaboratory test results has been generated at the Cement and Concrete Reference Laboratory (CCRL) since 1965. The database represents a rich resource inasmuch as the cements tested were produced by many different production facilities, from raw materials obtained from different geological areas, and over a long period of time. Participation varies from 120 to over 200 laboratories located throughout the United States and in several other

countries. Computer and statistical techniques are used to present the data from the first 72 Portland cement samples in graphical forms to better understand cement and cement testing. Data for each of 10 physical test properties and 11 chemical "compounds" of Portland cement are represented graphically through the use of box plots. For each property and compound, the box plots of data from multiple samples are plotted sequentially as distributed by CCRL and also sorted on median values. In several instances, box plots for one test property are ordered by the median values of another property to analyze possible relationships. Also, the characteristics of each of 72 cements are profiled (graphically) in relation to the population of results of other cements. These box plots and profiles provide insight for modeling cement performance which is the long-term goal of this study.

Steckler, K. D.

Steckler, K. D.; Hamins, A.; Kashiwagi, T.
Model for the Burning of a Horizontal Slab of Wood: Status Report.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 111-112 pp, 1994.

fire research; wood; slabs (members); burning rate; char; combustion; vapor phases; solid phases

We are in the process of developing a burning-rate model for char-forming materials. Currently, the combustion of a horizontal slab of wood, exposed to an external radiant source, is being modeled in terms of two coupled sub-models which simulate gas and solid (condensed) phase processes. Although there are still problems with the solid-phase model, the results to date are encouraging.

Stutzman, P. E.

Stutzman, P. E.
Quantitative X-Ray Powder Diffraction Methods for Clinker and Cement.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5403; 18 p. May 1994.
Available from National Technical Information Services

building technology; cements; clinker; phase abundance; x-ray powder diffraction; sample preparation

Performance of concrete is influenced by the portland cement phase composition. Phase abundance determination has traditionally been accomplished using two different methods; optical microscopy, and a Bogue calculation based on a chemical analysis. However, optical microscopy is an arduous method for routine clinker evaluation. Phase compositions by Bogue calculation are often in error because of necessary assumptions of the true compositions of the cement phases. X-ray powder diffraction is a direct, bulk analytical method for phase analysis of fine-grained materials including clinker and cements. Each phase produces a unique diffraction pattern independently of the others with each pattern intensity being proportional to phase concentration. Difficulties in X-ray powder diffraction analysis include correction for sample absorption, selection of reference standards, and determination of individual pattern intensity. These problems are minimized by use of an internal standard, profile fitting, and careful reference standard selection. The availability of computers has revitalized interest in quantitative powder diffraction analysis by facilitating profile fitting for diffraction peak intensity measurement and whole pattern-fitting methods where the entire diffraction pattern, compared to discrete peaks, is used in the analysis.

Stutzman, P. E.; Clifton, J. R.
Diagnosis of Causes of Concrete Deterioration in the MLP-7A Parking Garage.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5492; 17 p. June 1994.
Available from National Technical Information Services

PB95-143095

alkali-silica reaction; building technology; concretes; cracking; deterioration; expansion; petrography; water repellents

Parking garage MLP-7A at the National Institutes of Health (NIH) is a four-level, cast-in-place concrete structure, approximately seventeen years of age which is exhibiting expansion and cracking of the parapet walls. Field inspection, petrographic analysis of concrete cores and laboratory testing are being used to identify the processes responsible for expansion and cracking of the concrete, to determine the potential for additional expansion, and to evaluate the abilities of several commercially available water repellents applied to the concrete surface to reduce water infiltration. Evidence of alkali-silica reaction was observed in core samples extracted from the parapet walls, an inside wall from the lower level, and in the upper deck as one or more of the following; crack-filling, void-filling, or aggregate-rimming reaction gel. The quantity of reaction gel is greatest in cores removed from the upper, more exposed portions of the structure. The non-uniform distribution of entrained air voids observed in some of the cores is a result of their infilling due to precipitation of calcium hydroxide, ettringite, and gypsum and may result in poor freeze-thaw resistance. An accelerated expansion test of aggregate extracted from the structure indicates that the aggregate is reactive and that there is a potential for further expansion. The performance of water repellant treatments were evaluated in field studies on the garage structure. Each repellant treatment reduced water infiltration relative to an untreated test region however, some treatments performed better in regions with visible, fine surface cracks.

Suuberg, E. M.

Suuberg, E. M.; Milosavljevic, I.; Lilly, W. D.
Behavior of Charring Materials in Simulated Fire Environments.
Final Project Report. 1990-1992.
Brown Univ., Providence, RI
NIST-GCR-94-645; 651 p. June 1994.
Available from National Technical Information Services
PB94-196045

char; cellulose; cellulosic materials; char depth; fire research; model studies; pyrolysis

The focus of this study was the behavior of thick charring solids in fire situations. Clearly one of the most important parameters governing the fire phenomenon is the rate of release of combustible volatiles into the gas phase, in which they actually burn. Over the years, fire researchers have learned how to model the processes in the gas phase, so that the rate of heat feedback to the solid surface can be reasonably well predicted. Likewise, there exists the ability to model the heat transfer processes at the solid surface and within the solid itself. Finally, there is a large literature on the laboratory-scale pyrolysis of various charring polymers. It might appear that predicting the course of the fire would involve carefully coupling these different models together. There have unfortunately not been any successful demonstrations of the ability to do this, though in broad stroke, some models capture the key features of the processes. This study was concerned with the possibility that the inability to come to complete closure on the charring polymer fire problem might derive from difficulties in applying laboratory scale kinetics to actual fire conditions. Specifically, we were concerned about how well small scale laboratory experiments used to derive the kinetics of pyrolysis could be used to predict the behavior of charring solids in fire situations.

T

Tadros, M. K.

Tadros, M. K.; Einea, A.; Low, S. G.; Magana, R. A.; Schultz, A. E.
Seismic Behavior of a Six-Story Precast Office Building.
University of Nebraska-Lincoln, Omaha
LEAP Associates International, Inc., Tampa, FL
National Institute of Standards and Technology, Gaithersburg, MD
Federation Internationale de la Precontrainte (FIP). Proceedings of the 12th Congress. Volume 1. FIP'94. May 29-June 2, 1994, Washington, DC, E16-E22 pp, 1994.

office buildings; high rise buildings; concretes; gravity load; shear walls; structural analysis; structural member design; connections; beams; columns

As a part of the USA-Japan cordinated PREcast Seismic Structural Systems (PRESS) program, a research project is underway to investigate the behavior of a six-storey precast concrete office building under moderate seismicity. The structure is designed as a 'building frame system' in which the gravity loads are supported by a frame and lateral forces are resisted by shear walls. The gravity load resisting system consists of hollow core planks, prestressed wide and shallow beams, and columns. Shear wall and cruciform panels are the main lateral load resisting elements. Because current building codes in the United States do not address seismic design of precast concrete buildings specifically, a design process for the building system is developed to identify areas where research is needed.

Tanner, A. B.

Tanner, A. B.
Measurement and Determination of Radon Source Potential: A Literature Review.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5399; 196 p. April 1994.
Available from National Technical Information Services
PB94-165602

building technology; diffusion; indoor radon; permeability; predictive methods; pressure-driven flow; radium activity concentration; radon availability; radon potential mapping; site-specific characterization; soil testing

Radon source potential may be estimated for areas of a nation, state, county, housing development, or building lot. The critical characteristics of the soil are its radium concentration, emanation coefficient, permeability to gas, and diffusion coefficient for radon under typical conditions. Best estimates of these critical characteristics are applied to a scheme for obtaining a tiered ranking of subareas of the area of interest (radon potential mapping), or to a model for obtaining a single qualitative or quantitative estimate of the radon source potential of a single site (site-specific characterization). This report summarizes and evaluates available information on radon potential mapping and site-specific characterization. More than 100 reports have been found that bear on radon potential mapping, and indicate fair to good agreement with indoor radon results where correlations have been possible. Because site-specific characterization is not generally cost effective, it has not been extensively tested; however, it can readily discriminate the order of magnitude of indoor radon concentration to be expected in the absence of special measures to prevent radon infiltration. Several situations are proposed as being appropriate for its use.

Thompson, S. L.

Thompson, S. L.; Apostolakis, G. E.
Response Surface Approximation for the Bench-Scale Peak Heat Release Rate From Upholstered Furniture Exposed to a Radiant Heat Source.
California Univ., Los Angeles
Fire Safety Journal, Vol. 22, No. 1, 1-24, 1994.

upholstered furniture; heat sources; heat release rate; flame spread; scenarios; small scale fire tests

This work investigates the initial stages of a residential fire scenario: specifically the peak heat release rate from an item ignited by exposure to a radiant heat source. Parameters which may define a scenario include the material properties of the furniture and the ignition source. The emphasis is on the uncertainties in these parameters and their impact on the peak heat release rate. A response surface analysis is performed to determine the equivalent bench-scale heat release as a function of fabric, padding, oxygen concentration, and imposed radiant heat flux. A response surface is a polynomial which approximates the computer code and it may be used to predict heat release values, as well as the uncertainties in these values due to uncertainties in the model input variables.

Tinker, S.

Tinker, S.; diMarzo, M.
Water Droplet Evaporation from Radiantly Heated Solids. Final Report. September 1992-May 1994.

Maryland Univ., College Park
NIST-GCR-95-665; 158 p. December 1994.
Available from National Technical Information Services

industrial plants; cooling; drop sizes; droplets; evaporation; fire research; solid surfaces; sprinkler systems; water sprays

A model describing the configuration of a water droplet evaporating on the surface of a radiantly heated semi-infinite solid is developed. A shape factor and the solid-liquid-vapor contact angle describe the transient droplet shape, though the initial value of the latter parameter is found to have a negligible effect on the droplet's evaporation. The droplet shape model and a modified radiation heat term are incorporated into a previously developed computer model to predict the evaporation of a single droplet on a semi-infinite solid subjected to radiant heat input. The code predicts transient temperature profiles that agree well with experiment. A simplified, closed-form solution for the prediction of surface temperatures in the vicinity of an evaporating droplet is used to fit the data produced by the single droplet model. This closed-form solution facilitates calculations used in a model for the cooling of a surface by the evaporation of a sparse spray of water. The previously collected data base for sparse spray cooling using degassed water is expanded with a new set of experiments using water containing dissolved gases.

Todd, D. R.

Todd, D. R.
Seismic Safety of Federal Buildings - Initial Program: How Much Will It Cost?
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5419; 30 p. April 1994.
Available from National Technical Information Services
PB95-182291

seismic safety; federal buildings; costs; standards

This paper provides information on the approximate cost impacts that would arise from implementing an initial program aimed at laying the foundation for achieving the long-term goal of seismic safety in all Federal buildings. The initial program is set forth in a proposed Executive Order titled "Seismic Safety of Existing Federally Owned or Leased Buildings." Information from documents published by the General Accounting Office, Federal Emergency Management Agency, and the National Institute of Standards and Technology were combined with self-reported seismic evaluation and rehabilitation experiences by agencies that have ongoing programs to develop an estimate of the cost of implementation. The proposed order adopts "Standards of Seismic Safety for Existing Federally Owned or Leased Buildings" as the minimum level for Federal use, and makes mandatory seismic evaluation and, if necessary, rehabilitation under certain conditions, which are identified in the Standards. It is estimated that this requirement would result in about $5.3 million per year in recurring annual costs, spread across all agencies of the Federal government, to evaluate and seismically rehabilitate buildings that would not otherwise be addressed. The proposed Executive Order also directs all Federal departments and agencies to, within four years of signing, develop an inventory of their owned and leased buildings, and to estimate the cost of mitigating unacceptable seismic risks in their buildings. Costs to develop the required inventory and cost estimate are expected to be about $116 million, spread across all Federal agencies and over six years.

Todd, D. R.
Standards of Seismic Safety for Existing Federally Owned and Leased Buildings and Commentary.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5382; 137 p. February 1994.
Available from National Technical Information Services
PB95-130209

standards; safety; building construction; evaluation; mitigation; life safety

These seismic evaluation and mitigation standards, "Standards of Seismic Safety for Existing Federally Owned Or Leased Buildings and Commentary," were developed for use by the Federal government by the Interagency Committee on Seismic Safety in Construction (ICSSC) in conjunction with the National Institute of Standards and Technology (NIST). The project was funded by the Federal Emergency Management Agency (FEMA). The intent of this document is to provide Federal agencies with minimum standards for the evaluation and mitigation of seismic hazards in their building inventories. Substantial Life-Safety is defined as

the minimum acceptable performance objective for Federal buildings. FEMA 178, the "NEHRP Handbook for the Seismic Evaluation of Existing Buildings," is taken to be the primary basis for defining this life-safety goal. Four compliance categories are established: structural, nonstructural, geologic/site, and adjacency. Situations which require that an evaluation and if necessary, mitigation, be performed are identified. These Standards and Commentary include: an identification of situations which trigger application of the Standards, preliminary and detailed evaluation standards, mitigation standards, and advisory standards for achieving performance objectives beyond Substantial Life-Safety.

Todd, D. R.; Anderson, E.; Carino, N. J.; Cheok, G. S.; Chung, R. M.; Gross, J. L.; Phan, L. T.; Schultz, A. E.; Shenton, H. W., III; Taylor, A. W.; Yancey, C. W. C.
Performance of HUD-Affiliated Properties During the January 17, 1994 Northridge Earthquake.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5488; 66 p. August 1994.
Available from National Technical Information Services
PB95-174488

earthquakes; building collapse; damage; methodology; construction; disasters; residential buildings

The magnitude 6.8 January 17, 1994 Northridge Earthquake was centered under the densely populated San Fernando Valley northeast of Los Angeles, California. At the request of the Department of Housing and Urban Development (HUD), the Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST) conducted field observations of multi-family residences three stories or more in height in the affected area for the purposes of identifying common damage states in residential construction. Sixty-nine HUD-affiliated sites, totalling 425 buildings and over 10,000 living units, were visually examined from the exterior and interior. Buildings were selected for observation based on distance from the epicenter and amount of damage. Examinations were documented on a data collection form and with photographs. By collecting information primarily on damaged buildings, it was possible to identify typical types and degrees of damage to residential buildings. Only a few HUD-affiliated buildings were severely damaged. By and large the damage observed was minor and cosmetic, consisting largely of cracks to interior and exterior wall surfaces. Nevertheless, this type of nonstructural damage will be costly to repair. Documentation of the costs of repairing Northridge earthquake damage would greatly expand the existing body of knowledge on this subject. The damage observations suggest that further studies of the social and economic costs of earthquake damage are needed, along with studies of the costs and benefits of more stringent seismic design and construction requirements. These studies would illuminate many of the issues surrounding the current debate over whether seismic requirements for new and renovated construction should be upgraded to mandate property protection as well as protection of human life.

Todd, D. R.; Carino, N. J.; Chung, R. M.; Lew, H. S.; Taylor, A. W.; Walton, W. D.
1994 Northridge Earthquake: Performance of Structures, Lifelines and Fire Protection Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5396; 175 p. March 1994.
Available from National Technical Information Services
PB94-161114

earthquakes; bridges (structures); building technology; building fires; lifelines; overpasses; seismic

A magnitude 6.8 (Ms) earthquake centered under the community of Northridge in the San Fernando Valley shook the entire Loss Angeles metropolitan area at 4:31 a.m. local time on Monday, January 17, 1994. Moderate damage to the built environment was widespread; severe damage included collapsed buildings and highway overpasses. A total of 58 deaths were attributed to the earthquake by the Los Angeles Coroner. About 1,500 people were admitted to hospitals with major injuries; another 16,000 or so were treated and released. Estimates of the number of people temporarily or permanently displaced because of damage to their houses or apartments ranged from 80,000 to 125,000. Estimates indicate that this will be the United States' most costly natural disaster ever. A multi-agency team, organized under the auspices of the Interagency Committee on Seismic Safety in Construction and headed by the National Institute of Standards and Technology, arrived at the earthquake site within days of the event to document the effects of the earthquake. The team focused on the effects to the built environment, with the goal of capturing perishable data and quickly identifying situations deserving in-depth study. This report includes a summary of the team's observations. While most structural damage occurred in buildings and bridges of construction type and vintage known to be vulnerable to earthquake shaking, there were some unexpected failures. Notable among these were the collapses of relatively modern

parking structures and a bridge that appeared to be adequate by today's standards. Recommendations are made for further studies of the Northridge earthquake that can lead to improved mitigation of earthquake effects. [SEE ALSO: NIST SP 862]

Todd, D. R.; Carino, N. J.; Chung, R. M.; Lew, H. S.; Taylor, A. W.; Walton, W. D.; Cooper, J. D.; Nimis, R.
1994 Northridge Earthquake: Performance of Structures, Lifelines and Fire Protection Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 862; 186 p. May 1994.
Available from Government Printing Office
SN003-003-03264-6
Available from National Technical Information Services
PB94-207461

earthquakes; bridges (structures); building technology; building fires; lifelines; overpasses; seismic

A magnitude 6.8 (Ms) earthquake centered under the community of Northridge in the San Fernando Valley shook the entire Los Angeles metropolitan area at 4:31 a.m. local time on Monday, January 17, 1994. Moderate damage to the built environment was widespread; severe damage included collapsed buildings and highway overpasses. A total of 58 deaths were attributed to the earthquake by the Los Angeles Coroner. About 1,500 people were admitted to hospitals with major injuries; another 16,000 or so were treated and released. Estimates of the number of people temporarily or permanently displaced because of damage to their houses or apartments ranged from 80,000 to 125,000. Estimates indicate that this will be the United States' most costly natural disaster ever. A multi-agency team, organized under the auspices of the Interagency Committee on Seismic Safety in Construction and headed by the National Institute of Standards and Technology, arrived at the earthquake site within days of the event to document the effects of the earthquake. The team focused on the effects to the built environment, with the goal of capturing perishable data and quickly identifying situations deserving in-depth study. This report includes a summary of the team's observations. While most structural damage occurred in buildings and bridges of construction type and vintage known to be vulnerable to earthquake shaking, there were some unexpected failures. Notable among these were the collapses of relatively modern parking structures and a bridge that appeared to be adequate by today's standards. Recommendations are made for further studies of the Northridge earthquake that can lead to improved mitigation of earthquake effects. [SEE ALSO: NISTIR 5396]

Tolocka, M. P.

Tolocka, M. P.; Miller, J. H.
Measurement of Soot Oxidation in Post Flame Gases.
George Washington Univ., Washington, DC
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 135-136 pp, 1994.

fire research; soot; oxidation

In fires, the concentrations of soot and carbon monoxide are found to be strongly correlated and a significant fraction of the CO emitted from fires is believed to originate from soot particle oxidation. There have been a number of studies of particle oxidation within flames and in shock tubes, but little work on post-flame oxidation. We recently initiated a study of the transformation of post-flame smoke with an emphasis on the chemical transformation of surface-adsorbed polynuclear aromatic hydrocarbons and the subsequent formation of gas phase molecular oxidation products.

Trelles, J.

Trelles, J.; Pagni, P. J.
Practical Scheme for Calculating the Fire-Induced Winds in the October 20, 1991 Oakland Hills Fire.
California Univ., Berkeley

U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 297-305 pp, 1994.

fire safety; fire research; wind effects; wind direction; wind velocity; equations; expansion; vorticity

This research is based on the model developed by Howard Baum and Bernard McCaffrey. As a first step, a consistent set of characteristic scales are chosen to nondimensionalize all physical parameters and variables. The greatest advantage obtained by the following choice of nondimensionalization is that, once one has solved for the flow field induced by a single fire, the field produced by a series of fires is given by physically scaling each fire and then vectorially adding all the influences at a point. The nominal heat release, the ambient density, the ambient temperature, the specific heat, and the acceleration of gravity, are used to determine characteristic quantities, which are subscripted with a "c". The expressions for the characteristic length, velocity, vorticity, potential, and Stokes stream function, are given in Eq. (1). All the subsequent nondimensional quantities - superscripted with an asterisk - are obtained by dividing the dimensional quantity by the characteristic quantity.

V

Vandsburger, U.

Vandsburger, U.; Lattimer, B. Y.; Roby, R. J.
Compartment Fire Combustion Dynamics. Annual Report. September 1, 1993-September 1, 1994.
Virginia Polytechnic Institute and State University, Blacksburg, VA
Hughes Associates, Wheaton, MD
NIST-GCR-95-666; 54 p. December 1994.
Available from National Technical Information Services

compartment fires; combustion gases; carbon monoxide; ceilings; corridors; fire research; soffits; soot; toxic gases; wood

The overall scope of this research is to investigate the phenomena that control the generation and oxidation of 140 compartment fire exhaust gases (particularly carbon monoxide, CO) which are transported down an adjacent corridor. Results of the first two years of the project are summarized. During the past year three hallway soffit combinations were investigated in order to characterize the effects of varying the fluid mechanics on the burnout behavior of combustion gases. The findings show that the addition of a soffit at the fire enclosure end of the corridor increased the degree of burnout, while adding a soffit at the exit of the corridor decreased the degree of oxidation. Soffits at both ends yielded an intermediate result. Varying the size of the opening into the corridor had no effects on the results. A set of experiments are also summarized in which fires were burned in an enclosure having a wood ceiling. This resulted in the generation of very high concentrations of CO in agreement with the findings of Pitts et al.

Vazquez, I.

Vazquez, I.; Boyer, C.; Breuel, B. D.; Weber, L.; Huber, M.; Yang, J. C.
Measurements of Some Thermodynamic Properties of Alternative Agent/Nitrogen Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
National Institute of Standards and Technology, Boulder, CO
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 13-14 pp, 1994.

fire research; nitrogen; thermodynamic properties; nacelle fires

This study is a continuation of a U.S. Air Force/Navy/Army and FAA sponsored program, currently being conducted at NIST, to further evaluate some thermodynamic properties of the four selected alternative agents for in-flight aircraft fire protection in both dry bays and engine nacelles. The four selected agents are HFC-227ea, CF3I, FC-218, and HFC-125.

Vazquez, I.; Grosshandler, W. L.; Rinkinen, W. J.; Glover, M. P.; Presser, C.
Suppression of Elevated Temperature Hydraulic Fluid and JP-8 Spray Flames.
National Institute of Standards and Technology, Gaithersburg, MD
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 1255-1265 pp, 1994.

fire research; fire safety; fire science; hydraulic fluids; fire suppression; temperature; JP-8 jet fuel; aircraft engines; aircraft fires; halon 1301; turbulent combustion

A coaxial turbulent spray burner was used to determine the suppression characteristics of twelve different fire fighting agents in elevated temperature hydraulic fluid and jet fuel (JP-8) spray flames. The effectiveness of the gaseous agents, being considered as alternatives to halon 1301, was compared based upon the mass required for suppression and the equivalent storage volume, normalized by the amount of halon 1301 required to suppress the flame. The elevated temperature results were compared to measurements previously obtained with the incoming air and JP-8 at ambient temperature. No statistically significant difference in relative agent performance was found between the heated hydraulic flame and the previous JP-8 experiments. There was a trend toward higher agent concentrations when the fuel was JP-8 and the temperature of the incoming reactants was 150 deg C. In all three experiments, the halon 1301 required the least mass to extinguish the flame, followed by nitrogen. The rest of the alternative fluorinated agents considered required between 1.2 and 2.4 times more mass to suppress the various flames.

W

Walton, G. N.

Walton, G. N.
CONTAM93: User Manual.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5385; 77 p. March 1994.
Available from National Technical Information Services
PB94-164381

computer programs; manuals; air movement; air quality; multizone buildings

This manual describes the use of two computer programs for analyzing the air movement and indoor air quality in multizone buildings. The first program CONTAM is used to create and edit the building description including data for all features relating to airflow or to the generation and removal of contaminants. It uses a graphic interface to establish the spatial relationship of these features. These data along with weather data are used by the program CONTAMX to calculate the airflows and dynamic levels of indoor contaminants. The results of the calculation may be reviewed graphically in CONTAM and printable files may be generated. Together these two programs are called CONTAM93.

Walton, G. N.; Emmerich, S. J.
CONTAM93: A Multizone Airflow and Contaminant Dispersal Model With a Graphic User Interface.
National Institute of Standards and Technology, Gaithersburg, MD
Air Infiltration Review, Vol. 16, No. 1, 6-8, December 1994.

computer programs; air flow; air movement; graphic interface

A new multizone airflow and contaminant dispersal program CONTAM93 is described. While this program is based on existing theory of network airflow analysis and contaminant dispersal, it employs a unique graphic interface for data input and display. The interface uses a sketchpad to describe the connections between zones and icons to represent zones, openings, ventilation system components, and contaminant sources and sinks. The program, its graphic interface and plans for its further development are described.

Walton, W. D.

Walton, W. D.; McElroy, J.; Twilley, W. H.; Hiltabrand, R. R.
Smoke Measurements Using a Helicopter Transported Sampling Package.
National Institute of Standards and Technology, Gaithersburg, MD
Coast Guard, Groton, CT
Environment Canada. Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, 17th Proceedings. Volume 1. June 8-10, 1994, Vancouver, British Columbia, 735-764 pp, 1994.

oil spills; in situ combustion; smoke measurement; helicopters; sampling; instruments; experiments; burning rate; smoke yield; particle size distribution; polycyclic aromatic hydrocarbons

A first generation smoke sampling package designed to be deployed on a helicopter winch cable has been developed. The package contains three sampling pumps which are operated via radio control from the helicopter. The pumps can be fitted with a variety of sampling trains and gas collection bags. The package also contains instruments for measuring and recording temperature, relative humidity, barometric pressure, wind speed, and package orientation. The package was tested using a Coast Guard HH-65A helicopter for aerodynamic stability without a fire and was then used to collect smoke samples from two 231 m2 diesel fuel fires at the U.S. Coast Guard Fire and Safety Test Detachment in Mobile, Alabama. An improved smoke sampling package designed to be suspended beneath a tethered helium filled miniblimp was also developed and used to collect samples from a 37 m2 diesel fuel fire. The burning rate for diesel fuel on water as indicated by the surface regression rate was found to be 0.074 + 0.001 mm/s. Smoke particle yields ranged from 9 to 14% of the mass of fuel burned. PAH concentrations on the smoke particle were measured. The cumulative size distribution of aerodynamic effective diameters for the diesel fuel smoke particulate were found to be similar to those previously measured for crude oil.

Walton, W. D.; Twilley, W. H.; McElroy, J.; Evans, D. D.; Tennyson, E. J.
Smoke Measurements Using a Tethered Miniblimp at the Newfoundland Offshore Oil Burn Experiment.
National Institute of Standards and Technology, Gaithersburg, MD
Minerals Management Service, Herndon, VA
Environment Canada. Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, 17th Proceedings. Volume 2. June 8-10, 1994, Vancouver, British Columbia, Environment Canada, Ottawa, Ontario, 1083-1098 pp, 1994.

oil spills; smoke measurement; experiments; sampling; smoke yield; particle size distribution; in situ combustion

Smoke measurements were taken during the 1993 Newfoundland Offshore Oil Burn Experiment using a helium filled miniblimp tethered to a vessel operated approximately 300 m downwind of the fire. The smoke sampling package suspended from the miniblimp consisted of sampling pumps which drew smoke through either a cascade impactor or filter and discharged gas samples into collection bags. The smoke yield and smoke particle size distribution were found to be similar to previous measurements made for crude oil. The smoke yields of 14.8 to 15.5% of the mass of the fuel burned were measured and 83% of the particulate mass was below 9.8 mum in diameter as measured with a cascade impactor. Measurements of temperature, wind speed, and wind direction taken before and after the burns from the ocean surface to an altitude of 300 m using the tethered miniblimp and a radio telemetry weather station are reported.

White, G.

White, G.; Tinker, S.; diMarzo, M.
Modelling of Dropwise Evaporative Cooling on a Semi-Infinite Solid Subjected to Radiant Heat Input.
Maryland Univ., College Park
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Eitor, 217-228 pp, 1994.

fire research; fire safety; fire science; solids; cooling; evaporation; formulations; validation

A model for the prediction of dropwise evaporative cooling over hot solid surfaces is proposed for the case of radiant heat input. A detailed representation of the droplet shape during the transient is provided. The direct radiant contribution to the evaporative process is expressed as a liquid-vapor interfacial term and a constant heat absorption term within the liquid layer. The liquid layer is treated with a one-dimensional heat conduction approximation justified by previous results and three sub-models are used to describe it during the transient. A boundary element method for the solid thermal behavior, previously developed, is extended to this case. The results obtained from a closed-form solution, with simplified solid-liquid interfacial boundary conditions, are also included. Comparisons with the experimental data illustrate the adequacy of the model and the performance of the closed-form solution.

White, G.; Tinker, S.; diMarzo, M.
Transient Cooling of a Hot Surface by Droplets Evaporation. Final Report. September 1992-August 1993.
Maryland Univ., College Park
NIST-GCR-94-662; 177 p. November 1994.
Available from National Technical Information Services
PB95-143194

computer programs; droplets; evaporation; fire research; steady state; water

A computer code is developed and tested which simulates the transient evaporation of a single liquid droplet from the surface of a semi-infinite solid subject to radiant heat input from above. For relatively low temperature incident radiation, it is shown that the direct absorption of radiant energy by the droplet can be treated as purely boundary conditions, while a model for higher temperature incident radiation would require the addition of constant heat source terms. The heat equation is numerically coupled between the liquid and solid domains by using a predictor-corrector scheme. Three one-dimensional solution schemes are used within the droplet: a start-up semi-infinite medium solution, a tridiagonal Crank-Nicholson transient solution, and a steady-state solution. The solid surface temperatures at each time step are calculated through careful numerical integration of an axisymmetric Green's functions solution equation with the forcing function given by the past lower droplet surface and solid-vapor boundary heat fluxes. The time step is increased after a sensitive initial period to allow for reasonable run times. Two geometry models are included which give the droplet height as a function of current droplet volume and initial wetted radius; the second allows inclusion of the effects of initial contact angle and receding angle. Using water as the liquid and Macor, a low-thermal conductivity material, as the solid, the program output was compared to the experimental results in this line of research. They correlate well to the experiments in which the critical geometric shape factor and evaporation time were most easily measured.

Winslow, D. N.

Winslow, D. N.; Cohen, M. D.; Bentz, D. P.; Snyder, K. A.; Garboczi, E. J.
Percolation and Pore Structure in Mortars and Concrete.
Purdue Univ., West Lafayette, IN
National Institute of Standards and Technology, Gaithersburg, MD
Cement and Concrete Research, Vol. 24, 25-37, 1994.

mortar; concretes; percolation; pore structure; interfacial zone pores

The cement paste in concrete and mortar has been shown to have a pore size distribution different than that of plain paste hydrated without aggregate. For mortar and concrete, additional porosity occurs in pore sizes larger than the plain paste's threshold diameter as measured by mercury intrusion. Based on the assumption that these larger pores are essentially present only in the interfacial zones surrounding each aggregate, an experimental program was designed in which the volume fraction of sand in a mortar was varied in a systematic fashion and the resultant pore system probed using mercury intrusion porosimetry. The intrusion characteristics were observed to change drastically at a critical sand content. Similar results are observed for a series of mortar specimens in which the cement paste contains 10% silica fume. To better interpret the experimental results, a hard core/soft shell computer model has been developed to examine the percolation characteristics of these interfacial zone pores. Using the model, interfacial zone percolation in concretes is also examined. Finally, the implications of interfacial zone percolation for transport properties and durability of mortar and concrete are discussed.

Womeldorf, C. A.

Womeldorf, C. A.; Yang, J. C.; Grosshandler, W. L.
Halon 1301 Surrogates for Engine Nacelle Fire Suppression System Certification.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 9-10 pp, 1994.

fire research; halon 1301; nacelle fires; fire suppression; certification; aircraft engines

Until recently halon 1301 has been regularly discharged in Navy aircraft engine nacelles to certify that the fire suppression systems distribute the fire suppressant effectively. Halon 1301 can no longer be used in this manner because of its high ozone depletion potential. In order to continue to certify the fire suppression systems of Navy aircraft a surrogate for halon 1301 must be found. Ideally, this stimulant will have the physical and dynamical properties that will allow it to mimic halon 1301 in discharge behavior in any aircraft fire suppression system. This work presents the significant parameters relevant to agent discharge in an engine nacelle, as well as a discussion of the procedure and preliminary results of our search for a halon 1301 simulant.

Wright, R. N.

Wright, R. N.
Constructed Civil Infrastructure Systems R&D: A European Perspective. Appendix A: United Kingdom. Appendix B: Sweden.
National Institute of Standards and Technology, Gaithersburg, MD
CERF Report 94-5010; 29 p. 1994.

construction; industries; Western Europe; advanced technologies; bridges (structures); buildings; CCIT; government

This report documents the major findings gathered during a one-week task force trip to western Europe during June of 1993. The task force trip was organized by the Civil Engineering Research Foundation (CERF) in coordination with the National Science Foundation (NSF), which co-funded the study with CERF. Additional funding was provided by the Federal Highway Administration, the U.S. Army Corps of Engineers, and the U.S. Air Force. During the trip to Europe that is documented in this report, a team of 28 leaders from the construction industry, government, and academia visited six countries, observed a variety of laboratories and construction sites, and met with many private and public sector representatives to gain an understanding of constructed civil infrastructure systems R&D in western Europe.

Wright, R. N.
Public/Private Collaboration in Development and Implementation of Risk Reduction Practices.
National Institute of Standards and Technology, Gaithersburg, MD
Insurance Institute for Property Loss Reduction. Evaluating
Risks and Mitigating Losses: New Opportunities and New Challenges. Proceedings. Congress on Natural Disaster Loss Reduction, First (1st) Annual. June 17, 1994, Boston, MA, 15-19 pp, 1994.

risks; disasters; risk reduction; construction; building construction; private sector; public sector

Natural hazards (earthquakes, severe storms, etc.) are inevitable extreme environments, but natural disasters are not inevitable. Disasters occur when people are directly exposed to extreme environments or when constructed facilities fail to shelter and support human activities. Disasters can be prevented by preparing constructed facilities to resist extreme environments, or when the environments are predictable, removing persons from the areas affected.

Wright, R. N.; Rosenfeld, A. H.; Fowell, A. J.
Program of the Subcommittee on Construction and Building.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5443-A; 41 p. July 1994.
Available from National Technical Information Services
PB94-193646

construction; safety; building construction; industries; CCIT; government; industry

The President has established the National Science and Technology Council (NSTC), a cabinet-level group charged with setting Federal science and technology policy, to coordinate and prioritize R&D and deployment strategies across a broad cross-section of public and private interests. It has established nine research and development committees, including the Committee on Civilian Industrial Technology (CCIT) to collaborate with the private sector in developing a comprehensive national technology policy. The purpose of CCIT is to enhance the international competitiveness of U.S. industry through Federal technology policies and programs. The Subcommittee on Construction and Building coordinate and defines priorities for Federal research, development and deployment related to the industries that produce, operate and maintain constructed facilities, including buildings and infrastructure. The Subcommittee on Construction and Building has studied research priorities including those expressed by the construction industry and defined two priority thrusts: better constructed facilities and health and safety of the construction workforce. Goals for Better Constructed Facilities are: 50% reduction in delivery time, 50% reduction in costs of operation and maintenance, 30% increase in productivity and comfort, 50% fewer occupant related illnesses and injuries, 50% less waste and pollution, and 50% more durable and flexible. The goal for Health and Safety of Construction Workforce is a 50% reduction in job related illnesses and injuries. These goals will be achieved with improved housing affordability, and where possible with reduced construction, operation and maintenance costs (both initial and life cycle). The baseline for the improvements is today's business practices.

Wright, R. N.; Rosenfeld, A. H.; Fowell, A. J.
Rationale and Preliminary Plan for Federal Research for Construction and Building.
National Institute of Standards and Technology, Gaithersburg, MD
Department of Energy, Washington, DC
NISTIR 5536; 138 p. November 1994.
Available from National Technical Information Services
PB95-154704

construction; competitiveness; energy industry; research program; safety

The National Science and Technology Council (NSTC), a cabinet-level group charged with setting federal technology policy, coordinates R&D strategies across a broad cross-section of public and private interests. It has established nine research and development committees, including the Committee on Civilian Industrial Technology (CCIT), to collaborate with the private sector in developing a comprehensive national technology policy. The purpose of CCIT is to enhance the international competitiveness of U.S. industry through federal technology policies and programs. The Subcommittee on Construction and Building (C&B) of CCIT coordinates and defines priorities for Federal research, development and deployment related to the industries that produce, operate and maintain constructed facilities, including buildings and infrastructure.

Y

Yamada, T.

Yamada, T.; Cooper, L. Y.
Experimental Study of the Exchange Flow Through a Horizontal Ceiling Vent in Atrium Fires.
National Institute of Standards and Technology, Gaithersburg, MD
U. S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 12th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 63-66 pp, 1994.

fire safety; fire research; atriums; ceilings; vents; flow rate; experiments; salt water

This study is directed at understanding an exchange flow rate through a single top vent in an atrium-type compartment with a fire experimentally and obtaining basic knowledge of physical mechanism for developing a comprehensive atrium fire model. A series of experiments was conducted with two reduced scale cubic models with propane gas burner as a heat source. Under various conditions of heat release rate and top vent area, the exchange flow rates were estimated by oxygen consumption method. The result indicates that the dimensionless exchange rate of hot/cool gas is closed to an experimental constant value obtained by salt-water experiments in the past under small vent aspect ratio condition.

Yang, J. C.

Yang, J. C.; Breuel, B. D.
Thermodynamic Properties of Alternative Agents.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 861; April 1994.
Available from Government Printing Office
SN003-003-03268-9
Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays. Section 2, Grosshandler, W. L.; Gann, R. G.; Pitts, W. M., Editors, 13-35 pp, 1994.

halons; thermodynamic properties; halon 1301; solubility; fire extinguishing agents

Depending upon their applications, current halon 1301 (CF3Br) bottles are normally filled to about half of the bottle volume, and the bottle is then pressurized with nitrogen to 4.1 MPa (600 psig) at room temperature. The purpose of using the pressurization gas is to expedite the discharge of the agent and to increase the penetration distance of the agent during discharge. However, this driving force, i.e., the total pressure in the bottle, will vary depending on the ambient temperature because the vapor pressure of the agent and the solubility of the pressurization gas in the liquid agent vary with temperature. The current military specification (MIL-C-22284A) for halon 1301 containers stipulates that the container should have a proof pressure of 9.62 MPa (1400 psig), a burst pressure of 12.37 MPa (1800 psig), and a frangible disc that will rupture at a pressure between 8.59 MPa (1250 psig) and 9.62 MPa (1400 psig) at 70 deg C. In order to explore the possibility of using existing halon 1301 bottles for "drop-in" replacement agents or to provide safety guidelines on bottle design for the alternative agents, two important tasks are to determine (1) the solubility of the pressurization gas in the liquid agent and (2) the final pressure of the vessel when exposed to different ambient temperatures.

Yang, J. C.; Cleary, T. G.; McLane, R.; Grosshandler, W. L.
Experimental Studies on Discharge of Alternative Agent/Nitrogen Mixtures in a Simulated Dry Bay.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 15-16 pp, 1994.

fire research; nitrogen; discharge; halon 1301; fire extinguishing agents

Discharge of the three selected alternative agents for aircraft dry bay fire protection has been conducted in a simulated dry bay (i.e., in an unconfined space). The three selected agents are CF3I, FC-218, and HFC-125. Halon 1301 is also included in the study for the purpose of comparison.

Yang, J. C.; Hamins, A.; Kashiwagi, T.
Estimate of the Effect of Scale on Radiative Heat Loss Fraction and Combustion Efficiency. Short Communication.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Science and Technology, Vol. 96, 183-188, 1994.

radiative heat loss; burning rate; combustion efficiency; flame height

The effect of the fire size on radiative heat loss fraction and combustion efficiency was examined by an analysis of scale for pool flames with varying diameter (D). Correlations between D and radiative heat loss fraction or combustion efficiency were obtained. For 0.1m < diameter < 1m, radiative heat loss fraction and combustion efficiency are relatively constant and independent of D. For larger pool diameters, radiative heat loss fraction decreases with increasing D.

Yang, J. C.; Pitts, W. M.; Breuel, B. D.; Gmurczyk, G. W.; Rinkinen, W. J.; Cleveland, W. G.
Discharge Characteristics of Cryogenic Fluids From a Pressurized Vessel.
National Institute of Standards and Technology, Gaithersburg, MD
Institute for Liquid Atomization and Spary Systems (ILASS-Europe) and CORIA. Liquid Atomization and Spray Systems, 6th International Conference Proceedings. ICLASS 94. July 18-22, 1994, Rouen, France, Begell House, Inc., NY, Yule, A. J.; Dumouchel, C., Editors, 1047-1054 pp, 1994.

cryogenic fluids; discharge rate; halon 1301

An experimental technique to study the rapid release of liquid cryogenic fluids from a pressurized vessel orientated downward is described. A rupture disc was used as the release mechanism. Experimental observations were made on the discharge characteristics of two cryogenic fluids, C4F10 (FC-31-10) and C3F8 (FC-218), which were proposed as potential candidates for replacement of halon 1301 (CF3Br) as fire suppressant. For comparison, halon 1301 was also included in this study. Various parameters that could influence the discharge process were studied. These parameters were: (1) orifice opening, (2) the effect of an extension tube at the vessel exit, and (3) initial charge pressure. The events occurring internal and external to the vessel during discharge of FC-31-10 or FC-218 were studied with high-speed photography and a transparent acrylic vessel. The average penetration velocities of the spray at various locations downstream were measured by means of a laser extinction technique. Two distinct flashing behaviors were observed at the vessel exit. The first flashing occurred immediately after the bursting of the rupture disc, and the second appeared at or before the moment the liquid was depleted from the vessel. During depressurization, no internal boiling of FC-31-10 or FC-218 was observed. Increasing the initial charge pressure reduced the emptying time of the liquid. Decreasing the orifice opening was found to increase the liquid emptying time significantly. The behavior of the liquid inside the vessel was found to be very similar whether an extension tube was present or absent at the vessel exit: an indication of two-phase critical flow.

Z

Zarr, R. R.

Zarr, R. R.
Control Stability of a Heat-Flow-Meter Apparatus.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Thermal Insulation and Building Environments, Vol. 18, 116-127, October 1994.
American Society for Testing and Materials. Measurement Errors and Methods of Calibration of Heat-Flow-Meter Apparatus. ASTM C-16 Workshop. April 9, 1994, Williamsburg, VA, 1994.

building technology; heat flow meter; control stability; fibrous glass; heat transmission; steady state

Calibration measurements of a commercial heat-flow-meter apparatus are presented. The apparatus has been calibrated using the same specimen of high-density fibrous-glass board over a period of four years, from 1989 to 1993. A total of seventy-three tests have been conducted generally, at ambient conditions of 24 deg C with a moderate temperature difference of either 15, 22 or 27 deg C across the specimen. Variations within a set of data for each test have been examined to verify underlying assumptions of randomness, normal frequency distribution of errors, repeatability, and stability of the data. Variations between test data indicate a small drift, on the order of one percent over four years, in the calibration factor of the apparatus. A model has been developed to describe the small drift with time. The analysis of variations between test data has also identified intermittent shifts in the precision of the calibration factor of the apparatus.

Zarr, R. R.; Nguyen, T.
Effects of Humidity and Elevated Temperature on the Density and Thermal Conductivity of a Rigid Polyisocyanurate Foam Co-Blown With CCI3F and CO2.

National Institute of Standards and Technology, Gaithersburg, MD
Journal of Thermal Insulation and Building Environments, Vol. 17, 330-350, April 1994.
Society of the Plastics Industry of Canada's. Workshop on Long-Term Performance of Cellular Plastics, 3rd International. October 4-6, 1993, Ontario, Canada, 1-21 pp, 1993.

polyisocyanurate foam; humidity; temperature; density effects; thermal conductivity; rigid foam; trichlorofluoromethane; carbon dioxide

Measurements of density and apparent thermal conductivity are presented for specimens of rigid polyisocyanurate (PIR) foam cut from a commercial insulation co-blown with trichlorofluoromethane (CCl3F) and carbon dioxide (CO2). Eight specimens, nominally 580 by 580 mm, were prepared from two boards (1.2 by 2.4 m by 50 mm) of foam laminated with permeable facers. Facers and excess foam were removed by sanding the specimens to a thickness of about 27 mm. Four specimens were placed in ambient conditions of 22 deg C and 40% relative humidity (RH). The other four specimens were each placed in one of the following environments: [1] 60 deg C and <10% RH; [2] 60 deg C and 40% RH; [3] 60 deg C and 60% RH; and, [4] 60 deg C and 75% RH. Measurements of apparent thermal conductivity were conducted at 24 deg C and a temperature difference of 22 deg C using a heat-flow-meter apparatus. Measurements were conducted over a period of 372 days at approximately 50-day intervals. Curves of specimen mass, volume, density, and thermal conductivity versus time are presented and the implications of changes in these properties are discussed.

Zarr, R. R.; Nguyen, T.
Effects of Humidity and Elevated Temperature on the Density and Thermal Conductivity of a Rigid Polyisocyanurate Foam.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Cellular Plastics, Vol. 30, 316-337, July 1994.
Society of the Plastics Industry (SPI). Polyurethanes 92. Annual Technical/Marketing Conference, 34th. October 21-24, 1992, New Orleans, LA, 422-430 pp, 1992.

polyisocyanurate foam; rigid foams; humidity; temperature effects; density effects; thermal conductivity

Measurements of apparent thermal conductivity are presented for specimens of rigid polyisocyanurate (PIR) foam cut from a commercial insulation product and aged in air at 60 deg C and different humidities. Eight specimens, nominally 600 by 600 mm, were prepared from two boards (1.2 by 2.4 by 0.05 m) of rigid PIR foam blown with trichlorofluoromethane (CCl3F) and having permeable organic-inorganic facers. Facers and excess foam were removed by sanding the specimens to a thickness of 27.9 + 0.1 mm. Four specimens were placed in ambient conditions of 22 deg C and 40% relative humidity (RH). The remaining four specimens were each placed in one of the following environments: (1) 60 deg C and <10% RH; (2) 60 deg C and 40% RH; (3) 60 deg C and 60% RH; and, (4) 60 deg C and 75% RH. Measurements of apparent thermal conductivity were conducted at 24 deg C and a temperature difference of 22 deg C using a heat-flow-meter apparatus conforming to ASTM Test Method C 518. Measurements were conducted for a period of 357 days at approximately 50 day intervals. Aging curves of specimen mass, volume, density, and thermal conductivity for rigid PIR foam are presented and implications of changes in these properties are discussed in the paper. Supplemental measurements using Fourier transform infrared spectroscopy and scanning electron microscopy are also described in the paper.

Zhang, Z.

Zhang, Z.; Ezekoye, O. A.
Combustion of a Spherical Diffusion Flame in a Radiative Field.
University of Texas, Austin
American Society of Mechanical Engineers. Fire, Combustion, and Hazardous Waste Processing. HTD-Vol. 296. November 6-11, 1994, Chicago, IL, American Society of Mechanical Engineers, NY, Acharya, S.; Annamalai, K.; Presser, C.; Skocypec, R. D., Editors, 7-13 pp, 1994.

combustion; hazardous materials; waste disposal; diffusion flames; combustion; flow; soot

One methodology for modeling fire induced flow fields is based upon a Lagrangian view of the fire. Large scale processes are modeled using a Large Eddy Simulation (LES) method and are then appropriately coupled to a subgird scale model of the small scale combustion processes. The subgrid scale combustion model utilizes Lagrangian flamelets. On the subgrid scale, detailed computations are performed to calculate the combustion history of an individual fuel element with prescribed initial conditions. In

this paper, the soot evolution and burning characteristics within a spherical diffusion flame element are phenomenologically model and the possibility of radiation quenching for certain soot loadings is noted. A comparison is made between finite rate chemistry effects and fast or diffusion limited chemistry results.

Zhou, X. C.

Zhou, X. C.; Gore, J. P.
Effects of a Floor on the Entrainment Flow Field Induced by a Pool Fire.
Purdue Univ., West Lafayette, IN
NISTIR 5499; September 1994.
Available from National Technical Information Services
PB95-104964
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 17-20, 1994, Gaithersburg, MD, 81-82 pp, 1994.

fire research; pool fires; entrainment; flow fields; floors; laser doppler velocimetry

The entrainment flow field of a 7.1 cm toluene fire with a 51 cm floor has been recently studied using a laser Doppler velocimeter (LDV) and a particle imaging velocimeter (PIV). The results of these studies showed that the fire induced flow field in the presence of a floor is highly transient with root mean square (RMS) entrainment velocities having the same order of magnitude as the mean entrainment velocities.

Zukoski, E. E.

Zukoski, E. E.
Mass Flux in Fire Plumes.
California Institute of Technology, Pasadena, CA
International Association for Fire Safety Science. Fire Safety Science. Proceedings. 4th International Symposium. July 13-17, 1994, Ottawa, Ontario, Canada, Intl. Assoc. for Fire Safety Science, Boston, MA, Kashiwagi, T., Editor, 137-147 pp, 1994.

fire research; fire safety; fire science; mass flux; fire plumes; entrainment; diffusion flames

A review is given of data that describe the mass flux of gas in large buoyant diffusion flames, with the aim of developing a rational picture for this process as well as a correlation of the data. A brief review of flame-height scaling parameters is followed by a discussion of measurement techniques, the previous work on far-field and fire-plume models, and a description of an effort to develop a rational entrainment model.

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