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ABSTRACT

Building and Fire Research Laboratory 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.

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1. LITERATURE CITATIONS ARRANGED BY FIRST AUTHOR

A

Abib, A. H.

Abib, A. H.; Jaluria, Y.
Generation of Stable Thermal Stratification by Turbulent Flows in a Partially Open Enclosure.
Rutgers University, New Brunswick, NJ
American Society of Mechanical Engineers (ASME). Fundamentals of Natural Convection. HTD-Vol. 264. 1993, Am. Soc. of Mechanical Engineers, New York, NY, 127-140 pp, 1993.

enclosures; stratification; turbulent flow; equations; flow fields; velocity; temperature; heat transfer; ceiling jets; penetration

A numerical study of the turbulent flow induced by the energy input due to a heat source at the bottom boundary in a partially open rectangular cavity is carried out. Such flows are of interest in enclosure flows induced by localized sources such as fires and electronic components. The flow in the open cavity interacts with its surroundings through the opening. Of particular interest is the influence of opening height on the generation of thermal stratification within the cavity. Therefore, the effect of opening height is explored for an isothermal ambient medium using a wide range of Grashof numbers, spanning both laminar and turbulent regimes. A control-volume finite-difference method, in stream function vorticity formulation, is employed for the solution of the initial-value problem. A low Reynolds number kappa - epsilon turbulence model is used for the turbulent flow calculations. This model is particularly suitable for flows in which the possibility for re-laminarization exists. It was found that, for high Grashof numbers and for relatively small opening heights, particularly for doorway openings, a strong stable thermal stratification is generated within the cavity, with a cooler essentially uniform lower-layer and warmer linearly stratified upper-layer. As a consequence, turbulence is suppressed and the flow in the upper region of the cavity becomes laminar with turbulence confined to isolated places such as the thermal plume above the source and the shear-layer at the opening. The penetration distance and the height of the interface are both found to decrease with a reduction in the opening height. The Nusselt number for heat transfer from the source is seen to be affected to a small extent by the opening height.

Atreya, A.

Atreya, A.
Extinguishment of Combustible Porous Solids by Water Droplets. Annual Progress Report.
Michigan State Univ., East Lansing
NIST-GCR-93-621; Annual Progress Report; 28 p. April 1993.
Available from National Technical Information Services
PB93-198893

porous solids; extinguishment; diffusion flames; fire extinguishing; fire suppression; flame spread; droplets; water; infrared photography; polymethylmethacrylate

This report presents a brief summary of the previous research on fire suppression with the objective to provide guidance for the present work. Reasons for the adopted methodology are summarized and the apparatus developed for the study is described. Finally, some results for PMMA are presented along with conclusions and future work. Two experimental configurations are chosen for this study: (1) Stagnation-point flow apparatus: which allows studying both the gas-phase and the condensed-phase suppression actions and enables transient chemical measurements in the exhaust gas. These measurements are used to study the suppression mechanisms and quantify the suppression effectiveness. (2) Counterflow diffusion flame apparatus: which allows detailed flame structure measurements but is limited to studying gas-phase suppression mechanisms (chemical and/or physical). Initally, the work is done using the stagnation-point flow apparatus with water as the extinguishing agent and PMMA as the burning solid to establish a standard for comparison of suppression effectiveness of various agents. Our experimental results for PMMA show that there are two simultaneous effects as a result of water application: (1) chemical enhancement of the burning rate (which is important only when the flames are sooty; Note: most fires are sooty), and (2) physical cooling of the solid via water evaporation. The chemical effect has not been previously noted because water is usually applied in much greater quantities than needed and in this domain the physical cooling effect dominates. Thus, future work is directed toward better understanding the suppression mechanisms.

B

Babrauskas, V.

Babrauskas, V.
Bench-Scale Predictions of Mattress and Upholstered Chair Fires: Similarities and Differences.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5152; 22 p. March 1993.
Available from National Technical Information Services
P93-186005

mattresses; upholstered furniture; fire hazard; fire tests; heat release rate; scaling; fire spread; prisons

The life safety hazard issues associated with flaming fires of mattress and upholstered furniture are explored. It is shown that full-scale heat release rate (HRR) is the dominant variable which needs to be controlled. This can be determined directly by full-scale measurement. In many cases, full-scale tests are not convenient to conduct. It is, thus, desirable that bench-scale procedures be available which can be used to predict some of the important features of the full-scale test. Such procedures have been developed at the National Institute of Standards and Technology for upholstered furniture during several prior studies. In the present work, differences between the behavior of mattresses and of upholstered furniture are explored. Mattresses and upholstered chairs are soft goods which are constructed in a somewhat similar way: both use padding foams or battings, covered by upholstery fabric. There are differences in construction, however. Mattresses are flat, whereas upholstered chairs normally have seats, backs, and sidearms. Also, an upholstered chair is normally constructed on a wood frame, whereas a mattress has no structural components, or else has steel innersprings. The quantitative knowledge of mattress behavior is still not as advanced as that for upholstered furniture. Nonetheless, based on a recent set of tests, the behavior of mattress fires can initially be quantified. Especially, data are now available to predict whether or not a particular mattress construction will lead to a propagating fire. Similarly as for upholstered furniture, such a limit value can be used to determine whether certain regulatory pass/fail criteria are met. The relationship obtained is incomplete, however, because the known roles of ignition source power level (i.e., kilowatts output) and geometrical configuration are not yet quantified. Also, there is not yet a detailed explanation for differences between the observed relationships for mattresses and for upholstered chairs. Thus, future work will need to be done to address and further quantify these effects.

Babrauskas, V.
Specimen Heat Fluxes for Bench-Scale Heat Release Rate Testing.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers. Interflam '93. Fire Safety. International Fire Conference, 6th. March 30-April 1, 1993, Oxford, England, Interscience Communications Ltd., London, England, Franks, C. A., Editor, 57-74 pp, 1993.

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

When a specimen is tested for its heat release rate (HRR) behavior using a bench-scale test such as ISO 5660 or equivalent, one very important test condition is not pre-standardized and must be set: the heat flux to be imposed on the specimen by the heater. The heat flux cannot be legitimately standardized, since the value appropriately to be used will differ according to purpose or application. The present paper sets forth the considerations which should govern the correct choice of heat flux. A discussion is given of minimum ignitability level; statistical variability at low heat fluxes; the ranges of heat fluxes associated with small actual ignition sources; the heat fluxes associated with fires away from the ignition source, all the way up to fully-involved room fires; the applicaton of the product; and the needs associated with mathematical modeling of room fires. Correlational approaches are also illustrated and contrasted to physics-based ones. Finally, the empirical nature of the present situation is emphasized. Judged from first principles, it would appear that successful prediction of room fire results from bench-scale test data would require both the testing at a large number of different heat fluxes and the use of algorithms to permit time-dependent interpolation. Such algorithms have been proposed; however, some very successful predictions are noted with much simpler techniques.

Babrauskas, V.
Ten Years of Heat Release Research With the Cone Calorimeter.
National Institute of Standards and Technology, Gaithersburg, MD
Tsukuba Building Test Laboratory, Center for Better Living. Japan
Symposium on Heat Release and Fire Hazard, First (1st) Proceedings. Session 3. Scope for Next-Generation Fire Safety Testing Technology. May 10-11, 1993, Tsukuba, Japan, III/1-8 pp, 1993.

heat release; fire hazard; cone calorimeters; standards; databases; heat release rate

ISO 5660 standard is only being published in final form in 1993. However, the Cone Calorimeter was first announced in 1982. Thus, heat release rate (HRR) research work using the Cone Calorimeter started at that time, even though certain features, e.g., the smoke photometer, were not developed until a few years afterwards. In this paper a review is made of what has been learned so far and where strong research successes have been obtained. A number of applications where Cone Calorimeter data are already being used are cited. In addition, some indications are given of where Cone Calorimeter research and application activities are likely to progress in future years.

Babrauskas, V.; Twilley, W. H.; Parker, W. J.
Effects of Specimen Edge Conditions on Heat Release Rate.
National Institute of Standards and Technology, Gaithersburg, MD
Fire and Materials, Vol. 17, No. 2, 51-63, March/April 1993.

heat release rate; cone calorimeters; fire models

When bench-scale specimens are tested for heat release rate, it is generally of interest that the behavior of the specimen simulate, as much as is possible, that of a real-scale product performing in a real fire. A number of issues have been raised recently by workers trying to understand the optimal conditions of specimen preparation and mounting. In the present study a large number of materials were explored in the Cone Calorimeter to determine the effect of edge conditions and edge frames. It was found that by the use of an insulated edge frame, heat release rate values can be obtained which are slightly closer to expected true values. The testing procedure, however, is significantly more complicated. This makes the insulated edge frame useful for collecting specialized data for fire modeling, but not for conducting routine reaction-to-fire tests. For routine testing use, it is recommended: (1) that no edge frame needs to be used unless the test specimen presents special difficulties, such as due to intumescence; (2) that in those cases where the use of the steel edge frame is found necessary, the results should be reported on the basis of an effective exposure area of 0.0081 m2. When reported on such a basis, the heat release rate results do not show a systematic bias, compared to results with no edge frame.

Bentz, D. P.

Bentz, D. P.; Garboczi, E. J.
Computer Model for the Diffusion and Binding of Chloride Ions in Portland Cement Paste.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5125; 24 p. February 1993.
Available from National Technical Information Services
PB93-159051

cements; computer models; diffusion; adsorption; binding; building technology; chloride ions; concentration profiles; hydration; microstructure; random walk; simulation

A two-dimensional computer model has been developed to simulate the diffusion and binding of chloride ions in cement paste. The model is based on a random walk algorithm in which chloride species randomly diffuse throughout the cement paste microstructure and interact with various phases of the paste. Reaction with unhydrated C3A and C4AF and adsorption by the C-S-H gel phase are the two binding processes included in the model. Input to the model is a digital image of cement paste microstructure which can be obtained from a real cement sample or from a digital-image-based microstructure model. The operation of the diffusion and binding model is demonstrated on pastes made from two cements whose differing compositions are captured by combining backscattered electron and x-ray images obtained using a scanning electron microscope. These initial images are "hydrated" using the microstructure model to produce final images to be utilized as input into the diffusion model. Chloride concentration profiles are generated for both the binding and no-binding cases for both microstructures for times of up to several hours after exposure to the chloride. Binding is seen to have a significant effect on the early-time penetration of chlorides into cement paste. Results for the two cements indicate that a higher chloride diffusion coefficient may be offset, at least initially, by a greater chloride binding capacity.

Bentz, D. P.; Garboczi, E. J.; Coverdale, R. T.
Computational Materials Science of Cement-Based Materials: An Education Module.
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1405; 43 p. August 1993.
Available from National Technical Information Services
PB94-111424
Available from Government Printing Office
SN003-003-03229-8

cements; computers; computer programs; microstructure

An education module demonstrating the principles of computational materials science has been developed. The module consists of: software that executes on a personal computer, and this NIST Technical Note, which provides documentation and instructions for using the computer software. The computer programs are availabe for both DOS-compatible PC and Macintosh computing environments. Four separate computer programs illustrate the development of microstructure during cement hydration, mercury intrusion porosimetry, percolation of overlapping ellipses and rectangles as a function of aspect ratio, and percolation of non-overlapping hard cores each encompassed by a soft overlapping shell. All of the programs operate on two-dimensional microstructures due to the space and time limitations imposed by a personal computer environment. The computer software is interactive and highly graphics-oriented. To date a preliminary version of the computer module has been utilized in a variety of undergraduate and graduate level civil engineering classes. Feedback from faculty and students has been used to revise and enhance the capabilities of the computer program.

Brehob, E. G.

Brehob, E. G.; Kulkarni, A. K.
Time-Dependent Mass Loss rate Behavior of Wall Materials Under External Radiation.
Pennsylvania State Univ., University Park, PA
Fire and Materials, Vol. 17, No. 5, 249-254, September/October 1993.

walls; mass loss; data analysis; enclosures; flammability

External radiation in enclosure fires can significantly enhance flame spread and fire growth. One of the effects of external radiation is to increase the mass loss rate of the fuel, which in turn produces larger flames. In this work, a measurement of mass loss with and without aplied radiation was made as a function of time for three types of materials: a plastic (polymethylmethacrylate), wood-based products (particle board and hardboard), and a paper-based product (cardboard). The levels of applied radiation ranged from 0 to nearly 12 kW m-2. The purpose of the investigation was to (1) quantitatively determine the effect of external radiation on the mass loss of various materials, (2) measure various parameters which may be used to characterize the mass loss rate history of the materials and (3) determine a method for expressing the mass loss rate as a function of time for input into numerical models. Higher levels of external radiation resulted in higher peak mass loss rates and quicker consumption of the material. Quantities which are useful for ranking the flammability of materials have been measured for the samples tested and are tabulated.

Bukowski, R. W.

Bukowski, R. W.
Balanced Design Concepts Workshop. June 30, July 1-2, 1993.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5264; 212 p. September 1993.
Available from National Technical Information Services
PB94-108388

containment; fire detectors; fire risk; reliability; sprinklers

This report contains an attendance list, handout materials, copies of visuals from invited papers, and notes from three breakout sessions held during a June 30 to July 2 workshop. The purpose of the workshop was to gather information and support for a study to quantify the performance and reliability of fire detection and suppression systems, and of compartmentation, and the degree to which any one could be reduced or eliminated without undue risk of loss. The workshop and study are being conducted as required in PL 102-522.

Bukowski, R. W.
Review of International Fire Risk Prediction Methods.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers. Interflam '93. Fire Safety. International Fire Conference, 6th. March 30-April 1, 1993, Oxford, England,
Interscience Communications Ltd., London, England, Franks, C. A., Editor, 437-446 pp, 1993.

fire safety; fire science; risk assessment; fire risk

The long sought after benefits of performance based codes may finally be within reach as many countries are developing comprehensive building fire risk evaluation methods to support the determination of compliance with their goals. The Japanese published a formal method of establishing compliance with their Building Standard Law in 1988 which is now in use. Australia is presently developing such a method as part of a national building code regulatory reform project. The Canadian government has committed to adopt the Australian method once completed. In 1990, NIST published a product fire risk evaluation method which can also be used for quantifying the risk presented by a specific building design. Similar projects are known in the United Kingdom, Finland, and Sweden. The Japanese have further funded a project to study the various methods developed or in process and to suggest ways of harmonizing the results. This paper reviews the US, Japanese, and Australian efforts and summarizes their extensive similarities and few diferences. Given the similitude a collaboration is recommended which would result in a coordinated approach incorporating the best aspects of each method.

Bukowski, R. W.
Studies Assess Performance of Residential Detectors.
National Institute of Standards and Technology, Gaithersburg, MD
NFPA Journal, Vol. 87, No. 1, 48-54, January/February 1993.

smoke detectors; heat detectors; residential buildings; standards; technology utilization

Current thinking on the performance of residential heat detectors compared to that of smoke detectors, as embodied in most U. S. codes, recently has been challenged. This article assembles from the literature a comprehensive picture of what is known about the relative performance of these two detector types in residential fires. The studies cited here were identified in a recently published, comprehensive literature review and are available in the open literature. In each case, the study has been summarized and its conclusions on heat and smoke detector performance are quoted.

Burch, D. M.

Burch, D. M.
Analysis of Moisture Accumulation in the Walls Subjected to Hot and Humid Climates.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions: Symposia, Vol. 99, No. 2, 1013-1022, 1993.

moisture; walls; climate; construction

A detailed computer analysis was conducted to investigate the moisture accumulation in walls subjected to a hot and humid climate (Lake Charles, LA). The analysis revealed that the use of low-permeability wallpaper (e.g., vinyl wallpaper) causes moisture to accumulate within adjoining gypsum board. At this location, the surface relative humidity can rise above 80% and approach a saturated state, thereby providing a conducive environment for mold and mildew growth. A variation of parameters was carried out to investigate which parameters are important. Parameters found to have a significant effect included indoor temperature, permeance of the wallpaper, the amount of outdoor infiltration, the permeance of exterior construction, and the initial moisture content of the construction materials. Parameters found to have a less important effect included orientation, insulation thermal resistance, the permeance of exterior paint, and the type of wall construction. Based on the analysis, the following practices for controlling moisture accumulation in walls exposed to hot and humid climates are recommended. Vapor retarders should not be used at interior surfaces. An exterior vapor retarder should be installed in the construction. The infiltration of outdoor air into the construction should be minimized by installing an exterior air barrier and eliminating negative pressurization of the indoor space. Construction with moist materials should be avoided. The indoor space should not be cooled below its design setpoint temperature.

Burch, D. M.; TenWolde, A.
Computer Analysis of Moisture Accumulation in the Walls of Manufactured Housing.
National Institute of Standards and Technology, Gaithersburg, MD
Forest Products Lab., Madison, WI
ASHRAE Transactions: Symposia, Vol. 99, No. 2, 977-990, 1993.

housing; moisture; walls; climate

A detailed computer analysis was conducted to investigate the effectiveness of three alternative practices for controlling moisture accumulation in the walls of manufactured housing during the winter. The three practices included (1) providing an interior vapor retarder, (2) using permeable sheathing and siding, and (3) providing an outdoor ventilated cavity. The current HUD Manufactured Home Construction and Safety Standards do not require a vapor retarder for practices 2 and 3. The analysis was carried out for a cold winter climate (Madison, WI), an intermediate winter climate (Boston, MA), a mild winter climate (Atlanta, GA), and a Pacific Northwest climate (Portland, OR). The practice of providing a vapor retarder was found to be effective in all four climates. The moisture content of the siding was always considerably below fiber saturation. On the other hand, the practice of using permeable sheathing and siding and the practice of providing an outdoor ventilated cavity were not always effective in colder climates. Moisture accumulated above fiber saturation, and free liquid water existed within the pore structure, providing a potential for material degradation. A detailed computer analysis was also conducted of moisture accumulation in manufactured housing walls in a hot and humid climate (Lake Charles, LA). During the summer, moisture from the outdoor environment is transferred into manufactured housing by diffusion and, more important, infiltration. As a result, moisture accumulates at interior layers of the construction cooled by air conditioning. When an interior vapor retarder is used in the construction, the relative humidity at the outside surface of the vapor retarder can approach saturation, thereby providing an environment conducive to mold and mildew growth.

Burch, D. M.; Thomas, W. C.
MOIST: A PC Program for Predicting Heat and Moisture Transfer in Building Envelopes. Version 2.0.
National Institute of Standards and Technology, Gaithersburg, MD
Virginia Polytechnic Institute and State Univ., Blacksburg, VA
NIST SP 853; 75 p. September 1993.
Available from National Technical Information Services
PB94-112448

building technology; computer programs; heat transfer; moisture control; moisture transfer; wall performance

This report is a users manual for a computer program called MOIST. MOIST is a user-friendly personal computer program that predicts the one-dimensional transfer of heat and moisture in multi-layer walls, cathedral ceilings, and low-sloped roofs. The algorithms in the program predict moisture transfer in the diffusion through the capillary flow regimes. The program has a provision to account for convective moisture transfer by including embedded cavities which may be coupled to indoor and/or outdoor air. The user can readily include the water-vapor resistance offered by paint layers, wallpaper, and vapor retarders in simulations. The program generates a plot on the computer screen of the average moisture content of the construction layers versus time of year as the program executes. The program generates output files which may be imported into plotting programs for preparing reports.

C

Carino, N. J.

Carino, N. J.
Statistical Methods to Evaluate In-Place Test Results.
National Institute of Standards and Technology, Gaithersburg, MD
American Concrete Institute. New Concrete Technology: Robert E. Philleo Symposoum. SP-141-3. 1993, Liu, T. C.; Hoff, G. C., Editors, 39-64 pp, 1993.

statistical analysis; compressive strength; construction; in-place testing; loads (forces); pullout tests; regression analysis; repeatability; safety; strength; tests

In-place testing is used to estimate the compressive strength of concrete in a structure by measuring another related property. A strength relationship is used to convert the in-place test results to an estimate of the compressive strength. Statistical methods are needed for reliable estimates of in-place strength. Such methods should account for the uncertainities in the measured property, the uncertainty of the strength relationship, and the variability of the in-place concrete. Standard statistical procedures for dealing with these uncertainities have not yet been adopted in North American practice. Recommendations are provided for developing the strength relationship, and a reliable, easy-to-use approach is presented to estimate in-place characteristic strength.

Celebi, M.

Celebi, M.; Phan, L. T.; Marshall, R. D.
Dynamic Characteristics of Five Buildings During Strong and Low-Amplitude Motions.
U.S. Geological Survey, Menlo Park, CA
National Institute of Standards and Technology, Gaithersburg, MD
Structural Design of Tall Buildings, Vol. 2, 1993.

buildings; damping; earthquakes; frequency; period; strong-motion; testing; vibration

The objectives of this paper are to present [1] a comparison of dynamic characteristics of five buildings determined from recorded strong-motion response data and from low-amplitude (ambient vibration) tests, and [2] a description of the low-amplitude ambient testing and PC-based data-acquisition approach that is integrated with the permanent strong-motion instrumentation in the five buildings. All five buildings are within the San Francisco Bay area and the strong-motion dynamic characteristics are extracted from the October 17, 1989 Loma Prieta earthquake response records. Ambient vibration tests on the same five buildings were conducted in September 1990. Analyses of strong-motion response and low-amplitude test data have been performed by many investigators. The present study differs from numerous previous investigations because [1] in this study, accelerometers in the five permanently-instrumented buildings were used during the low-amplitude testing, and [2] rapid screening of the strong-motion response data was achieved with a concerted use of a system identification software. The results show for all cases that the fundamental periods are appreciably lower than those determined from strong-motion response records. The data set collected during this study is a useful contribution to the data base of dynamic characteristics of engineered structures and reconfirms the differences between the dynamic characteristics identified from storng-motion records and from low-amplitude tests.

Chan, W. R.

Chan, W. R.; Zukowski, E. E.; Kubota, T.
Experimental and Numerical Studies on Two-Dimensional Gravity Currents in a Horizontal Channel.
California Institute of Technology, Pasadena, CA
NIST-GCR-93-630; 261 p. July 1993.
Available from National Technical Information Services
PB94-165941

compartment fires; fire models; fire research; gravity current; inclined tests; room fires; smoke

The objective of this investigation is to examine the behavior of two-dimensional gravity currents, especially as applied to the spreading of smoke, generated from a room fire, along a long corridor. Both experimental and numerical techniques were used to provide a model that can adequately explain and predict the behavior of a gravity current under certain boundary conditions. A series of experiments was carried out to study the effects of Reynolds number on gravity currents in a horizontal water channel. Measurements of the time varying front position, velocity profile of the following current, and the depth of a gravity current were made using either dyed liquids or hydrogen bubble technique. Quantitative results were shown to agree with previously published results. A model was put forth to bridge the gap between the existing models for an inertia-buoyancy dominated gravity current and a viscous-buoyancy dominated one. Comparison between the experimental results and numerical results obtained from the model proved that the model can adequately explain the behavior of the phenomenon. A second series of experiments was conducted to investigate the behavior of gravity currents in an inclined channel. The quantitative results obtained were less scattered than those obtained in previous research. The gravity current was found to be unsteady in a horizontal channel, while a channel with an angle of inclination of one degree was found to produce a steady flow behind the front of the gravity current. The change of the gravity currents from an unsteady to a steady nature due to the change in the inclination of the channel was found to be gradual and much less abrupt than assumed in previous studies.

Cheok, G. S.

Cheok, G. S.; Lew, H. S.
Model Precast Concrete Beam-to-Column Connections Subject to Cyclic Loading.
National Institute of Standards and Technology, Gaithersburg, MD
PCI Journal, Vol. 38, No. 4, 80-92, July/August 1993.

concretes; beams; columns; cyclic loading; failure modes; displacement ductility; connection strength; energy dissipation

Experimental results of eight 1/3-scale model precast concrete beam-to-column connections are presented. The test specimens consisted of interior connections designed in accordance with the 1985 Uniform Building Code provisions for Seismic Zones 2 and 4. These tests constitute the second and third phases of a multi-year test program being conducted at the National Institute of Standards and Technology. The objective of the test program is to develop guidelines for an economical precast beam-to-column connection for regions of high seismicity. Variables considered in the research program include location of the post-tensioning steel, the use of post-tensioning bars vs. prestressing strands and fully bonded vs. partially bonded strands. Specimens were subjected to reversed cyclic loading according to a prescribed displacement history. Comparisons were made between the behavior of precast concrete specimens and the monolithic specimens tested previously in Phase 1. These comparisons were based on connection strength, ductility and energy dissipation characteristics. Comparisons of results with the monolithic test specimens indicates that the post-tensioned precast concrete specimens had comparable connection strengths, higher ultimate displacement ductilities and total energy dissipation to failure, but lower energy dissipation per cycle.

Cheok, G. S.; Stone, W. C.
Overview of NIST Research on Seismic Performance of Moment Resisting Precast Concrete Beam-Column Joints Containing Post-Tensioning.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5257; 42 p. August 1993.
Available from National Technical Information Services
PB94-103686

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

The experimental test program being conducted at the National Institute of Standards and Technology on 1/3-scale model precast concrete beam-to-column connections is summarized. The objective of the test program is to develop guidelines for an economical precast beam-to-column connection for regions of high seismicity. The basic concept of the study is the use post-tensioning for connecting the members. The monolithic test specimens were interior moment resisting connections designed using the Uniform Building Code [ICBO, 1985 and 1988] criteria for seismic Zones 2 and 4 as guidelines. The designs of the precast specimens were based on the monolithic design. To date, seventeen specimens have been tested. Variables in the study include location of the post-tensioning steel, the use of post-tensioning bars versus strands, fully bonded versus partially bonded strands, and the comination of low strength steel and post-tensioning. Specimens were subjected to reversed cyclic loading according to a prescribed displacement history. Comparisons were made between the behavior of the precast specimens and monolithic specimens. The comparisons were based on connection strength, connection ductility, and energy dissipation characteristics.

Cheok, G. S.; Stone, W. C.
Performance of 1/-3-Scale Model Precast Concrete Beam-Column Connections Subjected to Cyclic Inelastic Loads. Report No. 3.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5246; 136 p. August 1993.
Available from National Technical Information Services
PB94-101813

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

Test results of hydrid post-tensioned precast concrete beam-to-column connections are presented. These tests represent Phase 4 A of an experimental program on 1/3-scale model precast concrete moment resisting connections being conducted at the National Institute of Standards and Technology. Previous test results in Phases 1 to 3 are summarized. The objective of the test program is to develop guidelines for an economical precast beam-to-column connection for regions of high seismicity. The basic concept of the study is to use post-tensioning to connect the members and to eliminate the use of column corbels. Monolithic control specimens tested in Phase 1 were designed to model interior moment resisting connections designed in accordance with the Uniform Building Code [ICBO, 1985 and 1988] criteria for seismic Zones 2 and 4. The precast specimens were designed to achieve moment and geometric compatibility with the monolithic design. To date, twenty specimens have been tested. Variables in the study include the location of the post-tensioning steel (Phase 1), the use of post-tensioning bars versus strands (Phase 2), the use of fully and partially bonded and unbonded strands (Phase 3), and the combination of low strength steel and post-tensioning (Phase 4, described in this report). Specimens were subjected to reversed cyclic loading according to a prescribed displacement history. Comparisons are made between the behavior of the precast specimens and monolithic specimens. The comparisons are based on connection strength, drift capacity of the connection, and energy dissipation characteristics.

Cheok, G. S.; Stone, W. C.; Lew, H. S.
Seismic Performance Behavior of Precast Concrete Beam-Column Joints.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers (ASCE). Structural Engineering in Natural Hazards Mitigation. Structures Congress '93 Proceedings. Volume 1. April 19-21, 1993, Irvine, CA, Am. Soc. of Civil Engineers, New York, NY, Ang, A. H. S.; Villaverde, R., Editors, 83-88 pp, 1993.

concretes; beams; columns; seismic performance

The experimental test program being conducted at the National Institute of Standards and Technology on 1/3-scale model precast concrete beam-to-column connections is summarized. The objective of the test program is to develop guidelines for an economical precast beam-to-column connection for regions of high seismicity. The test specimens were interior connections designed using the Uniform Building Code [ICBO, 1985 and 1988] criteria for seismic Zones 2 and 4 as guidelines. To date, fifteen specimens have been tested. Variables in the study include location of the post-tensioning steel, the use of post-tensioning bars versus prestressing strands, fully bonded versus partially bonded strands, and the combination of low strength steel and post-tensioning. Specimens were subjected to reversed cyclic loading according to a prescribed displacement history. Comparisons were made between the behavior of precast specimens and monolithic specimens. The comparisons were based on connection strength, connection ductility, and energy absorption characteristics.

Choi, M. Y.

Choi, M. Y.; Hamins, A.; Kashiwagi, T.
Simultaneous Optical Measurement of Soot Volume Fraction and Temperature.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Central and Eastern States Section. Combustion Fundamentals and Applications. Joint Technical Meeting. March 15-17, 1993, New Orleans, LA, 1-5 pp, 1993.

soot; optical measurement; volume fraction; temperature

Radiative heat transfer processes in large fires govern the burning rate, the flame spread rate and the potential for fire hazards. These processes are controlled by the detailed structure of the fire, primarily the temperature and soot distributions. In an attempt to characterize the radiative heat transfer, Gore and coworkers developed an optical probing technique [Sivathanu et al., 1991; Klassen et al., 1992a, 1992b]. The technique utilizes a multi-line emission and absorption probe to simultaneously measure the temperature and soot volume fraction within a narrow region of a fire.

Choi, M. Y.; Hamins, A.; Rushmeier, H.; Hubbard, A.; Kashiwagi, T.
Simultaneous Optical Measurement of Soot Volume Fraction and Temperature in Heptane Pool Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. Technical Meeting, October 25-27, 1993, Princeton, NJ, 366-369 pp, 1993.

soot; optical measurement; volume fraction; temperature; heptanes; pool fires; heat flux

In large pool fires radiative heat transfer governs the burning and flame spread rates and therefore is a key factor in assessing potential fire hazards. The radiative heat feedback from the flame to the fuel surface is controlled by the temperature and soot distribution inside the fire. Early attempts at modeling this process involved several assumptions including the use of average flame emissivity, constant flame temperatures, absorption/emission cofficients as a function of height and effective flame shapes. Due to the turbulent nature of these fires, the use of mean radiative properties can lead to significant differences between the predicted and measured fuel burning rates. Markstein investigated spatial and temporal variations of the emission intensity for pool fires and suggested the importance of turbulent fluctuations of temperatures and soot volume fractions on the heat transfer mechanism. Direct integration of the turbulent radiative heat transfer to the fuel surface requires the time-varying local temperature and emissivity distributions within the region between the fuel surface and the flame. The primary motivation for this study is to understand the mechanisms governing the gasification and heat feedback rates to the fuel surface. The 3-line emission/absorption technique was used to measure the temperature and soot volume fractions in pool fires burning heptane. The temporal and spatial results will be used to determine the radiative feedback to the surface and the burning rate using a reverse Monte Carlo method for comparisons with the measured values.

Choi, M. Y.; Mulholland, G. W.; Hamins, A.; Kashiwagi, T.
Comparisons of Soot Volume Fraction Measurements Using Optical and Isokinetic Sampling Techniques.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. October 25-28, 1993, Princeton, NJ, 1-4 pp, 1993.
soot; optical measurement; volume fraction; sampling; experiments

In a previous study, the performance of a three-line optical probe technique for measuring soot volume fraction and temperature was assessed by conducting experiments in the path-invariant environment of a premixed flame. In that study, the temperature and soot volume fraction (fva, based on absorption measurements at 632.8 nm and fve, based on emission measurements at 900 nm and 1000 nm) measurements in a premixed ethylene/air flame were compared to the results of Harris and Weiner. 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.

Collins, B. L.

Collins, B. L.
Evaluation of Subjective Response to Lighting Distributions: A Literature Review.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5119; 69 p. February 1993.
Available from National Technical Information Services
PB93-173458
luminance distribution; color; lighting design; lighting equipment; luminance; occupant; psychology; subjective response; uniformity

The research literature on the subjective response to lighting and luminance distributions is reviewed. It includes an assessment of the lighting design parameters and system features which have been linked to occupant response, both positive and negative. Features such as uniformity, color, visual clarity, glare, gloom, daylighting, task lighting, and lighting geometry are addressed. Occupant response is discussed in terms of affect, preference, and behavior. Both laboratory and field research results are reviewed. The review of the literature suggests strongly that luminance distribution and patterns play an important role in determining positive psychological response to lighting. these findings have important implications for lighting design.

Collins, B. L.; Ouellette, M. J.; Perry, M. J.; Slater, A. I.; Tiller, D. K.; Treado, S. J.; Sanders, P. A.
Initial Procedure for Evaluation of a CCD Photometer.
National Institute of Standards and Technology, Gaithersburg, MD
Lux Europa Proceedings. April 1993, Edinburg, Scotland, 1-4 pp, 1993.
photometers; evaluation; luminescence

The recent advent of Charge Coupled Device (CCD) luminance mapping devices and video photometers has significantly increased the ability to measure luminance distributions within a space. While the flexibility of such photometers is unquestioned, there is little documented information on the reliability, accuracy, and precision of CCD photometers used in lighting research and design. An evaluation procedure with initial data from a round robin evaluation of one type of CCD luminance mapping photometer is discussed.

Cooper, L. Y.

Cooper, L. Y.
Combined Buoyancy- and Pressure-Driven Flow Through a Horizontal Vent: Theoretical Considerations.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5252; 17 p. September 1993.
Available from National Technical Information Services
PB94-103694
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 315-318 pp, 1993.

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

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. For arbitrary specified cross-vent pressure difference, boundary value problems for the flow are formulated for cases where the fluid media in the two spaces are the same perfect gas, with relatively high and low temperature (corresponding to low and high density) in the lower and upper spaces, respectively. Two separate classes of problem are distinguished. In the first, the higher pressure is in the space above the vent. This enhances the downward component of the flow from the top to the bottom space, and diminishes, or reduces to zero, the upward flow. In the second, the higher pressure is in the lower space leading to enhancement of the upward flow, etc. Relationships between the two boundary value problems and their solutions are identified. These are useful for extending an available solution for one class of problem to that of the other and for unified understanding and correlation of experiment data for the two flow configurations.

Cooper, L. Y.
Discharge of Fire Suppression Agents From a Pressurized Vessel: A Mathematical Model and Its Application to Experimental Design.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5181; 59 p. May 1993.
Available from National Technical Information Services
PB93-198927

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

A mathematical model and associated computer program is developed to simulate the discharge of fire extinguishment agents from N2-pressurized vessels. The model is expected to have three applications. First, to establish an experimental design and procedure which closely simulates discharge of a field-deployed vessel; second, to evaluate the discharge characteristics of a wide range of alternative-agent/pressure-vessel configurations, thereby extending the slow and relatively costly experimental method of making such evaluations; and finally, to predict vessel exit flow conditions to be used to solve the problem of agent dispersal outside of the discharge vessel. The model is used in example calculations which address the first of these applications. The field-deployed system, which forms the basis of the example calculations, involves a half-liter cylindrical discharge vessel with a circular discharge nozzle/orifice of diameter 0.019m. The vessel is half-filled with liquid Freon 22 and is pressurized with N2 to 41.37x105Pa (600psi). Vessel discharge is initiated by actuation of an explosive cap over the nozzle/orifice. The simulating experimental configuration involves a modified field-deployed system. A diaphragm with nominal 41.37x105Pa (600psi) rupture pressure [actual values between 37.92x105Pa (550psi) and 44.82x105Pa (650psi)] replaces the explosive cap. The system is equipped with a high-pressure N2 holding tank connected to the discharge vessel via an orifice. An experimental run begins with the onset of through-orifice N2 flow from the holding tank. The vessel is pressurized to the point of diaphragm rupture and this is immediately followed by vessel discharge. The model is used to simulate discharge of the field-deployed system and pressurization/discharge of the experimental system. Simulations of the experimental system involve holding tank volumes of 2.5x10-3m3 or 2.5x10-5m3; orifice diameters of 0.005m, 0.001m, or 0.0005m; and initial vessel pressures of 9.38x105Pa (136psi) (the saturation pressure of Freon 22 at 294K) and 34.47x105Pa (500psi). From the calculations it was determined that the 2.5x10-3m3 holding tank with the 0.0005m orifice could be used to simulate accurately the discharge of the field-deployed system and that it is reasonable to expect that this experimental design would give good simulations even when extended to a range of parameters and agent materials well beyond the scope of the present calculations. Calculations also indicated that use of the 2.5x10-5m3 holding tank and/or the 0.005m orifice would not be consistent with an acceptable experimental design.

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; 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

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.
Fire-Plume-Generated Ceiling Jet Characteristics and Convective Heat Transfer to Ceiling and Wall Surfaces in a Two-Layer Zone-Type Fire Environment: Uniform Temperature Ceiling and Walls.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Science and Technology, Vol. 13, No. 1/2, 1-17, 1993.

ceiling jets; building fires; compartment fires; computer models; fire models; heat transfer; mathematical models; zone models

It has been determined by Sandia National Laboratories and the U. S. Nuclear Regulatory Commission that the use of deterministic, multi-room, zone-type fire modeling technology could enhance the reliability of their recent reactor safety risk studies. These studies are confined to the relatively early detection times of fire development when fire-driven ceiling jets and gas-to-ceiling convective heat transfer are expected to play a particularly important role in room-to-room smoke spread and in the response of near-ceiling mounted detection hardware. A parameter of concern in these risk analyses is the location of the fire within the space of fire origin. One goal of the analyses is to determine the significance to risk of this fire-position parameter. This work presents a model to predict the instantaneous rate of convective heat transfer from fire plume gases to the overhead ceiling surface in a room of fire origin. The room is assumed to be a rectangular parallelopiped and, at times of interest, ceiling temperatures are simulated as being uniform. Also presented is an estimate of the convective heat transfer, due to ceiling-jet-driven wall flows, to both the upper and lower portions of the walls. The effect on the heat transfer of the location of the fire within the room is taken into account. Finally presented is a model of the velocity and temperature distributions in the ceiling jet. The model equations were used to develop an algorithm and associated modular computer subroutine to carry out the indicated heat transfer calculations. The subroutine is written in FORTRAN 77 and called CEILHT. The algorithm and subroutine are suitable for use in two-layer zone-type compartment fire model computer codes. The subroutine was tested for a variety of fire environments involving a 10(7)W fire in a 8m x 8m x 4m high enclosure. While the calculated results were plausible, it is important to point out that CEILHT simulations have not been experimentally validated.

Cooper, L. Y.
Some Factors Affecting the Design of a Furniture Calorimeter Hood and Exhaust.
National Institute of Standards and Technology, Gaithersburg, MD
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.

Crompton, T.

Crompton, T.; Atreya, A.
Quantifying the Effectiveness of Fire Suppressants in a 1-D Laminar Diffusion Flame.
University of Michigan, Ann Arbor
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 471-474 pp, 1993.

combustion; fire suppression; fire tests; laminar flames; diffusion flames; effectiveness; polymethylmethacrylate; experiments; stagnation point

In this study a method for evaluating and ranking fire suppressants is being developed. A small scale, stagnation-point flow apparatus has been constructed that can test a variety of gas and liquid suppression agents. This apparatus allows well controlled, transient experiments to be conducted on solid, liquid, or gaseous fuels. The one-dimensional, laminar diffusion flame configuration is convenient for experimental measurements and theoretical analysis. Experiments can be performed using various fuel types, oxidizer concentrations, and external heat fluxes. Supporting flame structure measurements, with and without suppressants, are performed using a steady counter-flow diffusion flame apparatus. These experiments along with numerical modeling will reveal and quantify physical and chemical suppression mechanisms. A better understanding of fire suppression mechanisms will assist in the selection of an optimal suppressant and application method for a particular environment. The results from these tests will also aid in finding halon substitutes by identifying important properties of fire suppressants.

D

Dai, Z.

Dai, Z.; Tseng, L. K.; Faeth, G. M.
Mixture-Fraction and Velocity Statistics in Fully-Developed Plumes.
University of Michigan, Ann Arbor
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 173-176 pp, 1993.

combustion; turbulent combustion; plumes; velocity

An experimental investigation of mean and fluctuating mixture fractions and velocities within fully-developed round turbulent plumes is described. This problem is of interest as a classical buoyant turbulent flow that is relevant to flows found in fire environments. Conditions within the fully-developed, or self-preserving, portions of the flow were emphasized, where both mean and turbulent properties exhibit similarity when variables are scaled appropriately. Such conditions are helpful because turbulent flows is faciliated because effects of extraneous source disturbances have been lost.

Davis, G.

Davis, G.; Gross, J. G.
Standards Development in North America for Performance of Whole Buildings and Facilities.
International Center for Facilities, Ontario, Canada
National Institute of Standards and Technology, Gaithersburg, MD
Conseil International du Batiment (CIB). Some Examples of the Application of the Performance Concept in Buildings. The Performance Concept in Building. CIB Report Publication 157. W60. May 1993, 61-66 pp, 1993.

standards; office buildings; performance evaluation

This paper reviews the activities of ASTM Committee E06 on Performance of Buildings and the Subcommittee E06.25 on Whole Buildings and Facilities. Planned standards activities are outlined for 14 task groups. Under development are standards related to objective rating of quality and functionality of office facilities, area measurements, scales for comparing the operation and maintenance of facilities, rating scales for comparing the functionality and quality of educational facilities, behavioral measures, measurement of serviceability, rating buildings for their overall energy performance and monitoring and comparing end-use electrical consumption of commercial buildings and monitoring the energy use of residential buildings. An overview of the full ASTM Committee E06 on Performance of Buildings is provided.

Dawson, H.

Dawson, H.; diMarzo, M.
Experimental Study of Multiple Droplet Evaporative Cooling. Final Report. September 1991-December 1992.
Maryland Univ., College Park
NIST-GCR-93-624; Report 92-1; 116 p. April 1993.
Available from National Technical Information Services
PB93-198463

cooling; drop sizes; droplets; evaporation; solid surfaces; water

Techniques of infrared thermography were used to conduct an experimental study of the evaporative cooling of a hot, low thermal conductivity, non-metallic surface heated by radiation and subject to a random array of impinging water droplets. A droplet generating and distributing apparatus and a data acquisition system employing digital image analysis devices were also developed and implemented. Real time infrared images of the heated surface were recorded and digitized using computer resident fram grabbing hardware and analyzed on a pizel bases, giving a high degree of thermal and spatial resolution. From these analyses, the instantaneous surface temperature distribution and transient surface temperature profile were obtained for a range of initial temperatures and impinging mass fluxes. The surface temperature was found to decay exponentially with time to a steady state value for the fluxes used. Three dimensional plots of the temperature distribution on the surface also showed the significant lowering of the average surface temperature, and provided a qualitative description of the cooling phenomena at various stages during the transient. Results obtained will be used in the future validation of a computer model of the phenomena.

Deal, S.

Deal, S.
Evaluating Small Board and Care Homes: Sprinklered vs. Nonsprinklered Fire Protection.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5302; 63 p. November 1993.
Available from National Technical Information Services

board and care homes; sprinklers; fire protection; computer models; hazard analysis; evacuation time; fire detection; compartmentation; safety; toxicity

This report studied the effectiveness of sprinklered and nonsprinklered fire protection options in small Board and Care homes. The tools used to compare the effectiveness of these fire protection options were mathematical fire models, experimental data and documented fire incidents. The mathematical models estimated fire protection effectiveness through a margin of safety analysis. The margin of safety is defined in this report as the excess time an evacuee has to reach a point of safety before that evacuee's exit path becomes untenable. The margin of safety calculations considered fire growth, detection/alarm activation, evacuee egress movement and smoke tenability analysis. Two egress movement plans were simulated; one plan reflected necessary movement in a one-exit home, the second plan reflected movement in a two-exit home. Two fast-growing large flashover fires (with high and low CO production rates) and a small, smoldering fire were modeled. Two sets of full-scale sprinklered and post-flashover fire experiments, as well as 61 documented fire incidents were included in the study of fire protection system effectiveness. The overwhelming majority of B&C fatalities occur to residents who are challenged by some disability. This disability can be mental, developmental or physical. Examination using mathematical modeling supports the use of compartmentation/evacuation in providing the same margin of safety as sprinklers during the first 15 minutes of a ground floor fire when barriers perform according to their fire-resistance ratings. Examination of the historical fire record supports sprinkler effectiveness. To date, sprinklers are more reliable and more effective than compartmentation at preventing fatalities and protecting property in the occupancy. Detection system false alarms, smoke leakage through concealed spaces, fire degradation of wall and ceiling sheathing, and resident injuries which hamper evacuation all contrive to reduce reliability of the compartmentation/evacuation system, even when doors are not chocked open.

Domanski, P. A.

Domanski, P. A.; Didion, D. A.
Theoretical Evaluation of R22 and R502 Alternatives.
National Institute of Standards and Technology, Gaithersburg, MD
DOE/CE/23810-7; ARTI MCLR Project 650-50900; 27 p. January 1993.

refrigerants; heat transfer; evaluation; equations

The report presents the performance evaluation of nine R22 altervatives and three R502 alternatives. The study was conducted using a semi-theoretical model, CYCLE-11, with a pure cross-flow representation of heat transfer in the evaporator and condenser. The Carnahan-Starling-DeSantis equation of state was used for calculating thermodynamic properties. Transport properties were not involved in the simulations. Simulations were conducted for "drop-in" performance, for performance in a modified system to assess the fluids' potentials, and for performance in a modified system equipped with a liquid-line/suction-line heat exchanger. The results - presented on a relative basis to R22 and R502 performance - include the volumetric capacity, coefficient of performance, pressure increase across the compressor, and compressor discharge pressure and temperature.

Domanski, P. A.; Didion, D. A.
Thermodynamic Evaluation of R-22 Alternative Refrigerants and Refrigerant Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions: Symposia, Vol. 99, No. 2, 636-648, 1993.

refrigerants; thermodynamics; fluids; heat exchanger loading; heat transfer

This paper presents the performance evaluation of nine R-22 alternatives. The study was conducted using a semi-theoretical model, CYCLE-11, with a pure cross-flow representation of heat transfer in the evaporator and condenser. The Carnahan-Starling-DeSantis equation of state was used for calculating thermodynamic properties. Simulations were conducted for "drop-in" performance, for performance in a modified system to assess the fluids' potentials, and for performance in a modified system equipped with a liquid-linesuction-line heat exchanger. The results - presented on a relative basis to R-22 performance - include the volumetric capacity, coefficient of performance (COP), and compressor discharge pressure and temperature.

Duffin, W. J.

Duffin, W. J., Editor
1993 Annual Conference on Fire Research: Book of Abstracts.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5280; 209 p. October 1993.
Available from National Technical Information Services
PB94-121324

fire research; burning rate; fire detection; hazard analysis; fire models; fire risk; fire tests; flame spread; halons; plumes; suppression; water; smoke

The NIST Annual Conference on Fire research has long been a prime forum for presentation and discussion of the latest advances in fire science and engineering. The conference includes mostly fire research performed within Federal laboratories, or sponsored by Federal agencies. However, some private sector and foreign fire research is also included.

E

Evans, D. D.

Evans, D. D.
Sprinkler Fire Suppression Algorithm for HAZARD.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5254; 21 p. August 1993.
Available from National Technical Information Services
PB94-103678
U.S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 11th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan, Building Research Inst., Ibaraki, Japan, 114-120 pp, 1992.

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

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.

Ewens, D. S.

Ewens, D. S.; Vandsburger, U.; Roby, R. J.
Oxidation of Exhaust Gases From a Burning Compartment in a Remote Location.
Virginia Polytechnic Institute and State Univ., Blacksburg
Hughes Associates, Inc., Columbia, MD
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 323-326 pp, 1993.

combustion; exhaust gases; oxidation; compartments; experiments

Compartment fires under fuel rich conditions (typical of post flashover compartment fires) have been shown to produce hazardous levels of carbon monoxide and smoke. External burning occurs when fuel rich exhaust gases spill out of the compartment, mix with air, ignite and burn. Previous research has investigated the effect of external burning on exhaust gases spilling into the open atmosphere mixing with ambient air. That research has shown significant oxidation of carbon monoxide and smoke during sustained external burning of the exhausting gases. However, the leading cause of deaths in compartment fires is carbon monoxide inhalation in neighboring rooms, remote from the fire. The present study focuses on the transport, and oxidation, of fuel rich exhaust gases spilling into enclosed spaces located adjacent to and remotely from a compartment fire.

F

Fanney, A. H.

Fanney, A. H.
Field Monitoring of a Variable-Speed Integrated Heat Pump/Water Heating Appliance.
National Institute of Standards and Technology, Gaithersburg, MD
NIST BSS 171; 59 p. June 1993.
Available from Government Printing Office
SN003-003-03223-9

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

This report summarizes a study in which a variable-speed integrated heat pump/water heating appliance was monitored for 2 years while meeting the space conditioning and water heating needs of an occupied residence. Experimental results are presented which show that the total energy consumed by the residence was significantly reduced compared to previous years in which electric baseboard heat, a wood stove, and window air-conditioners were used. During the two space heating seasons, the variable-speed integrated heat pump/water heating appliance used 60% less energy than would have been consumed by an electric furnace with the same air distrubition system and a storage-type electric water heater. The monthly space cooling only coefficients of performance ranged from 2.50 to 4.03, whereas, the monthly space heating only coefficients of performance ranged from a low of 0.91 to a high of 3.33. A proposed index to quantify the overall system performance of integrated water heating/space conditioning appliances, referred to as the combined performance factor, ranged from 1.55 to 3.50. The majority of larger values occurred during months in which space cooling dominated. The combined performance factor for the entire 2-year study was 2.45. A conventional watthour meter supplied by the local electrical utility and an electronic digital power analyzer were used to measure the energy consumption of the variable speed heat pump in order to discern if variable-speed equipment introduces errors in conventional utility metering equipment. Measurements made using the two instruments were in excellent agreement. The monthly energy consumption and peak electrical demands of the residence, integrated heat pump/water heating appliance, supplemental space heater, and water heater are discussed. The influence of outdoor temperature on electrical power demand is presented.

Farias, T.

Farias, T.; Carvalho, M. G.; Koylu, U. O.; Faeth, G. M.
Computational Study of the Absorption and Scattering Properties of Soot.
Instituto Superior Tecnico, Lisbon, Portgal
University of Michigan, Ann Arbor
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 394-397 pp, 1993.

combustion; soot; absorption; scattering coefficient; simulation; aggregates

Soot is present within most nonpremixed hydrocarbon-fueled flames, which affects their structure, radiation and pollutant emission properties. Thus, the absorption and scattering properties of soot are of interest in order to estimate continuum radiation from soot and to interpret nonintrusive optical measurements of soot concentrations and structure. Soot optical properties are challenging, however, dut to the complexity of soot structure. For example, while soot consists of small primary particles that individually satisfy the small particle (Rayleigh) scattering approximation, these particles form branched aggregates that exhibit neither Rayleigh nor Mie scattering behavior. Nevertheless, a potentially useful approximate theory of soot optical properties (denoted RDG-FA theory in the following) has been developed recently, based on the Rayleigh-Debye-Gans (RDG) scattering approximation while assuming that soot aggregates are mass-fractal objects. Past theoretical and experimental evaluations of RDG-GA theory, however, have not been definitive due to computational and experimental limitations. Thus, the objective of the present investigation was to complete an additional theoretical evaluation of RDG-FA theory for soot, based on computations using more exact theory for populations of mass-fractal aggregates having prescribed properties.

Fattal, S. G.

Fattal, S. G.
Effect of Critical Parameters on the Behavior of Partially-Grouted Masonry Shear Walls Under Lateral Loads.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5116; 45 p. June 1993.
Available from National Technical Information Services

masonry; shear walls; building technology; critical parameters; reinforced walls; shear strength; test strength; structural design; ultimate deformations; ultimate strength

The effect of critical parameters on lateral-load response characteristics of partially-grouted masonry shear walls is evaluated by conducting a synthesis of available experimental data and by utilizing a predictive equation to estimate ultimate shear strength. The results of the study indicate a need to supplement the existing data base with additional experimental and analytical research to develop an adequate basis for design of masonry shear walls. Recommendations are made on the specific areas of research to accomplish this design objective.

Fattal, S. G.
Research Plan for Masonry Shear Walls.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5117; 33 p. June 1993.
Available from National Technical Information Services
PB93-206183

masonry; shear walls; building technology; deformations; earthquakes; limit states; partially-grouted; reinforcement; shear strength; strength design; tests

A masonry research plan is presented based on studies of the behavior of masonry shear walls conducted at the National Institute of Standards and Technology (NIST). The purpose of the plan is to acquire additional information to allow formulation of a design methodology. It consists of experimental and analytical investigations of masonry shear walls subjected reverse cyclic lateral loads. The experimental program consists of tests of lightly-reinforced and partially-grouted specimens representing design and construction practices in regions of low-to moderate seismicity. The analytical work consists of formulations of equations to evaluate strength and deformation limit states, and numerical studies of discrete models.

Fattal, S. G.
Strength of Partially-Grouted Masonry Shear Walls Under Lateral Loads.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5147; 67 p. June 1993.
Available from National Technical Information Services
PB93-206225

building technology; masonry walls; predicted strength; reinforced walls; sheat strength; shear walls; measured strength

A proposed equation for estimating the strength of partially-grouted masonry shear walls failing in the shear mode is used to compare predicted strengths with the test results of 72 specimens from three experimental programs. The comparison shows that the predictions become less consistent with decreasing specimen strength and amount of reinforcement. Overall, predictions were within 20% of the test results for 50% of the specimens. For unreinforced walls and walls which had no vertical reinforcement, the predicted strength was less than half the test strength. It is shown that by altering the parametric functions in the predictive equation to represent more closely post-cracking resistance mechanisms in shear walls, the correlation of prediction with measured strength can be improved significantly.

Fernandez-Pello, A. C.

Fernandez-Pello, A. C.
Fire Propagation in Concurrent Flows. Annual Progress Report. September 1, 1991-August 31, 1992.
California Univ., Berkeley
Annual Progress Report; 17 p. 1993.

fire spread; gas flow; oxygen concentration; experiments; turbulent flow; laminar flow

A research program is being conducted to study the mechanisms controlling the spread of fire in oxidizing gas flows moving in the direction of flame propagation. During this reporting period research has been conducted to study concurrent flame spread under varied oxygen concentrations, with emphasis on vitiated conditions. Experiments have been completed with laminar flow, and are currently underway in turbulent flow. 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. Experiments are conducted with thick PMMA sheets as fuel and mixtures of oxygen nitrogen as oxidizer. The results of the experiments show that at low oxygen concentrations, the flame spread rate increases almost linearly as the flow velocity or oxygen concentration is increased. For high oxygen concentrations, the dependence of the 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.

Fischer, R. M.

Fischer, R. M.; Ketola, W. D.; Martin, J.; Jorgensen, G.; Mertzel, E.; Pernisz, U.; Zerlaut, G.
Accelerated Life Testing of Devices With S/S, S/L, and S/G Interfaces.
3M Company, St. Paul, MN
National Institute of Standards and Technology, Gaithersburg, MD
National Renewable Energy Lab.
Goodrich (B. F.) Co., Avon Lake, OH
Dow Chemical, Midland, MI
SC-International Inc.
Critical Reviews in Surface Chemistry, Vol. 2, No. 4, 311-321, 1993.

devices; service life; weather effects; degradation; climate

A new approach for predicting service life for today's more durable materials exposed in an exterior weathering environment is proposed. Five priorities were identified and discussed: (1) adopt a new service life prediction methodology for weathering environments, (2) develop appropriate models for predicting "real" service life from accelerated tests, (3) quantify the stresses in exterior environments, (4) define and understand degradation mechanisms and their relationship to weathering stresses, (5) establish data bases for quantified climatic stresses and material responses to these stresses.

Forney, G. P.

Forney, G. P.; Bukowski, R. W.; Davis, W. D.
Field Modeling: Effects of Flat Beamed Ceilings on Detector and Sprinkler Response. International Fire Detection Research Project. Technical Report. Year 1.
National Institute of Standards and Technology, Gaithersburg, MD
Technical Report; Year 1; 59 p. October 1993.
Available from National Fire Protection Research Foundation,
Batterymarch Park, Quincy, MA 02269

fire detection; ceilings; detector response; sprinkler response; equations; turbulence; heat transfer; case histories; data analysis

This report documents 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. The second task consisted of performing a parameter study to show the effect of sensor response under beamed ceilings for various geometries and fire growth rates. 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 growth rates, beam depths, beam spacings and ceiling heights. These data are summarized and recommendations are made on placing sensors in rooms with beamed ceilings.

Fowell, A. J.

Fowell, A. J.
Developments Needed to Expand the Role of Fire Modeling in Material Fire Hazard Assessment.
National Institute of Standards and Technology, Gaithersburg, MD
Federal Aviation Administration (FAA). International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials. February 9-11, 1993, Atlantic City, NJ, 255-262 pp, 1993.
Available from National Technical Information Services
DOT/FAA/CT-93/3

aircraft interiors; fire resistant materials; test methods; fire safety; fire hazard; hazard assessment; fire models; validation; databases

To assess the fire hazards associated with aircraft interior materials, prediction of how the materials perform under different fire scenarios is needed. This requires information on a variety of fire characteristics including thermal inertia, ease of ignition, rate of heat release, flame spread, products of combustion and the response to suppressants. Exposure conditions such as location, orientation, ventilation and proximity to other materials can influence some of those characteristics. Pass/fail test methods of the past cannot provide the information to assure fire safety under a variety of circumstances. Fire modeling in combination with new bench scale material flammability test methods can meet the need. National and international developments in model validation, documentation and acceptance are presented. The transition to aircraft cabin fire hazard assessment using fire models requires a data base on material fire properties. The case is made for greater use of improved bench scale test methods which can provide data suitable for use in the fire models.

Fowell, A. J.
Fire Hazard Model Developments and Research Efforts at NIST.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Retardant Chemicals Association. International Conference on Fire Safety. Spring Conference, 1993. March 21-24, 1993, New Orleans, LA, Fire Retardant Chemicals Assoc., Lancaster, PA, 205-212 pp, 1993.

fire safety; research facilities; fire research; fire hazards; validation; databases

Historically, fire safety decisions on the suitability of materials for specific applications have been based on the use of standard fire tests, each designed to represent a single fire scenario. These standard fire tests are generally used as pass/fail tests, thereby providing very little information about the performance of the material in a scenario different from that represented by the test. To assess the real fire safety benefits or fire hazards of different materials requires prediction of material performance under different fire scenarios. Versatile predictive fire models in combination with data from new bench scale material flammability measurement methods will someday meet the need.

Frey, M.

Frey, M.; Simiu, E.
Deterministic and Stochastic Chaos.
Bucknell Univ., Lewisburg, PA
National Institute of Standards and Technology, Gaithersburg, MD
Computational Stochastic Mechanics, Computational Mechanics Publications, Boston, MA, Cheng, A. H. D.; Yang, C. Y., Editors, 195-216 pp, 1993.

equations; noise (sound); deterministic chaos; stochastic chaos; duffing oscillator; excitation

Stochastic differential equations and classical techniques related to the Fokker-Planck equation are standard bases for the analysis of nonlinear systems perturbed by noise. An alternative, complementary approach applicable to systems featuring heteroclinic or homoclinic orbits uses phase space flux as a measure of noise-induced chaotic dynamics. We continue our development of this method, extending our previous treatment of additive noise to the more general case of multiplicative noise. This extension is used with a new model of shot noise to treat the Duffing oscillator with shot noise-like dissipation.

Frey, M.; Simiu, E.
Noise-Induced Chaos and Phase Space Flux.
National Institute of Standards and Technology, Gaithersburg, MD
Physica D, Vol. 63, 321-340, 1993.

noise (sound); chaos; space flux; global perturbation methods; homoclinic orbit; asymptotic mean stationarity; sample-theoretic method

We study the effect of additive noise on near-integrable second-order dynmaical systems whose unperturbed flows have homoxlinic or heteroclinic orbits. The noise is represented by a type of Shinozuka stochastic process capable of artitrarily closely approximating Gaussian noise with any specified spectrum. We derive a formula for the flux factor applicable for any asymptotic mean stationary excitation. This derivation shows that, to first order, the effect of the external excitation on the system is mediated by a linear filter associated with the system homocolinic or heteroclinic orbit. It also shows that the stationary mean distribution of the filtered excitation determines the average phase space flux. This is true for both random and nonrandom excitations and indicates that, for the dynamical systems considered here, these two classes of excitation play substantially equivalent roles in the promotion of chaos.

Frohnsdorff, G.

Frohnsdorff, G. and Gross, J. L., Editors
High-Performance Construction Materials and Systems: An Essential Program for America and Its Infrastructure.
National Institute of Standards and Technology, Gaithersburg, MD
Technical Report 93-5011; 211 p. April 1993.
Available from American Society of Civil Engineers, Salem, MA

construction materials; concretes; standards; steel structures; construction; steels; technology transfer; management systems

This report, High Performance Construction Materials and Systems: An Essential Program for America and Its Infrastructure - Technical Report (Report No. 93-5011), outlines a program for a concerted effort to return the United States to the forefront of construction materials technology. The main two materials addressed in this report, the first of a series, are high performance concrete and steel. These two technologies are examined in parallel, first addressing the need for a unified, national program, then detailing a proposed national program plan, and a concomitant technical plan, management plan, and budget summary. The need for these programs is surveyed, in terms of the importance of these technologies, recent advances in materials science, potential benefits from the technology, and a vision of the future. The report then defines the goals of the nationally coordinated program. The technical plan describes mechanisms for improving technology transfer, as well as proposed research and development on high performance concrete and steel. The management plan discusses the requirements for a coordinated effort, including the establishment of several coordinating bodies made up of representatives from industry, government, and academia. Finally, the report presents a proposed budget and time schedule for converting the plan into reality. The report also contains three appendices: Appendix A - Technology Transfer, Appendix B - High Performance Concrete; and Appendix C - High Performance Steel. Appendix A - Technology Transfer depicts a number of methods for collecting and disseminating technical knowledge to the design and construction industry, as well as means for accelerating the acceptance of new technology. Appendix B provides a detailed examination of the state-of-the-art of materials and techniques relative to high-performance concrete. Appendix C provides a similar examination of the state-of-the-art of materials and techniques relative to high-performance steel.

G

Gaddy, G. D.

Gaddy, G. D.; Barbari, T. A.; Cullen, W. C.; Rossiter, W. J., Jr.
Impact of Exposure Conditions on the Mechanical Properties of Polyisocyanurate Foam Insulations.
Johns Hopkins Univ., Baltimore, MD
National Roofing Contractors Assoc., Rosemont, IL
National Institute of Standards and Technology, Gaithersburg, MD
National Roofing Contractors Association. Problems: Issues and Answers. 10th Conference on Roofing Technology, Proceedings. April 22-23, 1993, Gaithersburg, MD, National Roofing Contractors Assoc., Rosemont, IL, 64-71 pp, 1993.

polyisocyanurate foam; insulation; mechanical properties; blowing agents; building technolody; field exposure; roofing; low-sloped roofs; temperature exposures

The effects of various exposure conditions on tensile modulus, tensile yield strength, compressive modulus, and compressive yield strength of polyisocyanurate foam roofing insulation materials were investigated. The three foams, CFC-11, HCFC-14lb, and CFC-11/CO2 co-blown, tested in this study decreased in density, except the field-aged materials which did not change, with exposure time and no decrease in compressional modulus and compressional yield strength for laboratory exposure. The decreases in density were accounted for by the exchange of the less dense air for more dense blowing agent. The lack of decreases in the compressive properties may be due to a number of factors, including loss of the blowing agent which acts as a plasticizer when dissolved in the polymer and the completion of crosslinking reactions in the polymer. Some field exposed samples showed a decrease in compressional modulus which is attributed to the presence of blowing agent dissolved in the polymer. The extent to which each of these parameters contributes to the observed changes was beyond the scope of this study.

Gann, R. G.

Gann, R. G.; Braun, E.; Cleary, T. G.; Harris, R. H., Jr.; Horkay, F.; Linteris, G. T.; McKenna, G. B.; Nyden, M. R.; Peacock, R. D.; Ricker, R. E.; Stoudt, M. R.; Waldron, W. K.
Agent/System Compatibility for Halon 1301 Aviation Replacement.
National Institute of Standards and Technology, Gaithersburg, MD
U. S. Environmental Protection Agency, Enviornment Canada and United National Environmental Program. International CFC and Halon Alternatives Congerence, 1993. Stratospheric Ozone Protection for the 90's. October 20-22, 1993, Washington, DC, 753-760 pp, 1993.

halons; ozone; halon 1301; compatability; residues; storage; stability; combustion products; corrosion; elastomers; exposure

This project has developed measurement methods and provided data for the appraisal of 12 USAF-specified candidate halon 1301 replacements for compatibility with flight systems, people, and the environment. The exposures of metals, elastomers and lubricants involve an initial temperature and pressure of 298 K (77 deg F) and 4.1 MPa (600 psi), with a final temperature of 422 K (300 deg F). These data and those from the companion project, "Agent Screening for Halon 1301 Aviation Replacement," will enable the selection by September 30, 1993 of 3 of the chemicals for full-scale testing by the Air Force. Longer-term testing will then be commenced to increase confidence in the preliminary results for materials compatibility. A final report will be delivered by September 30, 1995.

Garboczi, E. J.

Garboczi, E. J.
Computational Materials Science of Cement-Based Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Materials and Structures, Vol. 26, 191-195, 1993.

cements; computational materials; microstructure; capillary pore space; transport properties; interfacial zone; percolation theory; calcium hydroxide leaching

This paper describes recent research and theoretical results obtained for cement-based materials using computational materials science techniques. Computer-generated microstructure models are used to simulate the microstructure development during hydration, and exact algorithms are applied to these models to compute experimentally verifiable physical properties. Good agreement is found between experimental and simulation results.

Garboczi, E. J.; Bentz, D. P.
Computational Materials Science of Cement-Based Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Materials Research Society MRS Bulletin, Vol. 18, No. 3, 50-83, March 1993.

cements; computational materials; microstructure; capillary pore space; electrical properties; diffusion; elastic properties

Cement-based materials are random composite materials over many length scales. In common with any random material, the two main problems that must be solved to obtain quantitative theoretical understanding of microstructure-property relationships are: (1) what actually is the microstructure, and (2) given enough knowledge of a microstructure, how can properties be calculated? In the past few decades, physicts and chemists have studied microstructure/property relationships for atomically disordered materials like semiconductor and metallic glasses, while mechanical engineers have done the same for continuum problems of macroscopic inclusions of one material distributed in a matrix of a second material. With the large memories and fast computational speeds of late 20th-century computers, it is now possible to attack problems that lie between these two extremes, namely random grain problems like those of cement-based and ceramic materials. For these kinds of materials, the important randomness for most problems is at the grain or particle level, not the atomic level, and is complicated by the fact that their microstructure changes markedly on time scales of hours and days, either due to sintering (ceramics), or hydration reactions (cement-based materials). The following sections of this paper describe how microstructures are simulated and properties like electrical conductivity and elastic moduli are computed - mostly for cement-based materials, but with some mention of parallel work on ceramic materials.

Ghoniem, A. F.

Ghoniem, A. F.; Zhang, X.; Knio, O.; Baum, H. R.; Rehm, R. G.
Dispersion and Deposition of Smoke Plumes Generated in Massive Fires.
Massachusetts Institute of Technology, Cambridge
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Hazardous Materials, Vol. 33, 275-293, 1993.

plumes; dispersion; smoke

Massive fires resulting from the uncontrolled burning of crude oil from spills or industrial accidents produce large smoke-laden buoyant plumes which rise in the wind direction before they equilibrate within a stably stratified atmosphere. Beyond this point, the plume material cools by entrainment and the plume becomes negatively buoyant due to the heavy smoke loading. The trajectory of the descending plume, which determines the ground distribution of smoke, is the subject of this paper. A computational model for the simulation of large-scale smoke plumes resulting from such fires is developed and applied to investigate the effects of the plume initial properties on its trajectory and smoke deposition patterns. Attention is focused on the descent and dispersion of wind-driven plumes in a homogeneous atmosphere, and the smoke deposition on flat terrain. Results show that the plume dynamics in the cross-wind direction are dominated by two buoyantly generated, coherent, streamwise vortices which distort the plume cross section into a kidney-shaped structure. The strength of the two vortices and their separation increase as the plume falls. The plume width grows under the action of these vortices at a rate which increases as the plume falls. The plume width grows under the action of these vortices at a rate which increases as the plume settles on the ground, leading to a smoke footprint which does not resemble the prediction of Gaussian dispersion models. The effects of the injection altitude and the initial shape of the plume cross section on the transport and dispersion of the negatively buoyant smoke plume are investigated. Plumes falling from higher elevations disperse more in the vertical direction while those falling from lower elevations disperse further in the horizontal cross-wind direction. Plumes with circular cross-sections reach the ground faster and disperse horizontally further than plumes with elliptical cross-sections with the minor axes in the vertical direction. Vertical plume dispersion is weakly dependent on the shape of its initial cross-section.

Glaser, S.

Glaser, S.
Estimating In Situ Liquefaction Potential and Permanent Ground Displacements Due to Liquefaction for the Siting of Lifelines.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5150; 108 p. March 1993.
Available from National Technical Information Services
PB93-178614

liquefaction; building technology; earthquakes; in situ testing; lifelines; material properties; permanent soil displacements

This report examines the state-of-the-art of two aspects of the liquefaction problem with special attention to lifelines. In situ methods of estimating liquefaction potential are studied, since it is believed to be impossible to test in the laboratory an "undisturbed" sample of loose sand, which is most susceptible to liquefaction. The state-of-practice is the SPT-based method championed by Seed, although the velocity-based predictors have a stronger physical basis. The Spectral Analysis of Surface Waves technique is especially suited for examining the large areal extents of lifeline routes. The state-of-the-art for estimating permanent ground displacements is purely empirical. Several methods are examined, and they all appear to have equal predictive abilities - within a factor of four. There have been a few recent attempts to construct constitutive models for post-liquefaction displacements, but at this time they are in formative stages and have not been rigorously proven.

Glaser, S.
Estimating Soil Parameters Important for Lifeline Siting Using System Identification Techniques.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5143; 96 p. March 1993.
Available from National Technical Information Services
PB93-178606

system identification; ARMA modeling; building technology; earthquakes; in situ testing; lifelines; liquefaction; spectral analysis

Liquefaction causes a large portion of all damage done by earthquakes. The damage is especially severe to lifeline structure such as pipelines. This report examines the state-of-the-art of the application of System Identification (SI) methods to the liquefaction problem, with special attention to lifelines. System identification is seen as the best way to ascertain large strain soil properties in situ. A thorough introduction to SI methods and spectral analysis is given. The traditional Fourier-based methods are found to be inexact since the sample variance is equal to the sample mean if averaging techniques are not used. There is an additional problem since earthquake signals are not stationary. Autoregressive-moving average models are seen as a better analysis method, especially the newer adaptive methods that are designed for non-stationary singlans. A significant bibliography is included.

Gmurczyk, G.

Gmurczyk, G.; Grosshandler, W. L.; Peltz, M.; Lowe, D. L.
Facility for Assessing Suppression Effectiveness in High Speed Turbulent Flames.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Fall Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 487-490 pp, 1993.

turbulent flames; suppression; halon 1301; aircraft engines; nacelle fires; fire protection; nitrogen

The work described in this paper is part of a larger effort focused on finding alternatives to halon 1301 for application to aircraft engine nacelle and dry bay in-flight fire protection. The engine nacelle encases the compressor, combustor and turbine. Protection is required to eliminate a possible fire resulting from leaking fuel, hydraulic, or lubrication lines. Dry bays refer to closed spaces in the wings and fuselage, inaccessible in flight, and into which fuel could spray and possibly ignite following an equipment malfunction. Alternative chemical compounds are sought which do not create unacceptable safety, environmental, or systems compatibility problems. Four burner arrangements are being used to rank the relative suppression effectiveness of different gaseous agents: [1] a cup burner similar to the design of Sheinson et al. (1989) [2] an opposed flow diffusion flame (OFDF) burner following the technique developed by Seshadri (1977), [3] a turbulent spray flame burner (Grosshandler et al., 1993), and [4] a detonation tube. The detonation tube discussed in this article has been chosen to examine the performance of alternative agents in a highly dynamic situation, in which the residence time of the agent in the reaction zone is an order of magnitude shorter than in the other three burners and in which pressure effects on the chemistry are thought to be important.

Groner, N. E.

Groner, N. E.
Guide to Board and Care Fire Safety Requirements in the 1991 Edition of the Life Safety Code.
George Mason Univ., Fairfax, VA
NIST-GCR-93-629; 151 p. July 1993.
Available from National Technical Information Services
PB93-220820

board and care homes; codes; egress; elderly persons; evacuation; fire emergency planning; fire safety; handicapped; NFPA 101; residential buildings; sprinklers

The board and care requirements in the Life Safety Code are often complicated and difficult to understand. This guide offers clear explanations and interpretations of the board and care requirements in the 1991 Edition of the Life Safety Code. Included are chapters that cover the historical origins of the requirements and explanations of the contents and administration of the Life Safety Code in general. Also included are an appendix that suggests appropriate requirements for very small board and care homes (fewer than four residents) and another appendix that offers fire emergency planning advice.

Gross, J. L.

Gross, J. L.
Plastic Hinge-Based Techniques for Advanced Analysis. Workgroup Summary Report.
National Institute of Standards and Technology, Gaithersburg, MD
Structural Stability Research Council. Plastic Hinge Based Methods for Advanced Analysis and Design of Steel Frames: An Assessment of the State-of-the-Art. March 1993, White, D. W., 175-177 pp, 1993.

plastics; design applications; steel frames; physical characteristics; geometrical effects; material effects; loading effects

The purpose of this workgroup was to demonstrate, clarify, and discuss the current capabilities and limitations of contemporary plastic hinge-based methods for advanced analysis and design of steel frames. The approach taken was to discuss and comment on whether capabilities of current methods are essential to advanced analysis, beneficial (and under what circumstances), or whether there is insufficient information for immediate application of the capability. Some capabilities were assumed to be beyond the present scope and were not addressed.

Gross, J. L.; Heckert, N. A.; Lechner, J. A.; Simiu, E.
Modeling of Extreme Loading by 'Peaks Over Threshold' Methods.
National Institute of Standards and Technology, Gaithersburg, MD
Dynamic Response and Progressive Failure of Special Structures. Response of Truss and Truss-Type Structures During Progressive Failure and Dynamic Loading and Analysis of Structures, Proceedings of the Technical Sessions. June 6-9, 1993, Charlottesville, VA, Malla, R. B., Editor, 135-147 pp, 1993.

extreme value theory; monte carlo method; peaks over threshold; wind velocity; simulations

In the past twenty years a new body of extreme value theory has been developed for the estimation of extremes from data exceeding a sufficienty high threshold. In the work reported herein, we seek to apply the "peaks over threshold" theory to the estimation of extreme wind speeds. The studies presented are based on Monte Carlo simulations for which the parameters of the population distributions were estimated from sets of actual extreme wind speed data. Results are presented 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 using largest yearly wind speeds. 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.

Grosshandler, W. L.

Grosshandler, W. L.
RADCAL: A Narrow-Band Model for Radiation Calculations in a Combustion Environment.
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1402; 52 p. April 1993.
Available from Government Printing Office
SN003-003-03215-8

models; radiation; combustion; radiative heat transfer; spectra; spectral absorptivity; spectral emissivity

Radiation within a medium containing products of combustion is dependent upon the temperature and concentrations throughout the entire field. The energy is distributed across the infrared spectrum in a highly nonlinear fashion, which greatly complicates modeling of the heat transfer within a burning environment. This report describes a numerical program, RADCAL, which predicts the radiant intensity leaving a nonisothermal volume containing nonuniform levels of carbon dioxide, water vapor, methane, carbon monoxide, nitrogen, oxygen, and soot. The absorption coefficient of the combined gases is calculated from a narrow-band model and a combination of tabulated spectral properties and theoretical approximations to the vibrational-rotational molecular bands. Soot is treated as a purely absorbing substance in the Rayleigh limit. Background on the development of the model, example calculations, and an explanation of input procedures are presented.

Grosshandler, W. L.; Braun, E.
Early Detection of Room Fires Through Acoustic Emission.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5269; 17 p. October 1993.
Available from National Technical Information Services
PB94-112257

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

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.; Hamins, A.; Nyden, M. R.; Pitts, W. M.; Yang, J.; Zachariah, M.
Agent Screening for Halon 1301 Aviation Replacement.
National Institute of Standards and Technology, Gaithersburg, MD
U. S. Environmental Protection Agency, Enviornment Canada and United National Environmental Program. International CFC and Halon Alternatives Congerence, 1993. Stratospheric Ozone Protection for the 90's. October 20-22, 1993, Washington, DC, 744-752 pp, 1993.

halons; ozone; halon 1301; thermal properties; dispersions; fluid mechanics; flame extinguishment; flammable materials

A comprehensive experimental program is described in which eleven gaseous agents and sodium bicarbonate powder have been screened, so that the best three candidates for subsequent full-scale aircraft fire extinguishment evaluation can be identified. Chemicals with both a low ozone depletion potential and a high fire suppression efficiency were sought. Because the effectiveness of a fire suppression agent is known to be related to its thermodynamic properties, its behavior during two-phase flow, its interaction with flame chemistry, the timing of its release and the nature of the fire, a series of carefully designed experiments was conducted to examine each of these factors. Theoretical models were used to interpret the results, to increase our understanding of the suppression process, and to predict behavior over an expanded range of operating conditions. A pressure vessel with a rupture disc was used to discharge the agent into the atmosphere. Nine pure fluorocarbons, two mono-chlorinated fluorocarbons, a fluorocarbon azeotrope, and sodium bicarbonate powder were tested mixed with nitrogen or CF3H. The existing jet was photographed and laser light extinction was used to determine the extent and velocity of the jet. Four different type flame measurements were used to characterize suppression effectiveness. A description of the various flame screens is presented here. Chemical kinetics and molecular dynamic modeling were used as a means to investigate the extinction mechanism and to identify alternative gaseous chemicals likely to be superior to the original list of eleven.

Grosshandler, W. L.; Lowe, D. L.; Rinkinen, W. J.; Presser, C.
Turbulent Spray Burner for Assessing Halon Alternative Fire Suppressants.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers (ASME). Winter Annual Meeting. November 28-December 3, 1993, 93-WA/HT-23, New Orleans, LA, 1-8 pp, 1993.

halons; halon 1301; in-flight fires; fire protection; air velocity; injection; nitrogen; pressure

A research program to characterize candidate compounds for replacing halon 1301 for in-flight aircraft fire protection is described in this paper. The thermodynamical, fluid mechanical, and flame extinction properties are examined, and a number of fuels and flame arrangements are investigated in an attempt to develop a general test protocol which will reliably predict the relative fire suppression efficiency of new agents being considered for a variety of applications. A coaxial turbulent spray burner was built to evaluate the relative effectiveness of agents for suppressing high intensity fuel fires such as one might encounter in a jet engine nacelle. Fuel is injected along the centerline of the 50 mm diameter burner, and air co-flows about the fuel passage at bulk velocities up to 33 m/s, producing an 18 kW flame with an overall equivalence ratio of 0.17. The flame is stabilized in the wake formed behind a 35 mm diameter disc surrounding the fuel nozzle. A key element of the facility is the agent delivery system, which is designed to inject the desired amount of material into the air upstream of the fuel nozzle. The amount of agent is controlled by varying the storage pressure and the duration of time (13 to 910 ms) that the solenoid valves remain open. The influence of air velocity, fuel flow, and injection period on the amount of a N2 required to extinguish the turbulent spray flame is discussed, and the effectiveness of twelve gaseous agents is compared.

Grosshandler, W. L.; Presser, C.; Lowe, D. L.
Validation of a Turbulent Spray Flame Facility for the Assessment of Halon Alternatives.
National Institute of Standards and Technology, Gaithersburg, MD
University of New Mexico; New Mexico Engineering Research Institute; Center for Global Environmental Technologies; National Association of Fire Equipment Distributors, Inc.; Halon Alternative Research Corp.; Fire Suppression Systems Assoc.; and Hughes Associates, Inc. Halon Alternatives Technical Working Conference 1993. Proceedings. May 11-13, 1993, Albuquerque, NM, 129-136 pp, 1993.

halons; validation; experiments; air velocity; injection; nitrogen; air temperature

The work discussed in this paper is part of a larger effort at NIST focused on finding an alternative to halon 1301 for application to aircraft engine nacelle and dry bay in-flight fire protection. Alternative chemical compounds are sought which will perform similarly to halon 1301, and whick do not create unacceptable safety, environmental, or systems compatibility problems. A cup burner, an opposed flow diffusion flame, a turbulent spray flame, and a deflagration/detonation tube are being used to rank the relative combustion suppression effectiveness of the following agents: R-32 (CH2F2), R-32/R-125 (CH2F2/CHF2CF3), HFC-227 (C3HF7), R-22 (CHF2Cl), HFC-134a (CH2FCF3), FC-116 (C2F6), HCFC-124 (CHFClCF3), R-125 (CHF2CF3), FC-218 (C3F8), FC-31-10 (C4F10), and FC-318 (cyclo-C4F8). Table 1 lists the fuels and agents to be evaluated and the experimental variables for each configuration.

H

Hall, J. R., Jr.

Hall, J. R., Jr.
U.S. Fires in "Board and Care" Homes Matrix Display of Selected Fatal Fires. Special Analysis.
National Fire Protection Association, Quincy, MA
NIST-GCR-93-627; 106 p. April 1993.
Available from National Technical Information Services
PB93-198869

board and care homes; building codes; building construction; building fires; death; egress; evacuation; exits; fire investigations; fire protection; human behavior

This report presents available information on 57 fatal U.S. fires occurring during 1971 to 1992 and recorded in the National Fire Protection Association's (NFPA's) Fire Incident Data Organization (FIDO) as fires of technical interest in "board and care" homes. It is an update of a report prepared in 1990 and adds nine incidents to that earlier study. It is part of a larger project on fire safety in board and care homes. The information has been organized into three tables. Included is information on: death tools, construction details, code compliance, occupant behaviors, fire development and building fire protection systems.

Hamins, A.

Hamins, A.
Soot.
National Institute of Standards and Technology, Gaithersburg, MD
Environmental Implications of Combustion Processes. Chapter 3, CRC Press, Boca Raton, FL, Puri, I. K., Editor, 71-95 p., 1993.

soot; health hazards; flame radiation; carbon monoxide; soot formation; flame research; smoke yield; smoke production

The major source of carbonaceous soot released into the environment is from the incomplete combustion of fossil fuels and other organic matter. Principal sources of soot emissions are coal burning furnaces, refuse burning, code production processes, wood burning in home fireplaces, the open burning of waste, and gasoline and diesel powered engines.

Hamins, A.; Yang, M. H.; Puri, I. K.
Structure of Inhibited Counterflowing Nonpremixed Flames.
National Institute of Standards and Technology, Gaithersburg, MD
Illinois Univ., Chicago
University of New Mexico; New Mexico Engineering Research Institute; Center for Global Environmental Technologies; National Association of Fire Equipment Distributors, Inc.; Halon Alternative Research Corp.; Fire Suppression Systems Assoc.; and Hughes Associates, Inc. Halon Alternatives Technical Working Conference 1993. Proceedings. May 11-13, 1993, Albuquerque, NM, 503-510 pp, 1993.

halons; suppression; flame structure; methodology; flame extinguishment

Recent international agreements call for a halt to the manufacture of CF3Br (Halon 1301), a commonly used halon fire suppressant, due to its high ozone-depletion potential. Ideally, the search for replacement compounds should be guided by fundamental studies of the detailed inhibition mechanisms of halogenated agents in flames. A large number of experimental and modeling studies have investigated the impact of halogenated inhibitors in premixed systems. Few studies, however, have investigated the detailed structure of nonpremixed flames with chemical inhibitors added to the oxidizer stream, a configuration that more closely corresponds to realistic fire situations. In an effort to construct a paradigm of flame inhibition by halogenated compounds, an experimental and numerical investigation of the effect of chloromethane addition to the oxidizer stream of counterflowing nonpremixed flames was conducted.

Harrington, J. E.

Harrington, J. E.; Shaddix, C. R.; Smyth, K. C.
Soot in a Time-Varying Flame: Are Scattering and Extinction Measurements Sufficient?
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 390-393 pp, 1993.

combustion; soot; flame research; scattering coefficient; extinction; experiments; diffusion flames; flame flicker

Laser-sheet scattering images of the soot region in a time-varying methane/air diffusion flame, whose fuel flow is modulated at a frequency matching the 10.13 Hz laser repetition rate, show at least a factor of ten enhancement in volume integrated scattering intensity when compared with images of a steady-state flame with the same mean fuel and air co-flows. However, only a small enhancement (~ 50%) appears in a comparison between the peak values of what is commonly interpreted as soot volume fraction, obtained through tomographic reconstruction of HeNe and Ar ion extinction measurements. The time-averaged soot, volume fraction in the entire flame is identical, within our measurement error, for the steady and time-varying flames. We anticipate an explanation of our scattering and extinction results based on changes in particle size and morphology induced by a different time-temperature history in the flickering flame.

Harrington, J. E.; Smyth, K. C.
Laser-Induced Fluorescence Measurements of Formaldehyde in a Methane/Air Diffusion Flame.
National Institute of Standards and Technology, Gaithersburg, MD
Chemical Physics Letters, Vol. 202, No. 3-4, 196-202, January 22, 1993.

diffusion flames; formaldehyde; lasers; fluorescence

Laser-induced fluorescence has been observed from the formaldehyde electronic transition in a well characterized, laminar methane/air diffusion flame burning at atmospheric pressure. This represents the first optical measurement in flames of naturally occurring formaldehyde, an important intermediate in the oxidation of hydrocarbons. Both 355 nm and tunable dye laser excitation of fluorescence are demonstrated. The observed fluorescence signals are corrected for partition function effects and for estimated collisional quenching rates to obtain relative concentration profiles.

Hill, E. D., Jr.

Hill, E. D., Jr.; Frohnsdorff, G.
Portland Cement Specifications: Performance, Prescription, and Prediction.
Openaka Corp., Inc., Denver, CO
National Institute of Standards and Technology, Gaithersburg, MD
American Society for Testing and Materials. Cement, Concrete and Aggregates, CCAGDP, Volume 15, No. 2, Winter, 1993, American Society for Testing and Materials, PA, 109-118 pp, 1993.

cements; specifications; image analysis; materials science; mathematical models; minimum strength levels; minor elements; performance attributes; prediction; prescription; research; uniformity

A major driving force for specification development, whether for a cement or other material, is a need for enhanced and more predictable performance. A prescriptive specification reduces the risk of poor performance by keeping the composition and other conveniently measurable characteristics of a product close to those of a product which has performed well. Although it is harder to develop and apply, a performance specification can be a valuable complement to a prescriptive one; apart from being less restrictive, its development focuses attention explicitly on the definition and the measurement of performance. Neither prescriptive nor performance specifications necessarily require scientific understanding of factors affecting performance, and so a third approach is proposed - a predictive specification based on scientific understanding. In the case of cement and concrete, it can be foreseen as a result of the continued strengthening of the materials science base of the technology combined with developments in computer simulation of the behavior of cementitious systems. While these developments are taking place, improvements must continue to be sought in the prescriptive and performance specifications to make sure they are as good as they can be. The desired improvements and the research needed to achieve them must be defined, and support for the research must be provided. For the near term, some suggestions for improving the existing portland cement specifications, ASTM C 150, are offered. They concern minimum strength levels, strength uniformity, and improvement of compound composition calculations.

I

Idriss, I. M.

Idriss, I. M.
Procedures for Selecting Earthquake Ground Motions at Rock Sites.
California Univ., Davis
NIST-GCR-93-625; 35 p. April 1993.
Available from National Technical Information Services
PB93-185973

earthquakes; acceleration response spectrum; attenuation relationships; earthquake ground motions

To estimate the spectral ordinates at a rock site for an earthquake having a given size (magnitude) and occurring at a specified distance from the site, available attenuation relationships are used. These relationships, which have been developed based on available recorded data and typically are for a spectral damping of 5%, provide estimates of the median spectral ordinates and a measure of the dispersion about the median. Four currently available relationships are summarized in this report. These relationships are those derived by Campbell (1990), Geomatrix (1991), Idriss (1991) and Joyner and Boore (1988). The equations to be used in conjunction with each relationship together with the description and the numerical values of the coefficients pertinent to that relationship are given.

J

Jaluria, Y.

Jaluria, Y.; Lee, S. H. K.; Mercier, G. P.; Tan, Q.
Visualization of Transport Across a Horizontal Vent Due to Density and Pressure Differences.
Rutgers, The State University of New Jersey, New Brunswick American Society of Mechanical Engineers (ASME). National Heat Transfer Conference. Visualization of Heat Transfer Processes. HTD-Vol. 252. August 1993, Atlanta, GA, Am. Soc. of Mechanical Engineers, New York, NY, 1-17 pp, 1993.

vents; water flow; air flow; flow visualization; experiments

A very important flow and transport circumstance that arises in practical problems such as enclosure fires is that of heat and mass transfer across a horizontal vent. Such vents exist in enclosed regions such as rooms and energy storage and ventilation systems. It is important to understand the basic nature of the transport processes that arise because of finite, non-zero, density and pressure differences that usually exist across such vents. The flow is driven by these two mechanisms and very complicated flow patterns arise, depending on the governing variables in the problem. For instance, a dominant pressure effect results in a unidirectional flow, whereas significant buoyancy effects lead to a bidirectional flow exchange. The heat and mass transfer associated with the flow is similarly strongly influenced by the flow regime. There is a strong need for visualization to determine if a unidirectional or a bidirectional flow exists across the vent and to study the basic characteristics of the transport processes involved. This paper presents a study of this heat and mass transfer problem employing water and air as the fluid media for two different experimental systems. Pure and saline water are used in the first case to obtain the unstably stratified circumstance with a pressure difference across the vent. Air at different temperature levels is used in the second case. A laser sheet, with smoke, is used for visualization in air and a shadowgraph for water. Other visualization techniques are also used to obtain qualitative and quantitative results on the flow direction, transport rates and the relevant mechanisms. Since transient effects are important in many cases, video recordings are employed to obtain the frequency of observed oscillations in the transport and for determining the transition from one regime to the other. Visualization is crucial to the understanding of these processes and to the determination of the transport regime under various operating conditions.

Jason, N. H.

Jason, N. H.
Building and Fire Research Laboratory Publications, 1992.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5172; 86 p. April 1993.
Available from National Technical Information Services
PB93-188845

fire research; building technology; earthquakes; refrigerants; fire suppression

Building and Fire Research Publications, 1992 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 1992. 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.

Jason, N. H.
Evolution of a United States Information System.
National Institute of Standards and Technology, Gaithersburg, MD
National Fire Protection Association and International Association of Fire Chiefs. inFIRE (international network for Fire Information and Reference Exchange. Annual Conference. Proceedings. April 28-30, 1993, Norwood, MA, Barnhart, A.; Swing, A., Editors, 89-98 pp, 1993.

information dissemination; libraries; information retrieval

As part of the current information activities in the United States, the Conference for Exploration of a National Engineering Information Service is discussed, in addition to the Internet and the proposed NREN (National Research and Education Network). Challenges to the fire community to bridge the information gap are presented.

Jason, N. H.
FIREDOC Users Manual. 3rd Edition.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5305; 44 p. December 1993.
Available from National Technical Information Services

databases; fire engineering; fire research; fire safety; information retrieval; information dissemination; manuals

FIREDOC is the on-line bibliographic database which reflects the holdings (published reports, journal articles, conference proceedings, books, and audiovisual items) of the Fire Research Information Services (FRIS) at the Building and Fire Research Laboratory (BFRL), National Institute of Standards and Technology (NIST). This manual provides step-by-step procedures for entering and exiting the database via telecommunication lines, as well as a number of techniques for searching the database and processing the results of the searches. This Third Edition is necessitated by the change to a UNIX platform. The new computer allows for faster response time if searching via a modem and, in addition, offers Internet accessibility. FIREDOC may be used with personal computers, using DOS or Windows, or with Macintosh computers and workstations. A new section on how to access Internet is included, and one on how to obtain the references of interest to you. Appendix F: Quick Guide to Getting Started will be useful to both modem and Internet users.

Jason, N. H.
Information Transfer in the 21st Century.
National Institute of Standards and Technology, Gaithersburg, MD
Society of Fire Protection Engineers. International Fire Information Conference, 1st. Proceedings. Cosponsored by International Fire Information Conference (IFIC) and international network for Fire Information and Reference Exchange (inFIRE). April 27-May 1, 1992, Moreton-in-Marsh, England, Society of Fire Protection Engineers, Boston, MA, Green, J. B.; Jason, N. H., Editors, 133-142 pp, 1993.

information dissemination; libraries; technology transfer

The impact of technological advances and some political events are discussed in the context of current information activities. Several examples of new and exciting projects in information technology in print and non-print activities are presented. The role of the information professional and specifically the future role of fire libraries concludes the discussion.

Jason, N. H.
Locating Fire Engineering Information.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Bulletin, 5-8, September/October 1993.

information retrieval; fire research; fire protection engineering; fire science; databases; information storage

Have you spent a lot of time trying to answer questions similar to these: Where are there a few good journal articles on wooden trusses? Who wrote the book Fire? When was the Third International Conference on Fire Safety Science held? Is there a published bibliography covering the cone calorimeter? Who has written the most recent article on fire and death statistics in the United States? Where is John Bryan located? These questions could be answered by calling or faxing a minimum of one colleague, by contacting your company, university or public librarian, or by plowing through your personal files. Of course, there is another way which is quicker. If you have a computer and a modem available, you can search a wealth of information from your desk.

Jason, N. H.
Summaries of BFRL Fire Research In-House Projects and Grants, 1993.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5263; 184 p. September 1993.
Available from National Technical Information Services
PB94-121050

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

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, 1992 through September 30, 1993.

Johnson, A. W.

Johnson, A. W.; Pitts, W. M.
Sidejet Strength and Mixing in Self-Excited Jets. [Abstract ONLY]
National Institute of Standards and Technology, Gaithersburg, MD
Bulletin of the American Physical Society, Vol. 28, No. 12, 2284, 1993.
American Physical Society. Annual Meeting, 46th. November 21-23, 1993, Albuquerque, NM, 1993.

jet induced flow; mixing; Rayleigh light scattering

Absolutely unstable jet flows are known to produce vigorous and intermittent lateral ejections of fluid, or 'sidejets'. Sidejet generation has been attributed to the near-field interaction of axisymmetric vorticies, streamwise vorticies, and lobes formed on the axisymmetric ring vorticies by the Widnall instability. Here we attempt to vary the strength of sidejets by varying the intensity of the primary oscillating mode associated with axisymmetric vorticies of self-excited absolutely unstable round helium jets. The resulting effects on the scalar mixing field have been documented. The intensity of the oscillating mode was manipulated by varying the velocity profile over a wide range of D/0. Here, D is the nozzle diameter and 0 is the momentum thickness of the velocity profile at the nozzle exit. Profiles of jet concentration were measured using Rayleigh light scattering (RLS). Simultaneous concentration and velocity measurements were made using hotwire probes and RLS in the near field. Strengthening the oscillating mode increased the radial extent and strength of the corresponding sidejets. Downstream spreading and the virtual origin of the jet were also dependent on sidejet strength. Qualitative results on the temporal and spatial properties of sidejets in these flows will also be presented.

Jones, W. W.

Jones, W. W.; Forney, G. P.
Improvement in Predicting Smoke Movement in Compartmented Structures.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 21, No. 4, 269-297, 1993.

smoke movement; structures; fire growth; smoke transport; toxic gases; compartments; zone models; equations; buoyant flow

This paper describes improvements which have been made in the CFAST model of fire growth and smoke transport for compartmented 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 actual situations relevant to fire growth and smoke propagation, as is demonstrated.

Jones, W. W.; Forney, G. P.
Modeling Smoke Movement Through Compartmented Structures.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Fire Sciences, Vol. 11, No. 2, 172-183, March/April 1993.
Sagamore Army Materials Research Conference, 39th. September 16-17, 1992, Plymouth, MA, 1992 AND U.S./Japan Government Cooperative Program on Natural Resources (UJNR). Fire Research and Safety. 11th Joint Panel Meeting. October 27-November 2, 1992, Tsukuba, Japan,
Building Research Inst., Ibaraki, Japan, Fire Research Inst., Tokyo, Japan, 34-41 pp, 1992.

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 predicitons 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 acutal situations relevant to fire growth and smoke propagation, as is demonstrated.

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.
NIST-GCR-93-634; 34 p. December 1993.
Available from National Technical Information Services
PB94-139722

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.

K

Kaetzel, L. J.

Kaetzel, L. J.
Highway Concrete (HWYCON) Expert System Requirements and Installation Guide.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5190; 29 p. May 1993.
Available from National Technical Information Services
PB93-198885

concretes; highways; building technology; concrete materials; expert systems; highway concrete; HWYCON; Strategic Highway Research Program

A computerized system that contains knowledge about materials related activities for highway concrete structures has been developed. The system, named HWYCON (HighWaY CONcrete), was developed by the National Institute of Standards and Technology in Gaithersburg, MD. HWYCON was developed for the Strategic High Research Program's Project C-206, "Optimization of Highway Concrete Technology." The knowledge contained in HWYCON consists of facts, rules of thumb, phogographs, drawings, and bibliographic references. The system is designed to assist highway departments in diagnosing distresses, selecting materials, and making repair and rehabilitation decisions related to highway concrete pavements, bridge decks, and bridge substructures. This document was written to identify the contents of the HWYCON implementation package, and to provide information on the requirements and installations of the computerized system.

Kaetzel, L. J.; Clifton, J. R.; Klieger, P.; Snyder, K.
Highway Concrete (HWYCON) Expert System User Reference and Enhancement Guide.
National Institute of Standards and Technology, Gaithersburg, MD
Consultant, Northbrook, IL
NISTIR 5184; 166 p. May 1993.
Available from National Technical Information Services

concretes; highways; building technology; diagnostics; expert systems; highway concrete; HWYCON; materials selection; repair and rehabilitation; SHRP

One of the major goals of the Strategic Highway Research Program (SHRP) was to improve the performance and durability of highway concrete. The SHRP Project C-206, "Optimization of Highway Concrete Technology," was created to disseminate knowledge of the results of SHRP-sponsored research and recent advancements in concrete materials technology. The products of this project included a synthesis of advances in highway concrete technology, training videos, and the expert system HWYCON (Highway Concrete). HWYCON is designed to assist state highway departments in three areas: 1) diagnosing distresses in highway pavements and structures, 2) selecting materials for construction and reconstruction, and 3) obtaining recommendations on materials and procedures for repair and rehabilitation methods. HWYCON is an operational system and will be distributed to state DOTs through SHRP. This document is intended to provide a reference for users of the system who need information that is not covered in the overview and installation document provided with the system.

Kapoor, K.

Kapoor, K.; Jaluria, Y.
Penetrative Convection of a Plane Turbulent Wall Jet in a Two-Layer Thermally Stable Environment: A Problem in Enclosure Fires.
Rutgers, The State University of New Jersey, New Brunswick
International Journal of Heat and Mass Transfer, Vol. 36, No. 1, 155-167, 1993.

enclosures; turbulent jets; flow fields; heat transfer; flow visualization; penetration

An experimental investigation has been carried out on the penetrative characteristics of a heated, two-dimensional, turbulent wall jet discharged downward into a two-layer thermally stable environment. Such flows, with opposing buoyancy effects, are frequently encountered in heat rejection processes and in enclosure fires. The discharge temperature of the jet is taken as higher than the upper layer temperature so that the jet is negatively buoyant in both layers. Of particular interest is the penetration of the jet into the lower layer. The conditions for which it fails to penetrate the interface between the two layers are also determined. The penetration distance of the jet is measured and related to the inflow conditions, particularly to the temperature and the velocity at the discharge. The thermal field is studied in detail to determine the basic characteristics of such flows. The mass flow rate penetrating downward as well as that rising upward due to thermal buoyancy are obtained and compared with the jet inlet mass flow rate. The heat transfer to the surface is measured for several wall temperatures and considered in terms of the penetrative flow. Flow visualization with smoke is also undertaken in order to obtain further insight into the basic nature of the flow.

Kashiwagi, T.

Kashiwagi, T.; Cleary, T. G.
Effects of Sample Mounting on Flammability Properties of Intumescent Polymers.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 20, No. 3, 203-225, 1993.
Interscience Communications Limited. Heat Release and Fire Hazard. 1st U. S. Symposium. Abstracts. December 1991, San Diego, CA, 4 pp, 1991.

heat release; fire hazard; sampling; flammability; polycarbonates; cone calorimeters; char; heat release rate; heat of combustion; soot; flame spread; flame spread rate

Various flammability properties of polycarbonate samples were measured with the Cone Calorimeter and Lateral Ignition and Flame Spread, LIFT, devices at various external fluxes. Four different sample mountings were used with the Cone Calorimeter to investigate the effects of sampling mounting on the flammability properties of these samples. One sample mounting configuration employed the standard metal edge frame and a grid to retain intumesced char. The other three samples mounting configurations allowed the intumesced char to rise free. The results show that peak heat release rates and heat release rate curves were significantly affected by the sample mounting configuration but total heat released, effective heat of combustion, and soot yield were not significantly affected. Flame spread characteristics were measured with the LIFT. Two sample mounting configurations were used, the standard method and the standard method with the addition of wire grid to retain intumesced char. Significant differences in flame spread rates were observed between the two sample mounting configurations with and without the grid. This was caused by difference in flame spread rates versus rising rates of char.

Kashiwagi, T.; Cleary, T. G.; Davis, G. C.; Lupinski, J. H.
Non-Halogenated, Flame Retarded Polycarbonate.
National Institute of Standards and Technology, Gaithersburg, MD
General Electric Co., Schenectady, NY
Federal Aviation Administration (FAA). International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials. February 9-11, 1993, Atlantic City, NJ, 175-187 pp, 1993.
Available from National Technical Information Services
DOT/FAA/CT-93/3

aircraft interiors; fire resistant materials; test methods; fire safety; polycarbonates; cone calorimeters; flame spread; furniture calorimeters; siloxanes; heat release rate; ignition delay; char

Various flammability properties of a siloxane-containing bisphenol-A polycarbonate sample, with the siloxane as an additive or as a copolymer, were measured and compared with those of a pure polycarbonate sample. The results show that the peak heat release rate for the siloxane-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 siloxane-containing sample is shorter than that for the pure polycarbonate sample. Also, the flame spread rate under an external radiant flux becomes faster for the siloxane-containing sample 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.
Simultaneous Visual and Calorimetric Measurements of R11, R123, and R123/Alkylbenzene Nucleate Flow Boiling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4948; 54 p. October 1992.
Available from National Technical Information Services
PB93-120756
American Society of Mechanical Engineers (ASME). Heat Transfer With Alternate Refrigerants. HTD-Vol. 243. 1993, NISTIR 4948, 27-33 pp, 1992.

refrigerants; alkylbenzene; alternative refrigerants; boiling; bubble parameters; building technology; calorimetric; chemistry; dichlorotrifluoroethane; trichlorofluoromethane; visualization

Bubble formation during horizontal flow boiling of trichlorofluoromethane (R11), 1,1-dichloro-2,2,2-trifluoroethane (R123) and two R123/alkylbenzene lubricant mixtures was investigated both visually and calorimetrically. The test fluid was pumped through the inside of a roughened, horizontal, quartz tube which was electrically heated with a metal strip. The refrigerant entered the test section with a quality slightly above the saturated state. Locally measured heat transfer coefficients were taken simultaneously with high speed motion picture images of the boiling process. Predictive equations from the literature yielded acceptable agreement with the measured bubble diameters and contact angles. The addition of lubricant to the R123 increased the size of the contact angle and reduced the size of the bubble. The agreement between existing correlations and the measured bubble frequencies and site densities was within the uncertainty of the measurements. The addition of a small amount (0.5%) of alkylbenzene to R123 increases the number of active nucleation sites by approximately 5 sites/cm2 which corresponds to a 12% to 50% increase in the site density. The increase in the site density contributed to the enhancement of the heat transfer coefficient of the R123/0.5% alkylbenzene mixture over that of the pure R123. Further increase in the amount of alkylbenzene to the R123 reduces the number of active sites to below that of pure R123 to approximately the value for that of R11. Consequently, the 0.5% lubricant mass fraction mixture exhibited a heat transfer coefficient that was larger than that of the 2% lubricant mass fraction mixture. Correspondingly, the lower heat transfer coefficient of R11 as compared to that of R123 was partially due to the lower number of active boiling sites for R11. The dependency of the measured two-phase heat transfer coefficient on the heat flux and Reynolds number was investigated. Increases in both the heat flux and the Reynolds number caused increases in the heat transfer coefficient. The heat flux has a much larger effect on the heat transfer coefficient than the Reynolds number.

Kedzierski, M. A.; Didion, D. A.
Horizontal Flow Boiling of Single Component and Binary Refrigerant Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
ER-8006-2; Research Project 2792-09; 106 p. 1993.
Available from Electrical Power Research Inst. (EPRI), Palo Alto, CA

refrigerants; heat transfer; degradation; nucleation; ozone; evaporation; visualization;

This report contains three studies on refrigerant mixture heat transfer funded by NIST and EPRI (RP 80006-21). The first study, Visualization of Nucleate Flow for an R22/R114 Mixture and Its Components, is presented in section 1. It investigates the phenomena of the suppression of nucleation due to increased mass flow while all other conditions are fixed. This study also compares the nucleate activity of the binary mixture to the nucleate activity of the pure components. The fluids investigated are a 37.7% mole R114 binary mixture and the individual components R22 and R114. The second study, Causes of the Apparent Heat Transfer Degradation for Refrigerant Mixtures, is presented in section 2. It investigates the causes of the apparent heat transfer degradation associated with horizontal - annular flow evaporation of refrigerant mixtures. For horizontal-annular flow evaporation, most of the heat transfer degradation is a consequence of the use of the locally uniform equilibrium temperature in the measurements and calculation of the heat transfer coefficient. The remainder of the heat transfer degradation is due to nonlinear mixture property effects. The focus of the study was to determine the magnitude and the cause of the individual components of the heat transfer degradation of the studied mixtures. The third study, A Comparison of Experimental Measurements of Local Flow Boiling Heat Transfer Coefficients for R11 and R123, is presented in section 3 and presents a comprison of the measured horizontal, smooth-tube, flow boiling heat transfer coefficient of R11 to that of its proposed near ozone safe replacement, R123. The fluid properties of R11 and R123 are similar. The flow boiling data for the two fluids are similar for the convective region. However, the heat transfer coefficient for R11 in the nucleate flow boiling region was consistently observed to be, on average, 8.5% to 33% larger than that for R123. For the convenience of the reader, both the R123 and R11 property data used in this study are presented.

Kedzierski, M. A.; Kaul, M. P.
Horizontal Nucleate Flow Boiling Heat Transfer Coefficient Measurements and Visual Observations for R12, R134a, and R134a/Ester Lubricant Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5144; 31 p. March 1993.
Available from National Technical Information Services
PB93-178598
Korean Society of Mechanical Engineers. Symposium on Transport Phenomena (ISTP-6) in Thermal Engineering, 6th International. Volume 1. May 9-13, 1993, NISTIR 5144, Seoul, Korea, Lee, J. S.; Chung, S. H.; Kim, K. H., Editors, 111-116 pp, 1993.

heat transfer; lubricants; building technology; boiling; dichlorodifluoromethane; 1,1,1,2-tetrafluoroethane; visualization

The heat transfer characteristics of horizontal nucleate flow boiling of R12, R134a, and R134a/Ester Lubricant mixtures were investigated both visually and calorimetrically. The effect of two different ester lubricants on the boiling characteristics of R134a were investigated. The test refrigerant entered a roughened quartz tube test section slightly above the saturated state. Both the heat flux and the Reynolds number were varied in order to investigate their effect on the heat transfer coefficient. The heat transfer increased nearly proportionally with an increase in the heat flux. An increase in the Reynolds number caused a marginal increase in the heat transfer coefficient. Locally measured heat transfer coefficients were taken simultaneously with high speed motion picture images of the boiling process. The motion pictures were used to obtain a descriptive behavior of the boiling which was compared directly to the measured heat transfer coefficients. The rate of bubble production for pure R134a was 38% greater than that of R12. This is the most likely reason that the R134a heat trasfer coefficient was approximately 20% greater than that of R12. The addition of lubricant to R134a caused a drastic reduction in the diameter of the bubbles. In fact, for one R134a/lubricant mixture, the bubbles were emitted from the of a mist. The addition of the low viscosity lubricant to R134a enhanced the heat transfer of R134a. For Reynolds numbers above 8000, the addition of the high viscosity lubricant degraded the heat transfer as compared to that of the pure component. A mechanistic explanation for the observed R134a/lubricant boiling is provided.

Kedzierski, M. A.; Worthington, J. L., III
Design and Machining of Copper Specimens With Micro Holes for Accurate Heat Transfer Measurements.
National Institute of Standards and Technology, Gaithersburg, MD
Experimental Heat Transfer, Vol. 6, 329-344, 1993.

copper; heat transfer; equations; wall temperature; temperature gradients; drilling

This article presents a technique that has been developed specifically for drilling 0.5334-mm-diameter, 19-mm-deep holes in copper for use in temperature measurement. The holes accept thermocouples, which are used for the measurement of the temperature gradient and the wall temperature of the specimen. Errors due to the intrusion of the probe, and the finite size and mass of the probe, are reduced as the diameter of the probes is reduced. A machining procedure for drilling deep micro holes in copper cannot be found in conventional tests, this article advocates holes that are deeper than those traditionally recommended. This article is written for both machinists and experimentalists. Both heat transfer and maching criteria are considered. The necessary equipment and their specifications are discussed. Special attention is given to specifying drilling speeds, feed rates, and lubricants. Step-by-step drilling instructions are given. An analysis is performed to reveal the important parameters for reducing the errors associated with the uncertainty in the location, the relative position of the thermocouples, and the individual temperature measurements.

Kim, M. S.

Kim, M. S.; Mulroy, W. J.; Didion, D. A.
Experimental Evaluation of the Flammability and Performance Potentials of Two Azeotropic Refrigerant Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
Korean Society of Mechanical Engineers. Symposium on Transport Phenomena (ISTP-6) in Thermal Engineering, 6th International. Volume 3. May 9-13, 1993, Seoul, Korea, Lee, J. S.; Chung, S. H.; Kim, K. H., Editors, 153-158 pp, 1993.

refrigerants; evaluation; flammability; heat pump; mixtures

The phaseout of CFC and HCFC refrigerants requies determination of substitute refrigerants for use in domestic heat pumps and refrigerators. This paper presents both flammability and heat pump performance test results of two azeotropic refrigerant mixtures of R-134a (1,1,1,2-tetrafluoroethane) with R-290 (Propane) and R-600a (Isobutane): R-290/134a (45/55), R-134a/600a (80/20). The flammability limit of R-290/134a is found as 2.9-11.0% by volume. And that of R-134a/600a is 3.9-13.3% by volume. Although the azeotropic mixtures remain flammable, they are less than their pure hydrocarbon components. The performance characteristics are compared with pure R-12, R-22, R-134a, and R-290 at test conditions including cases using liquid-line/suction-line heat exchange. In most cases, the coefficients of performance of the azeotropic mixtures are higher than that of R-12 and R-134a. In every case, the capacity for R-290/134a is higher than that for R-22. Also, the system capacity for R-134a/600a is higher than that for R-12 and R-134a. Results show that the discharge temperature for the azeotropic mixtures is always lower than that for the other refrigerants.

Klote, J. H.

Klote, J. H.
Air Moving Systems and Fire Protection.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5227; 17 p. July 1993.
Available from National Technical Information Services
PB93-234722

air movement; air conditioning; fire protection; fire safety; heating; smoke control; stairwells; ventilation systems

The fire hazards associated with heating, ventilating and air conditioning (HVAC) systems are significant. Protection is needed from the spread of fire and smoke due both to fires starting inside an HVAC system and fires starting outside an HVAC system. Fire performance of materials for HVAC components are reqired, and fire dampers and smoke dampers are needed. To provide smoke protection, an HVAC system can be shut down or it can be put into a special smoke control mode of operation. Smoke from building fires can be managed by the mechanisms of compartmentation, dilution, air flow, pressurization, and buoyancy.

Klote, J. H.
Design of Smoke Control Systems for Areas of Refuge.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5132; 25 p. March 1993.
Available from National Technical Information Services
PB93-183754

smoke control; refuge; elevators (lifts); evacuation; handicapped; life safety

There is a rising concern for the safety of persons from fire who cannot travel building emergency exit routes in the same manner or as quickly as expected of able persons. One proposed solution for providing safety for persons with mobility limitations is the concept of areas of refuge (AOR) where they can "safely wait" until they can be assisted in leaving the building. This paper presents information about the design of smoke control systems to prevent smoke infiltration into an AOR. Pressure differences produced when windows break both with and without wind can be significant, and the design of a smoke control system for an AOR needs to address these pressure differences. The paper identifies that wind data specifically for the design of smoke control systems is needed. The pressure fluctuations due to opening and closing building doors during fire situations can also be significant, and the

design of a smoke control system for an AOR needs to address these pressure fluctuations. An example analysis incorporating the pressure effects of broken windows, wind, and open doors illustrates the feasibility of designing smoke control systems for areas of refuge.

Klote, J. H.
Design of Smoke Control Systems for Areas of Refuge.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 99, No. 2, 793-807, 1993.

smoke control; refuge; elevators (lifts); evacuation; handicapped; life safety

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

Klote, J. H.
Method for Calculation of Elevator Evacuation Time.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Fire Protection Engineering, Vol. 5, No. 3, 83-96, 1993.

elevators (lifts); evacuation time; computer programs; people movement; time; emergencies

A detailed method of analysis of people movement by elevators during emergency building evacuation is presented. The time to evacuate a number of people using one group of elevators includes the sum of all the round trip times divided by the number of elevators plus the times needed to start up the elevator evacuation and to travel from the elevator lobby to the outside or to another safe location. A trip inefficiency is used to account for trips to empty floors and trips to pick up a few stragglers. The method includes detailed analysis of elevator car travel including constant acceleration, transitional acceleration, constant velocity, transitional deceleration, constant deceleration, and leveling. The time for people to enter and exit the elevator car is addressed including inefficiencies for elevator door sizes and types. The impact of elevator arrangements is addressed, and the difference between commonly accepted and unusual arrangements is presented. A computer program, ELVAC, was written to calculate elevator evacuation time, and an example calculation of evacuation time is provided using this program.

Klote, J. H.; Deal, S.; Donoghue, E. A.; Levin, B. M.; Groner, N. E.
Fire Evacuation by Elevators.
National Institute of Standards and Technology, Gaithersburg, MD
Edward A. Donoghue Associates, Inc., Salem, NY
George Mason Univ., Fairfax, VA
Elevator World, Vol. 41, No. 6, 66-70,72-75, June 1993.

evacuation; elevators (lifts); smoke control; staging areas; human beings; water; sprinklers

There is a rising concern for the safety of persons from fire who cannot travel building emergency exit routes in the same manner or as quickly as expected of able persons. One proposed solution for providing safety for these people is the use of elevators. However, today's elevators are not intended as means of fire egress and they should not be used for fire evacuation.

Klote, J. H.; Deal, S.; Levin, B. M.; Groner, N. E.; Donoghue, E. A.
Workshop on Elevator Use During Fires.
National Institute of Standards and Technology, Gaithersburg, MD
George Mason Univ., Fairfax, VA
Edward A. Donoghue Associates, Inc., Salem, NY
NISTIR 4993; 18 p. January 1993.
Available from National Technical Information Services

elevators (lifts); smoke control; evacuation; staging areas

Throughout most of the world, warning signs next to elevators indicate they should not be used in fire situations. These elevators are not intended as means of fire egress, and they should not be used for fire evacuation (Sumka 1988). The idea of using elevators to speed up fire evacuation and to evacuate persons with disabilities has gained considerable attention (Bazjanac 1974, Bazjanac 1977, Pauls, 1977, Pauls, Gatfield and Juillet 1991, Gatfield 1991, Degenkolb 1991, and Fox 1991). A Workshop on Elevator Use During Fires was held at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD on September 29, 1992. This workshop consisted of presentations and an opn discussion. The presentations were about NIST elevator research by John H. Klote, about human considerations by Bernard M. Levin and Norman E.Groner, and about industry concerns by Edward A. Donoghue. This paper is an overview of these presentations and the open discussions.

Klote, J. H.; Forney, G. P.
Zone Fire Modeling With Natural Building Flows and a Zero Order Shaft Model.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5251; 42 p. September 1993.
Available from National Technical Information Services
PB94-112166

zone models; air movement; fire models; smoke movement; stairwells

This paper addresses applications of zone fire models to simulate smoke flow in multistory buildings. Natural flows in buildings are discussed. A zero order model for shaft smoke flow was developed which treated the shaft as one perfectly mixed zone. A two zone fire model was modified to simulate natural flows and the zero order shaft smoke flow. The extent to which the one zone model and the two zone model are appropriate to simulate smoke flow in shafts is disucssed. The modifications for the natural building flow included development of new initial conditions and of the capability to simulate the gross effects of a heating and air conditioning system. Eighteen example zone model simulations were made to develop insight into the program modifications.

Klote, J. H.; Fowell, A. J.
Fire Protection Challenges of the Americans Disabilities Act: Elevator Evacuation and Refuge Areas.
National Institute of Standards and Technology, Gaithersburg, MD
University of Ulster and Fire Research Station. CIB W14: Fire Safety Engineering. International Symposium and Workshops Engineering Fire Safety in the Process of Design: Demonstrating Equivalency. Part 1. Symposium: Engineering Fire Safety for People With Mixed Abilities.
September 13-16, 1993, Newtownabbey, Northern Ireland, 79-95 pp, 1993.

fire safety; handicapped; fire protection; elevators (lifts); evacuation; refuge; people movement; smoke; water; piston effect; computer programs

There is a rising concern for the safety of persons from fire who cannot travel building emergency exit routes in the same manner or as quickly as expected of able persons. One proposed solution for providing safety for persons with mobility limitations is the use of elevators for fire evacuation. Another proposed solution is the concept of areas of refuge where they can "safely wait" until they can be assisted in leaving the building. The system concepts and interrelationships of these two alternatives are discussed. An overview of an area of refuge study conducted at NIST is presented. Other topics addressed are elevator people movement, elevator water problem, and smoke control concepts.

Kostreva, M. M.

Kostreva, M. M.; Wiecek, M. M.
Time Dependency in Multiple Objective Dynamic Programming.
Clemson Univ., SC
Journal of Mathematical Analysis and Applications, Vol. 173, No. 1, 289-307, February 1993.

time; planning; algorithms

The problem of planning paths is a network structure is important for many applications. Interest in path planning is strong in transportation, telecommunications, computer design, and fire hazard analysis. Such a problem is sometimes called a routing problem, or a shortest path problem. One of the earliest solutions to the problem was given by Bellman. Under the assumptions of constant travel times on each link, dynamic programming was applied to compute the path of minimum travel time through the network, from any node to a given destination node. Bellman applied the functional equations approach to devise an iterative algorithm which converges to the solution in at most N - 1 steps for a network with N nodes.

Koylu, U. U.

Koylu, U. U.; Dai, Z.; Tseng, L. K.; Faeth, G. M.
Radiation and Mixing Properties of Buoyant Turbulent Diffusion Flames.
Michigan Univ., Ann Arbor
NIST-GCR-93-631; 60 p. July 1993.
Available from National Technical Information Services

diffusion flames; fire plumes; fire research; optical properties; Rayleigh light scattering; soot

Two aspects of unwanted fires were considered: (1) the optical properties of soot in the fuel-lean region of buoyant turbulent diffusion flames, and (2) the structure and mixing properties of buoyant turbulent plumes. The scattering, absorption and extinction properties of soot were measured for conditions where soot structure was known from earlier transmission electron microscopy measurements. The measurements were compared with predictions based on the Rayleigh-Debye-Gans (RDG) scattering approximation for polydisperse fractal aggregates. The present soot aggregates exhibited significant departures from Rayleigh scattering, however, the RDG polydisperse fractual aggregate theory provided an acceptable basis to treat their optical properties. The plume study involved laser-induced iodine fluorescence measurements of mean and fluctuating mixture fractions. The results indicated that past measurements of plume properties represent transitional plumes and that self-preserving turbulent plumes are somewhat narrower, with higher levels of mean and fluctuating mixture fractions near the axis.

L

Lakhtakia, A.

Lakhtakia, A.; Mulholland, G. W.
On Two Numerical Techniques for Light Scattering by Dielectric Agglomerated Structures.
Pennsylvania State Univ., University Part
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Research of the National Institute of Standards and Technology, Vol. 98, No. 6, 699-716, 1993.

agglomerates; light scattering; smoke; equations

Smoke agglomerates are made of many soot spheres, and their light scattering response is of interest in fire research. The numerical techniques chiefly used for theoretical scattering studies are the method of moments and the coupled dipole moment. The two methods have been obtained in this tutorial paper directly from the monochromatic Maxwell curl equations and shown to be equivalent. The effects of the finite size of the primary spheres have been numerically delineated.

Lawson, J. R.

Lawson, J. R.
Fire Tests and Flooring Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Limited. Fire and Materials. International Conference, 2nd. September 23-24, 1993, Arlington, VA, 253-262 pp, 1993.

fire tests; flooring radiant panel test; hazard assessment; radiant flux profile

It was recognized during the early part of this century that flooring materials can be a critical player in fire growth and propagation. This national concern lead to regulations being written which quantified the behavior of flooring materials in fire tests. The first attempts to regulate flooring materials used the existing Stiener Tunnel, a test for flame spread developed at Underwriter's Laboratory, and the Pill Test was developed to identify easily ignited flooring materials. The Pill Test continues to be used because it is simple and provides acceptable ignitability information. Although used initially, the Stiener Tunnel did not provide the type of fire test data necessary for evaluating flooring materials in part because the tunnel was originally designed for testing ceiling and wall products. It was subsequently replaced by the Flooring Radiant Panel Test. In this paper, test method precision for the Flooring Radiant Panel Test is reviewed from the early days of test development to the present. It is shown that precision and test performance has improved over the years and that the test procedure can be used to quantify the flame propagation characteristic of critical radiant flux over a specified range. The performance of flooring products is discussed as it relates to the influence of aging and use. The Flooring Radiant Panel Test procedure and others are discussed as tools for input to computer models on fire growth and hazard analysis of flooring materials. The need for further development of the Flooring Radiant Panel Test is discussed.

Lechner, J. A.

Lechner, J. A.; Heckert, N. A.; Simiu, E.
Assessment of Recent Methods for Estimating Extreme Value Distribution Tails.
National Institute of Standards and Technology, Gaithersburg, MD
ICOSSAR'93 Proceedings. Structural Safety and Reliability, 6th International Conference. August 9-13, 1993, Innsbruck, Austria, Schueller, G. I.; Shinozuka, M.; Yao, J. T. P., Editors, 1663-1668 pp, 1993. A. A. Balkema, Rotterdam.

threshold modeling; equations; simulation

In the past twenty years a vast new body of extreme value theory has been developed, referred to as "peaks over threshold modeling." This theory allows the use in the analysis of all data exceeding a sufficiently high threshold, a feature that may result in improved extreme value estimates. The application of the theory depends upon the performance of methods for estimating the distribution parameters corresponding to any given set of extreme data. We present a comparative assessment of the performance of three such methods. According to our Monte Carlo simulation results the de Haan method is the best for applications in which the percent estimation errors are comparable to those typical in wind engineering.

Lechner, J. A.; Martin, J. W.
Modeling and Measuring Ultraviolet Radiation to Predict Damage to Macromolecular Materials.
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society. Proceedings. August 22-27, 1993, 1-2 pp, 1993.

ultraviolet radiation; damage; macromolecular materials; photodegradation; irradiance; spacing

In order to improve the scientific basis for predicting the photodegradation effects of UV radiation on macromolecular materials, an ongoing study of spectral UV measurement techniques is being conducted at NIST. This paper reports priminary results which indicate: 1) The importance of fine resulution - that is, a narrow measurement window - for spectral measurements of UV irradiance at the exposure site; and 2) The non-necessity of fine spacing in the center frequencies at which irradiance is measured. These findings are reported in the next two sections.

Lechner, J. A.; Simiu, E.; Heckert, N. A.
Assessment of 'Peaks Over Threshold' Methods for Estimating Extreme Value Distribution Tails.
National Institute of Standards and Technology, Gaithersburg, MD
Structural Safety, Vol. 12, 305-314, 1993.

distribution tails; extreme values; peaks over threshold methods; wind engineering

In the past twenty years a vast new body of extreme value theory was developed, referred to as "peaks over threshold modeling." This theory allows the use in the analysis of all data exceeding a sufficiently high threshold, a feature that may result in improved extreme value estimates. The application of the theory depends upon the performance of methods for estimating the distribution parameters corresponding to any given set of extreme data. We present a comparative assessment of the performance of three such methods. The assessment is based on Monte Carlo simulations from populations with four distributions: Gumbel, Weibull, generalized Pareto, and normal. The simulation results showed that the de Haan and the Conditional Mean Exceedance (CME) methods performed consistently better than the Pickands method (NIST implementation). For the distributions, parameter values, and mean recurrence intervals assumed in this work, the CME method outperformed the de Haan method only when the percent estimation errors were about one percent or smaller, a case unlikely to be encountered in wind engineering practice.

Lee, S. H. K.

Lee, S. H. K.; Chiu, W. K. S.; Jaluria, Y.
Experimental Study of Enclosure Fires With Horizontal Vents.
Rutgers Univ., New Brunswick, NJ
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 327-330 pp, 1993.

combustion; enclosures; vents; experiments

A very important flow and transport circumstance that arises in enclosure fires is that of heat and mass transfer across a horizontal vent. Such vents exist in enclosed regions such as rooms and energy storage and ventilation systems. It is important to understand the basic nature of the transport processes which arise due to density and pressure differences across such vents. These two mechanisms give rise to very complicated flow patterns, depending on the relative magnitude of each. This paper represents the second phase of an on-going experimental study on the flow of air across a horizontal vent in an enclosed region for arbitrary values of the governing variables and L/D, where L and D are the length and diameter of the vent respectively. The objective is to accurately quantify some of the results obtained from an earlier visualization study.

Levin, B. M.

Levin, B. M.; Groner, N. E.; Paulsen, R.
Affordable Fire Safety in Board and Care Homes. A Regulatory Challenge. Final Report.
George Mason Univ., Fairfax, VA
NIST-GCR-93-632; 79 p. July 1993.
Available from National Technical Information Services
PB93-219723

board and care homes; egress; elderly persons; evacuation; fire safety codes; handicapped; NFPA 101; residential buildings; sprinklers

This is the final technical report on a project concerning fire safety in Board and Care Homes. Homes vary greatly in the level of disability of residents and financial resources of the residents. A major concern is the availability of satisfactory care for clients with limited funds. Meeting fire safety codes can mean an unaffordable capital cost to financially marginal providers who cannot borrow money. One focus of the study is the use of the provisions in the Life Safety Code. Many agencies use these requirements and find they lead to a high level of safety without excessive costs. All have developed or adopted a procedure for rating Evacuation Difficulty that they find workable, and many find satisfactory. Other agencies use other requirements, sometimes more lenient and often more strict. Costs of fire safety systems, such as sprinklers, can vary greatly, impending a dialogue on the benefit-cost relationships of these systems. It appears that in some locations there are many homes that provide the services of Board and Care Homes but are not regulated.

Lew, H. S.

Lew, H. S.; Todd, D. R.
Seismic Standards for Existing Federally Owned and Leased Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers. Structural Engineering in Natural Hazards Mitigation. Volume 1. Structures Congress '93. April 19-21, 1993, Irvine, CA, American Society of Civil Engineers, New York, NY, Ang, A. H. S.; Villaverde, R., Editors, 440-444 pp, 1993.

standards; safety; building construction

Public Law 101-64 requires the Interagency Committee on Seismic Safety in construction to develop "standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government." Congress has directed the President to adopt these standards by December 1, 1994. This paper describes the content of a draft standards being developed; presents the results of an Issues Workshop at which philosophical and administrative concerns were addressed; and describes the anticipated content of the standard.

Liu, S. T.

Liu, S. T.; Kelly, G. E.
Predicting the Energy Performance Ratings of a Family of Type I Combination Appliances.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5250; 27 p. August 1993.
Available from National Technical Information Services

Annual Fuel Utilization Efficiency; ANSI/ASHRAE Std. 103; ASHRAE Std. 124-1991; boiler; building technology; combination appliance; combined annual efficiency; DOE water heater test procedure; energy factor; linear interpolation,; rating; space heating; tankless coil; water heating

ANSI/ASHRAE Standard 124-1991 specifies the laboratory tests and the calculation procedure for estimating seasonal and annual performance of combination appliances which are designed to provide both space heating and water heating. A boiler that includes a tankless coil for water heating is covered by those sections in ASHRAE Standard 124 that pertain to Type I combination appliances. In an effort to minimize the test burdens on manufacturers, a computer simulation study was conducted to determine if a subset of a family series of Type I combination appliances could be tested and used to predict the performance of the rest of the appliances in the family. Computer simulation was conducted on a family of five different size boilers with an identical tankless coil to calculate their Combined Annual Efficiency (CAE) as specified in ASHRAE Standard 124. To this end, the Energy Factor (EF) for water heating and the Annual Fuel Utilization Efficiency (AFUE) for space heating were calculated. For the water heating test that was simulated, daily hot water draw volumes of 243.4 liters (64.3 gal.) and 454.2 liters (120 gal.) were used. The results showed that for the five boilers, the AFUE for space heating differed by less than 1 percent. On the other hand, the EF for water heating depended strongly on the size of the boilers for the same daily hot water drawn and on the volume of daily water drawn for a given size boiler. However, for the same daily hot water draw volume, the EF was an approximate linear function of the boiler size. The results also showed that the CAE varied by slightly over 1 percentage point among the five boilers when the same daily water draw volume was used and by less than 0.8 percentage points for the same boiler when the two different hot water draw volume were used. Thus a single linear interpolation based on either water draw volume appears adequate for determining the Combined Annual Efficiency CAE.

Lomakin, S. M.

Lomakin, S. M.; Brown, J. E.; Breese, R. S.; Nyden, M. R.
Investigation of the Thermal Stability and Char-Forming Tendency of Cross-Linked Poly(methyl methacrylate).
National Institute of Standards and Technology, Gaithersburg, MD
Polymer Degradation and Stability, Vol. 41, 229-243, 1993.

polymethylmethacrylate; thermal stability; char formation; crosslinking; thermal degradation

The thermal degradation of two network copolymers of methyl methacrylate was studied as a function of the chemical nature of the cross-linking agent and the frequency of cross-links. Unlike the linear homopolymer, both the trimethylopropane triacrylate and trimethylolpropane trimethacrylate networks were found to char when burned. The corresponding derivative thermograms indicate that there are dramatic differences in the thermal degradation of these polymers even in the absence of oxygen. These differences are interpreted in terms of a simple model for the kinetics of depolymerization.

M

Marshall, R. D.

Marshall, R. D.
Evaluation of Design Wind Loads for Manufactured Homes and Needed Improvements.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers. Huarricanes of 1992. Andrew and Iniki One Year Later. Proceedings. December 1-3, 1993, Miami, FL, A1/IV1-10 pp, 1993.

housing; wind velocity; evaluation; damage; wind effects; cladding

Widespread damage to manufactured homes in Hurricane Andrew has called into question the wind load provisions of the Manufactured Home Construction and Safety Standards (MHCSS) and the structural performance of manufactured homes subjected to extreme winds. This paper presents a summary comparison of the MHCSS design wind loads with design loads from selected codes and standards that are in use in hurricane-prone areas of the United States. Critical areas that are in urgent need of improvement and updating are identified.

Marshall, R. D.
Wind Load Provisions of the Manufactured Home Construction and Safety Standards: A Review and Recommendations for Improvement.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5189; 103 p. May 1993.
Available from National Technical Information Services

building technology; wind; wind damage; manufactured homes; codes; standards; hurricanes; mobile homes; natural disasters; structural engineering

Limited wind speed measurements obtained during landfall of Hurricane Andrew in south Florida and wind speed estimates obtained from a computer-based model and from analyses are summarized and compared with code-specified design speeds for the affected area. Published reports of wind damage to manufactured homes and to conventional wood-framed dwellings are reviewed to identify modes of failure and intensity of damage. In general, manufactured homes which were built subsequent to issuance of the Manufactured Home Construction and Safety Standards (MHCSS) suffered less damage than did units built prior to issuance of the MHCSS. However, conventional residential construction performed better than did manufactured homes, including HUD-labeled units. Wind load provisions of selected codes and standards are compared and it is concluded that ASCE Standard 7-88 (Minimum Design Loads for Buildings and Other Structures) should be the basis for upgrading and improving the current wind load requirements of the MHCSS. Draft wind load requirements of the HUD Proposed Rule are reviewed and it is concluded that some clarification and refinement of these requirements are in order.

Marshall, R. D.; McDonald, J. R.; Perry, D. C.
Manufactured Homes in Hurricane Andrew and the Need for Improved Design Wind Load Criteria.
National Institute of Standards and Technology, Gaithersburg, MD
Texas Tech Univ., Lubbock, TX
Texas A & M Univ., College Station, TX
U.S. National Conference on Wind Engineering, 7th Proceedings. Volume 1. 1993, Los Angeles, CA, 423-432 pp, 1993.

housing; weather effects; building design; wind effects; wind velocity; damage; building codes; structural stability; safety standards

On Monday, August 24, 1992, Hurricane Andrew made landfall in south Florida between Key Biscayne and Key Largo. The maximum sustained wind speed over water is estimated to have been 144 mph which corresponds to a category 4 hurricane on the Saffir-Simpson scale. Fifteen deaths were directly attributable to Hurricane Andrew and an additional 28 deaths were indirectly related. Approximately 28,000 dwellings were destroyed or heavily damaged, and more than 160,000 people were left homeless in Dada County. Damage surveys carried out following the passage of Hurricane Andrew show that manufactured housing suffered a disproportionate level of damage when compared with traditional single-family dwellings. In more than one manufactured housing park the destruction due to wind effects was close to 100 percent. The reasons for this high level of damage and steps that can be taken to reduce future damage are examined in this paper.

Martin, J. W.

Martin, J. W.
Quantitative Characterization of Spectral Ultraviolet Radiation-Induced Photodegradation in Coating Systems Exposed in the Laboratory and the Field.
National Institute of Standards and Technology, Gaithersburg, MD
Progress in Organic Coatings, Vol. 23, 49-70, 1993.

ultraviolet radiation; photodegradation; coatings; total effective dose; mathematical evaluation

Experimental and mathematical procedures used by the coatings and polymeric building materials community for characterizing the photodegradation effects of UV radiation are compared with those used in the medical, biological, and agricultural communities. In these other disciplines, field and laboratory photodegradation data are related through total effective dosage, which is derived from the cumulative spectral UV irradiance to which a material is exposed and the material's absorption and quantum yield parameters. Total effective dosage has been shown to be a good predictor of human response to solar UV radiation. The mathematical basis for determining the total effective dosage and the assumptions underlying its computation are reviewed. The intent of this presentation is to identify methods for improving the design of laboratory and field experiments for evaluating photodegradation in coatings and other building material systems.

McGrattan, K. B.

McGrattan, K. B.; Nakabe, K.; Baum, H. R.; Kashiwagi, T.
Transition From Localized Ignition to Flame Spread Over a Thin Cellulosic Material in Microgravity.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 409-412 pp, 1993.

combustion; microgravity; ignition; flame spread; cellulosic materials; vapor phases

Ignition and flame spread processes are complicated by strong coupling between chemical reactions and transport processes, not only in the gas phase but also in the condensed phase. In most previous studies, ignition and flame spread were studied separately with the result that there has been little understanding of the transition from ignition to flame spread. In fire safety applications this transition is crucial to determine whether a fire will be limited to a localized, temporary burn or whether it will grow to become a large fire. In order to understand the transition to flame spread, the transient mechanisms of ignition and subsequent spread must be studied. However, there have been no definitive experimental or modeling studies because of the complexity of the buoyancy-induced flow near the heated sample surface. One must solve the full Navier-Stokes equations over an extended region to represent accurately the highly unstable buoyant plume and entrainment of surrounding gas. To avoid the complicated nature of the plume problem under normal gravity, previous detailed radiative ignition models were assumed to be one-dimensional or were applied at a stagnation point. Unfortunately, these models could not be extended to include the transition to flame spread.

McGrattan, K. B.; Putorti, A. D.; Twilley, W. H.; Evans, D. D.
Smoke Plume Trajectory From In Situ Burning of Crude Oil in Alaska.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5273; 70 p. October 1993.
Available from National Technical Information Services
PB94-114519

crude oil; oil spills; pool fires; smoke; fire plumes

Experimentation, analysis, and modeling have been performed to predict the downwind dispersion of smoke resulting from in situ burning of oil spills. North Slope and Cook Inlet crude oils are burned on water in a 1.2 meter diameter pan. Smoke yields were found to be 11.6% + 1.0 for North Slope crude, and 9.2% + 0.6 Cook Inlet crude by mass of fuel consumed, with a 95% confidence interval. Burning rates and smoke aerosol size distributions are also measured, and found similar to previous work with different crude oils. Derivation of scaling factors for predicting the burning rates and smoke yields of large scale fires are guided by previous experiments with Louisiana crude oil. Scaled burning rates and smoke yields are supplied as input parameters for the LES (Large Eddy Simulation) model, version 2.0, of windblown smoke transport over flat terrain. For weather conditions appropriate for the Cook Inlet and North Slope areas, model results are presented which predict downwind dispersion and ground level concentrations of the fire generated particulate matter. The model predicts that ground level particulate concentrations in excess of 150 mg/m3 are limited to strips 5 km long and 1 km wide downwind of the fire for all meteorological conditions considered.

McKnight, M. E.

McKnight, M. E.; Seiler, J. F., Jr.
Quality Control Tests for Adhesion of Paint on the Panels of Tactical Rigid Wall Shelters. Phase 2.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4958; 29 p. March 1993.
Available from National Technical Information Services
PB93-173474

paint; quality control; adhesion; aluminum; coatings; test methods; adhesion tests; bond strength; building technology; relocatable structures; tactical rigid wall shelters

At the request of the U. S. Army Natick Research, Development and Engineering Center, a practical method was developed for measuring the adhesion of paints applied to shelters. As recommended in the Phase 1 report, a pull-off test based on the use of a commercially available pneumatic testing device was chosen. The procedure includes ways of controlling the substrate stiffness, a parameter that affects the test results, and a process for obtaining acceptable levels of adhesion for a particular substrate. The estimated precision (standard deviation) of the method is 9 percent. In a pilot study to determine the extent to which small differences in surface preparation would affect differences in pull-off test results, it was found that, at least for aluminum, the procedure was insensitive to small differences in surface preparation.

Mitler, H. E.

Mitler, H. E.; Steckler, K. D.
Comparison of Wall-Fire Behavior With and Without a Ceiling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5380; 32 p. November 1993.
Available from National Technical Information Services

wall fires; ceiling fires; ceiling jets; burning rate; fire research; radiation feedback; spread rates

This paper demonstrates that the effects of the ceiling on the progress of a wall fire are quite significant, and that a project to quantify and model the effects of a ceiling on the progress of a wall fire is indeed justified. Experimental results from the open literature are used for this purpose, as well as previously-unpublished experimental results obtained at NIST. The wall-fire model SPREAD and the room-fire model FIRST are used seriatim to show that part of this effect can be calculated now.

Mitler, H. E.; Walton, G. N.
Modeling the Ignition of Soft Furnishings by a Cigarette. Volume 3.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 852; Volume 3; 169 p. August 1993.
Available from National Technical Information Services
PB94-109014
Available from Government Printing Office
Available from U.S. Consumer Product Safety Commission, Washington, DC 20207

cigarettes; ignition; furniture; computer models; mathematical models; pyrolysis; simulation; smoldering; substrates

This paper describes the user-friendly computer models CIGARET and SUBSTRAT. CIGARET calculates the time-dependent behavior of a cigarette smoldering quietly in the air, away from surfaces. The model incorporates diffusion and convection of gases, as well as the kinetics of char oxidation. It calculates the internal heat fluxes, as well as the internal distributions of temperature, gas velocity, and oxygen concentration. SUBSTRAT determines whether a two-layer solid (with an air gap in between), exposed to a moving heating flux such as is produced by a cigarette, will ignite. Among the processes taken into consideration are three-dimensional heat conduction in the substrate and its pyrolysis. This model has successfully simulated the thermal runaway signifying smoldering ignition of the substrate when it is exposed to a set of external heating fluxes. SUBSTRAT and CIGARET have been designed to work in tandem to simulate the most frequent cause of fatal fires: cigarette ignition of upholstered furniture and bedding. Users' guides are included.

Mulroy, W. J.

Mulroy, W. J.; Domanski, P. A.; Didion, D. A.
Glide Matching With Binary and Ternary Zeotropic Refrigerant Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
International Conference Energy Efficiency in Refrigeration and Global Warming Impact. 1993, Belgium, 1-20 pp, 1993.

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

An improvement of the coefficient of performance (COP) of the regrigeration 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. 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 a R23/22/142b ternary mixture in a generic laboratory breadboard refrigeration system.

N

Nguyen, T.

Nguyen, T.; Byrd, E.; Bentz, D.
Measuring Transport of Liquid Water Through Organic Coatings Adhered to a Substrate.
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society. Proceedings. March 28-April 1, 1993, Denver, CO, 1-2 pp, 1993.
substrates; water; organic coatings; FT-IR

Water transport through a coating on a substrate is the subject of great interest in many areas involving a polymer film on a substrate, e.g., organic coatings, adhesives and sealants, asphalt pavement, and electronic packaging. There is currently no method available to measure this property. In previous publications, we described a method based on FTIR-multiple internal reflection spectroscopy (FTIR-MIR) for studying water in situ at the coating/metal (germanium and iron) interface. We also reported the application of this technique for obtaining qualtitative information on water at the coating/substrate interface. In this paper, we describe a method based on FTIR-MIR spectroscopy for measuring the diffusion coefficient of liquid water thorugh an organic coating adhered to a substrate.

Nguyen, T.; Byrd, E.; Bentz, D.
Quantifying Water at the Organic Film/Hydroxylated Substrate Interface.
National Institute of Standards and Technology, Gaithersburg, MD
Adhesion Conference Proceedings. February 1993, Williamsburg, VA, 1-3 pp, 1993.
water; substrates; FT-IR; organic film

Water at the organic film/ substrate interface causes disbondment of coated substrates when these materials are exposed to an aqueous solution or high relative humidities. The most visible effects are blistering and delamination. For metal substrates, water is necessary for corrosion reactions to occur. Measurement of water at the organic film/substrate interface is a subject of great interest in many fields such as polymer coatings, adhesives, and asphalt pavements. In a previous publication, we reported the development of a technique based on Fourier transform infrared - multiple internal reflection (FTIR-MIR) spectroscopy for studying in situ water at the polymer/metal interface. This paper presents a quantitative study of water at the interface between an organic film and a hydroxylated substrate. Since the surface of most common metals is covered with an hydroxylated oxide layer, quantitative information on water at the organic film/hydroxylated substrate interface should enhance our understanding of the mechanisms of blistering, delamination, and corrosion of coated materials.

Nguyen, T.; Byrd, E.; Zarr, R. R.; Stutzman, P.
Effects of Humidity on Chemical Structure and CFC Loss of Polyisocyanurate Foam Blown With CFC and CFC/CO2 Mixture.
National Institute of Standards and Technology, Gaithersburg, MD
Society of the Plastics Industry of Canada's. Workshop on Long-Term Performance of Cellular Plastics, 3rd International. October 4-6, 1993, Ontario, Canada, 1-28 pp, 1993.
polyisocyanurate foam; humidity; chemical structure; carbon dioxide

The effects of humidity on the microstructure, chemical structure, and blowing agent loss of unfaced, chlorofluorocarbon (CFC) and CFC/CO2-blown polyisocyanurate (PIR) foams were investigated using scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). The exposure environments were: [1] ambient conditions; [2] 60 deg C in dry air (<10% RH); [3] 60 deg C and 40% RH; and [4] 60 deg C and 75% RH. SEM analyses were done for CFC/CO2 foam efore and after one-year exposure. FTIR measurements were conducted using 2-mm thick specimens of both foams before exposure and at regulat time intervals for up to one year. All exposure conditions caused little change of the cell microstructure of foams taken 1 mm below the exposed surfaces. However, the change in the size of KC1 particles, which were present amply on cell membrane surfaces, was a function of humidity. All exposures had little effect on the C=O, NH, or CH groups but decreased the NCO and carbodiimide groups of the foam polymers, and caused a loss of the CFC blowing agent in both CFC- and CFC/CO2-blown foams. The change in chemical structure and CFC loss were a function of humidity, the higher the humidity the faster the loss and degradation. The CFC loss was also faster at the elevated temperature than at ambient temperature. The effective diffusion coefficients of CFC from the two foams, obtained from the desorption data using the FTIR technique for the whole exposure duration, were in the 10-8

cm2/s range. The diffusion of CFC in CFC/CO2-blown foam followed a Fickian process while that in the CFC foam did not. Information on the microstructure and chemical properties of the two foams before exposure is also given.

Nguyen, T.; Hubbard, J. B.; Pommersheim, J. M.
Models for the Degradation of Organic Protective Coatings on Steel.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
Durability of Building Materials and Components 6. Volume 2. Durability, Repair, Design. Proceedings of the Sixth (6th) International Conference. Chapter 5.4. October 26-29, 1993, Omiya, Japan, E & FN Spon, New York, Nagataki, S.; Nireki, T.; Tomosawa, F., Editors, 1070-1079 pp, 1993.
steels; coatings; degradation; blisters; diffusion

Conceptual and mathematical models for the degradation of a protective coating on a steel substrate exposed to an electrolytic environment are described. This is part of our continuing effort to develop credible approaches to service life prediction. The models were developed based on the concept that corrosive species attack the metal following their transport through imperfect regions in the coatings; the attack then causes separation of the coating from the substrate near the corroded sites. The imperfect regions are assumed to be defects in an impermeable film. Models for the separation (delamination and blistering) resulting from corrosion reactions are based on the diffusion of cations along the coating/steel interface from the defects to cathodic sites under the coatings. The mathematical models are solved to prediction fluxes and concentration profiles along the interface and within blisters. Model variables include blister size, distance between blister and defect, ion diffusivity, and potential gradients. Experimental results agree well with theoretical predictions.

Nguyen, T.; Pommersheim, J. M.
Diffusion of Cations Along the Polymer/Metal Interface Under an Applied Electrical Potential.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
Materials Research Society Symposium Proceedings. Volume 304. 1993, 15-20 pp, 1993.
diffusion; coatings; sodium; mathematical models; experiments; equations

Diffusion of cations along the polymer/metal interface controls the rate of blistering of polymer coatings on metals exposed to electrolytes. Cations are driven by both concentration and electrical potential gradients. A theoretical and experimental study was carried out on the diffusion of sodium ion along the polymer coating/steel interface under an applied potential. Mathematical models, consisting of initial and propagation stages, are derived based on a moving boundary diffusion problem. Model variables include ion diffusivity, potential grandient and distance between defects and delamination sites. Models are solved to predict ion fluxes and concentration in the blistering areas. Experimental data are analyzed to extract model parameters. Model predictions agreed well with experimental data and practical observations.

Nolle, C. S.

Nolle, C. S.; Koiller, B.; Martys, N.; Robbins, M. O.
Morphology and Dynamics of Interfaces in Random Two-Dimensional Media.
Johns Hopkins Univ., Baltimore, MD
Pontificia Universidade Catolica do Rio de Janeiro, Brazil
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review Letters, Vol. 71, No. 13, 2074-2077, September 27, 1993.
morphology; dynamics; interfaces

We study the morphology and dynamics of an interface driven through a disordered two-dimensional medium by an applied force. At large length scales the interface is self-affine with roughness exponent alpha = 1/2. The structure at small scales may be self-similar or self-affine, depending on the degree of disorder. Simulations of wetting invasion produce self-affine interfaces with alpha = 0.8 and a power law distribution of local interface velocities. Numerical results are in excellent agreement with experiment. A technique that distinguishes between true self-affine scaling and a crossover is presented, and applied to the invasion model and a model for magnetic domain growth.

Norton, T. S.

Norton, T. S.; Smyth, K. C.; Miller, J. H.; Smooke, M. D.
Comparison of Experimental and Computed Species Concentration and Temperature Profiles in Laminar, Two-Dimensional Methane/Air Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
George Washington, Univ., Washington, DC
Yale Univ., New Haven, CT
Combustion Science and Technology, Vol. 90, No. 1-4, 1-34, 1993.

laminar flames; diffusion flames; species concentrations; temperature profiles; flame structure

Experimental concentration measurements of the major stable species and five radical species (OH, H atom, O atom CH, and CH3) obtained on a rectangular Wolfhard-Parker slot burner are compared with a detailed computation of the chemical structure of an axisymmetric laminar, CH4/air diffusion flame burning at atmospheric pressure. In order to examine these CH4/air flames with different geometries and different sizes, the species profiles are plotted as functions of the local mixture fraction, and the scalar dissipation rate has been matched in a region around the stoichiometric surface. The overall agreement in the absolute concentrations, the shape of the profiles, and their location in terms of the local mixture fraction is good to excellent for the stable species (except for O2) and for the most abundant radicals OH, H atom, and O atom. For example, the calculated OH maximum concentration is in much better agreement with the experimental results than are full equilibrium and partial equilibrium estimates. Less satisfactory agreement is found for the CH and CH3 radicals. In addition, significant discrepancies are observed in the temperature field and in the degree of O2 penetration into rich flame regions.

Notarianni, K. A.

Notarianni, K. A.
Measurement of Room Conditions and Response of Sprinklers and Smoke Detectors During a Simulated Two-Bed Hospital Patient Room Fire.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5240; 138 p. July 1993.
Available from National Technical Information Services

sprinklers; fire research; fire tests; sprinkler response; smoke detectors; hospital fires; life safety

A series of experiments are reported in which a wood crib was burned within a simulated two bed hospital patient room in order to measure the activation times of various types of quick and standard response sprinklers and ionization and photoelectric smoke detectors at several locations in the room simulating multiple options for protection of the space. Gas and surface temperatures, heat flux, carbon dioxide, carbon monoxide, and oxygen concentrations were continuously measured in order to access the tenability of the room. Of the parameters measured, temperature was the best indicator of the tenability of the space. Temperature at time of activation of the quick response sprinklers was at or below 77 deg C (171 deg F) at the five foot level and at or below 40 deg C (118 deg F) at the three foot level between the patient beds, in all tests with the exception of the shielded fire scenario where temperatures at the five and three foot levels reached 111 deg C (232 deg F), and 78 deg C (172 deg F) respectively. An initial detector activation was received between 232-277 seconds prior to activation of the first sprinkler, and 552-722 seconds prior to activation of the QR-EC sidewall sprinkler.

Notarianni, K. A.
Water Mist Fire Suppression Workshop Summary.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Bulletin, 8-9, Summer 1993.

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

The imminent lack of availability of halon fire suppressants has sparked worldwide efforts in developing other total-flooding agents. Water mist systems are potential replacements in many industrial uses, as well as in new markets, such as residences and commercial aircraft. To facilitate the process of commercializing water mist systems, a workshop on water mist fire protection was held at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD, 1-2 March 1993. The workshop was funded by the Building and Fire Research Laboratory (BFRL) and the Advanced Technology Program (ATP) at NIST. One goal of the workshop was to stimulate proposals to the ATP program in the area of water mist fire protection.

Notarianni, K. A.; Davis, W. D.
Use of Computer Models to Predict Temperature and Smoke Movement in High Bay Spaces.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5304; 64 p. December 1993.
Available from National Technical Information Services
PB94-145976

computer models; temperature; smoke movement; clean rooms; computational fluid dynamics; detector response; field modeling; fire detection; fire models; forced air flow; fire plumes; fire tests; high bays; response time; sprinkler response

The Building and Fire Research Laboratory (BFRL) was given the opportunity to make measurements during fire calibration tests of the heat detection system in an aircraft hangar with a nominal 30.4 m (100 ft) ceiling height near Dallas, TX. Fire gas temperatures resulting from an approximately 8250 kW isopropyl alchol pool fire were measured above the fire and along the ceiling. The results of the experiments were then compared to predictions from the computer fire models DETACT-QS, FPETOOL and LAVENT. In section A of the analysis conducted, DETACT-QS and FPETOOL significantly underpredicted the gas temperatures. LAVENT at the position below the ceiling corresponding to maximum temperature and velocity provided better agreement with the data. For large spaces, hot gas transport time and an improved fire plume dynamics model should be incorporated into the computer fire model activation routines. A computational fluid dynamics (CFD) model, HARWELL FLOW3D, was then used to model the hot gas movement in the space. Reasonable agreement was found between the temperatures predicted from the CFD calculations and the temperatures measured in the aircraft hangar. In section B, an existing NASA high bay space was modelled using the computational fluid dynamics model. The NASA space was a clean room, 27.5 m (90 ft) high with forced horizontal laminar flow. The purpose of this analysis is to determine how the existing fire detection devices would respond to various size fires in the space. The analysis was conducted for 32 MW, 400 kW, and 40 kW fires.

Notarianni, K. A.; Davis, W. D.
Use of Computer Models to Predict the Response of Sprinklers and Detectors in Large Spaces.
National Institute of Standards and Technology, Gaithersburg, MD
Society of Fire Protection Engineers and Worcester Polytechnic Institute. Computer Applications in Fire Protection. Proceedings. June 28-29, 1993, Worcester, MA, 27-33 pp, 1993.

computers; fire protection; computer models; sprinkler response; detector response; aircraft hangars; test fires; fire models

Measurements were made during fire tests conducted in an aircraft hangar with a ceiling height of 30.4 m. Fire gas temperatures and disk temperatures were measured above the fire and along the ceiling in locations corresponding to the expected location of detectors or sprinklers. Instrument locations were determined utilizing the computer fire models FPETOOL, DETACT-QS, and LAVENT. The results of the fire experiments were then compared to the predictions from the computer models in order to determine the limits of applicability of the models and to develop recommendations for use in large spaces. In the analysis conducted, computer fire models underpredicted the ceiling jet temperatures and thus are conservative in their activation

predictions. For large spaces, a model should be developed that includes hot gas transport time and fire plume dynamics. In the ongoining phase of this project, a computational fluid dynamic model, HARWELL FLOW3D, is used to model the space. Initial comparisons between the computational fluid dynamic calculations and the experiment for the centerline plume temperatures are in reasonable agreement.

Notarianni, K. A.; Evans, D. D.; Walton, W. D.
Smoke Production From Large Oil Pool Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers. Interflam '93. Fire Safety. International Fire Conference, 6th. March 30-April 1, 1993, Oxford, England, Interscience Communications Ltd., London, England, Franks, C. A., Editor, 111-119 pp, 1993.

fire safety; fire science; pool fires; smoke production; oil spills; crude oil; smoke yield

This study is motivated by a desire to understand the near and far field effects of large fires, and in particular the current need to understand the consequences of burning large pools of oil as a means of responding to a spill emergency. A concern related to burning oil is that the smoke particulate content of the plume may be a health hazard. The smoke yield (fraction of the burned fuel that is emitted as smoke particulate) was measured for crude oils in laboratory and mesoscale field experiments conducted in the United States and Japan. Scaling of smoke yield from laboratory to large scale fires is based on results from pool fire experiments from 0.85 m to 17.2 m in diameter. An important finding of this study is that smoke yield varies approximately by a factor of two between laboratory tests (6 percent smoke yield) and larger diameter fires conducted out-of-doors (13 percent smoke yield). The large laboratory experiments conducted in Japan, showed that a pool fire of a 2 m in diameter produced nominally the same smoke yield as the largest fires tested.

Notarianni, K. A.; Jason, N. H., Editors
National Institute of Standards and Technology, Gaithersburg, MD
Water Mist Fire Suppression Workshop. Proceedings. March 1-2, 1993.
NISTIR 5207; 156 pp. 1993.
Available from National Technical Information Services
PB93-219780

fire suppression; water fog; water mist; water sprays; fire research; droplets; drop sizes; fire extinguishment; sprinklers; aircraft; electronic facilities; marine transportation

The water mist fire suppression workshop was organized to facilitate the commercialization of water mist technology in the United States. The imminent lack of availability of halon fire suppressants has sparked worldwide efforts in developing alternative fire fighting agents and delivery systems. Water mist systems are potential replacements in many industrial uses, as well as in new markets, such as commercial passenger aircraft. Speakers presented state-of-the-art papers on the incentives of using misting sprays, the advances in spray drop size measurement and the engineering criteria for water mist fire suppression systems. Three papers discussed projects demonstrating the use of water mist systems in aircraft, marine, and telecommunications applications. With this background the speakers and attendees were divided into three panels: research needs, end use criteria, and marketing. The purpose of the panel sessions [Methodology, Panel Summaries, and Ranking of Panel Ideas] was to identify the areas of concern relating to the commercialization of water mist systems. The proceedings brings together the recommendations of each panel and the individual technical papers.

Nyden, M. R.

Nyden, M. R.; Brown, J. E.
Computer-Aided Molecular Design of Fire Resistant Aircraft Materials.
National Institute of Standards and Technology, Gaithersburg, MD
DOT/FAA/CT-93/3;
Federal Aviation Administration (FAA). International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials. February 9-11, 1993, DOT/FAA/CT-93/3, Atlantic City, NJ, 147-158 pp, 1993.
Available from National Technical Information Services

aircraft interiors; fire resistant materials; test methods; fire safety; computer models; simulation; cone calorimeters; polyethylene; composite materials; commercial aircraft; ceilings

Molecular dynamic simulations and Cone Calorimeter measurements were used to assess the effects of electron beam irradiation and heat treatments on the flammability of the honeycomb composites used in the sidewalls, ceilings and stowage bins of commercial aircraft. The irradiaiton of this material did not result in any measureable changes. A dramatic reduction in the peak rate of heat release, however, was observed in samples that had been heated overnight at 250 deg C.

Nyden, M. R.; Grosshandler, W. L.; Lowe, D. L.; Harris, R. H., Jr.; Braun, E.
Application of FTIR Remote Sensing Spectroscopy in Environmental Impact Assessments of Oil Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Air and Waste Management Association. Optical Sensing for Environmental Monitoring (SP89). International Specialty Conference Proceedings. October 11-14, 1993, Atlanta, GA, Air and Waste Management Assoc., Pittsburgh, PA, 767-779 pp, 1993.

oil spills; FT-IR; benzene; environmental effects; spectroscopy; crude oil; evaporation; combustion

A series of laboratory measurements was conducted to determine the extent to which benzene and other aromatic components are destroyed when crude oil is burned on the open seas. The atmosphere above a pan containing Alaskan North Slope crude oil was monitored with a remote sensing FTIR spectrometer during both evaporation and burning. This data was used in conjunction with gas chromatographic analyses of the oil obtained before ignition and after the fire was extinguished (by covering the pan with a marinite slab) to estimate the C6H6 destruction efficiency of the oil fire. The results of these laboratory measurements are viewed in the context of data collected during mesoscale oil fires conducted at Little Sand Island in Mobile, Alabama.

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Ohlemiller, T. J.

Ohlemiller, T. J.; Cleary, T. G.; Brown, J. E.; Shields, J. R.
Assessing the Flammability of Composite Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Fire Sciences, Vol. 11, No. 4, 308-319, July/August 1993.
Sagamore Army Materials Research Conference, 39th. September 16-17, 1992, Plymouth, MA, 1992.

composite materials; flammability; ignition source; bulkheads; heat release rate; flame spread

Composite materials offer the potential for substantial weight savings in the structure of both surface ships and submarines. However, the organic nature of the binder resins in these materials implies that one would be replacing non-flammable materials (aluminum, steel) with materials that could possibly contribute to a fire. This points to a critical need for methods which allow reliable prediction of the extent of fire involvement which a given material may exhibit in a particular application. There are numerous aspects of this which must ultimately be considered; these range from the strength of the composite under a fire heat load to potential toxicity and corrosivity of the fire gases.

Ohlemiller, T. J.; Shields, J. R.
One- and Two-Sided Burning of Thermally Thin Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Fire and Materials, Vol. 17, 103-110, 1993.

heat release rate; experiments; combustion; flammability; composite materials

The rate of heat release from a thermally thin material burning on both sides will be more than twice the value seen when only one side is burning. Two simplified models demonstrate that this is a consequence of the Arrhenius temperature deptndence of the gasification rate of the solid. Experiments carried out on three composite materials over a range of incident heat fluxes confirm this effect. It is inferred that a further consequence of this heat release enhancement is an increased tendency for concurrent flame spread in the two-sided burning case. Materials whose application could lead to two-sided burning should thus be assessed in this mode to obtain a true picture of their flammability potential.

Ohlemiller, T. J.; Villa, K. M.; Braun, E.; Eberhardt, K. R.; Harris, R. H., Jr.; Lawson, J. R.; Gann, R. G.
Test Methods for Quantifying the Propensity of Cigarettes to Ignite Soft Furnishings. Volume 2.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 851; Volume 2; 166 p. August 1993.
Available from National Technical Information Services
PB94-108644
Available from Government Printing Office
Available from U.S. Consumer Product Safety Commission, Washington, DC 20207

cigarettes; test methods; ignition; upholstered furniture; statistical analysis

Research funded under the Fire Safe Cigarette Act of 1990 (P.L. 101-352) has led to the development of two test methods for measuring the ignition propensity of cigarettes. The Mock-Up Ignition Test Method uses substrated physically similar to upholstered furniture and mattresses: a layer of fabric over padding. The measure of cigarette performance is ignition or non-ignition of the substrate. The Cigarette Extinction Test Method replaces the fabric/padding assembly with multiple layers of common filter paper. The measure of performance is full-length burning or self-extinguishment of the cigarette. Routine measurement of the relative ignition propensity of cigarettes is feasible using either of the two methods. Improved cigarette performance under both methods has been linked with reduced real-world ignition behavior; and it is reasonable to assume that this, in turn, implies a significant real-world benefit. Both methods have been subjected to interlaboratory study. The resulting reproducibilities were comparable to each other and comparable to those in other fire test methods currently being used to regulate materials which may be involved in unwanted fires. Using the two methods, some current commercial cigarettes are shown to have reduced ignition propensities relative to the current best-selling cigarettes.

P

Palmer, M.

Palmer, M.; Gilbert, M.
Guidelines for the Development and Approval of STEP Application Protocols. Version 1.1.
National Institute of Standards and Technology, Gaithersburg, MD
Trident Research Center, North Charleston, SC
NISTIR 5110; ISO TC184/SC4-PMAG-N103; Supersedes: SC4/WG4-N66-P5; 70 p. November 30, 1993.
Available from National Technical Information Services

application activity model; application interpreted model; application protocol; application protocol qualification; application reference model; conformance requirements

This document defines the concept and components of STEP application protocols and explains the process of developing, qualifying and approving STEP application protocols. This document also provides the forms for proposing STEP application protocol planning projects and STEP application protocol projects to ISO TC184/SC4.

Parker, W. J.

Parker, W. J.; Filipczak, R.
Modeling the Heat Release Rate of Aircraft Cabin Panels. Final Report.
National Institute of Standards and Technology, Gaithersburg, MD
DOT/FAA/CT-92/3; 52 p. February 1993.
Available from National Technical Information Services

aircraft compartments; heat release rate; calorimeters; computer models

A computer model was developed to calculate the heat release rate of aircraft cabin composite panels based on the panel's thermophysical, chemical, and geometric properties. The model calculates the temperature through the panel as a function of time and uses this along with measured kinetic constants to deduce mass loss rate which is multiplied by the heat of combustion of the volatiles. The calculated results are in general agreement with the measured heat release obtained from the Ohio State University (OSU) calorimeter.

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
Interscience Communications Limited. Fire and Materials. International Conference, 2nd. September 23-24, 1993, Arlington, VA, 171-180 pp, 1993.

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

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.; Forney, G. P.; Reneke, P. A.; Portier, R. W.; Jones, W. W.
CFAST, The Consolidated Model of Fire Growth and Smoke Transport.
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1299; 246 p. February 1993.
Available from Government Printing Office
SN003-003-03194-1

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

CFAST is a zone model capable of predicting the environment in a multi-compartment structure subjected to a fire. It calculates the time evolving distribution of smoke and fire gases and the temperature throughout a building during a user-specified fire. This report describes the equations which constitute the model, the physical basis for these equations, data which are used by the model, and details of the operation of the computer program implementing the model. A set of comparisons between the model and a range of real-scale fire experiments is presented. In general, the CFAST model compares favorably with the experiments examined in this paper. Although differences between the model and the experiments were clear, they can be explained by limitations of the model and of the experiments. This paper documents the equations which are used in CFAST and how they are implemented. The means by which one can add new phenomena is detailed, as are the variables and structure of the model. NOTE: If a copy of the software is needed, contact Dr. Walter W. Jones, NIST, Bldg. 224, Rm. A249, Gaithersburg, MD 20899 Tel: 301/975-6887 or e-mail wwj@enh.nist.gov.

Peacock, R. D.; Jones, W. W.; Bukowski, R. W.
Verification of a Model of Fire and Smoke Transport.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 21, No. 2, 89-129, 1993.

fire models; smoke transport; computer models; experiments; zone models; fire tests

A set of comparisons between a comprehensive room fire model and a range of real-scale fire experiments is presented. For these comparisons, a zone-based model, CFAST ('consolidated fire and smoke transport' model) is used. The model predicts the evolution of a fire in a room and the subsequent transport of the smoke and toxic gases which result from this fire. These comparisons serve two purposes: to determine, within limits, the accuracy of the predictions for those quantities of interest to the users of the models (usually those extensive variables related to hazard), and to highlight the strengths and weaknesses of the underlying algorithms in the models to guide future improvements in this and other models. The predicted variables selected for comparison deal with both of these purposes. Although differences between the model and the experiments were clear, they can be explained by limitations of the model and of the experiments.

Persily, A. K.

Persily, A. K.
Assessing Ventilation Effectiveness in Mechanically Ventilated Office Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Room Air Convection and Ventilation Effectiveness, International Symposium, 1992. 1993, Murakami, S.; Kaizuka, M.; Yoshino, H.; Kato, S., Editors, 201-212 pp, 1993.

office buildings; ventilation; effectiveness; systems engineering; zone models

Mechanical ventilation systems are designed and operated to bring outdoor air into buildings, distribute ventilation air within the occupied space, remove internally generated contaminants, and maintain thermal comfort. While standard measurement techinques exist to evaluate thermal comfort, air change rates and some aspects of ventilation air distribution in mechanically ventilated buildings, procedures to assess the uniformity of air distribtuion within a building and the degree of mixing within an occupied space are still being developed. This paper presents a general dicusssion of ventilation effectiveness in mechanically ventilated office buildings as the ability of the ventilation system to provide ventilation air in a manner consistent with the design goals of the system. The design and performance of air distribution systems are discussed on a range of scales, from the air handler to the individual workspace, as are the means for assessing ventilation effectiveness on each of these scales. Various approaches to the assessment of mixing within ventilated spaces, the most common conception of ventilation effectiveness, are presented and discussed in relation to their use in mechanically ventilated office buildings.

Persily, A. K.
Building and HVAC Characterization for Commercial Building Indoor Air Quality Investigations.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4979; 143 p. May 1993.
Available from National Technical Information Services
PB93-198844

commercial buildings; heating; ventilation; air conditioning; building diagnostics; building performance; indoor air quality; office buildings

A series of parameters has been developed for describing building and HVAC characteristics of commercial buildings in conjunction with indoor air quality investigations. These parameters were developed in association with the activities of the Building/HVAC Team and the Steering Committee of the U.S. Environmental Protection Agency (EPA) Building Assessment Survey and Evaluation (BASE) Program. The building and HVAC characterization includes those features considered essential to an investigation intended to obtain baseline information on a test space within a building as opposed to a detailed research study or an effort to diagnose a specific problem. The parameters include both general information on the building as well as more specific information on the space being investigated. This report consists of checklists for recording information on the building and HVAC parameters in the field, along with instructions for completing the checklists. The checklists cover four areas: A) Whole Building Description, B) Test Space Description, C) HVAC System Description, and D) HVAC System Performance. The Whole Building Description checklists provide a description of the basic features of the building being studied. The Test Space Description checklists are used to obtain more detailed information on the space within the building that is being studied, although the test space could be a whole building. The HVAC System Description checklists are used to describe the HVAC system serving the test space, and the HVAC System Performance checklists cover selected performance measurements on that HVAC system.

Persily, A. K.
Envelope Design Guidelines for Federal Office Buildings: Thermal Integrity and Airtightness.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4821; 208 p. March 1993.
Available from National Technical Information Services
PB93-183770

office buildings; thermal integrity; air tightness; design applications

Office building envelopes are generally successful in meeting a range of structural, aesthetic and thermal requirements. However, poor thermal envelope performance does occur due to the existence of defects in the envelope insulation, air barrier and vapor retarder systems. These defects result from designs that do not adequately account for heat, air and moisture transmission, with many being associated with inappropriate or inadequate detailing of the connections of envelope components. Other defects result from designs that appear adequate but can not be constructed in the field or will not maintain adequate performance over time. Despite the existence of these thermal envelope performance problems, information is available to design and construct envelopes that do perform well. In order to bridge the gap between available knowlege and current practice, NIST has developed thermal envelope design guidelines for federal office buildings for the General Services Administration. The goal of this project is to transfer the knowledge on thermal envelope design and performance from the building research, design and construction communities into a form that will be used by building design professionals. These guidelines are organized by envelope construction system and contain practical information on the avoidance of thermal performance problems such as thermal bridging, insulation system defects, moisture migration, and envelope air leakage.

Persily, A. K.
Modeling Radon Transport in Multistory Residential Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
American Society for Testing and Materials. Modeling of Indoor Air Quality and Exposure. ASTM STP 1205. 1993, Am. Soc. for Testing and Materials, PA, Nagda, N. L., Editor, 226-242 pp, 1993.

radon; residential buildings; airflow; contaminant dispersal; indoor air quality; multizone

Radon concentrations have been studied extensively in single-family residential buildings, but relatively little work has been done in large buildings, including multistory residential buildings. The phenomena of radon transport in multistory residential buildings is made more complicated by the multizone nature of the airflow system and the numerous interzone airflow paths that must be characterized in such a system. This paper presents the results of a computer simulation of airflow and radon transport in a twelve-story residential building. Interzone airflow rates and radon concentrations were predicted using the multizone airflow and contaminant dispersal program CONTAM88. Limited simulations were conducted to study the influence of two different radon source terms, indoor-outdoor temperature difference and exterior wall leakage values on radon transport and radon concentration distributions.

Persily, A. K.
Ventilation, Carbon Dioxide and ASHRAE Standard 62-1989.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Journal, Vol. 35, No. 7, 40,42-44, July 1993.

ventilation; carbon dioxide; standards; air quality

This article is an attempt to reduce some of the confusion concerning the issues of ventilation, carbon dioxide (CO2) and ASHRAE Standard 62-1989 that has been evident in recent discussions of indoor air quality. For example, at the last three ASHRAE meetings, there have been programs addressing carbon dioxide, indoor air quality and ventilation. While these programs included some new and interesting material, some of the presentations and remarks from the audience reflected a lack of understanding of the relationship between indoor CO2 concentrations and ventilation rates and of some important aspects of Standard 62. This article presents a brief discussion of how indoor CO2 levels are related to ventilation rates, including the use of indoor concentration measurements to determine outdoor air flow rates. The role of carbon dioxide in Standard 62, specifically the significance of the 1.000 ppm guideline, is also discussed. This article primarily addresses mechanically ventilated office buildings, but many of the statements are also relevant to other building types.

Phan, L. T.

Phan, L. T.; Todd, D. R.; Lew, H. S.
Seismic Strengthening of Reinforced Concrete Frame Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
Central United States Earthquake Consortium. Earthquake Hazard Reduction in the Central and Eastern United States: A Time for Examination and Action. National Earthquake Conference Proceedings, 1993. Volume 2. May 2-5, 1993, Memphis, TN, 235-244 pp, 1993.

reinforced concretes; structures; earthquakes; failure; validation; seismic strengthening

Most reinforced concrete (RC) frame structures in the mid-western and eastern regions of the United States are built mainly for gravity loads without proper seismic design, and thus are vulnerable to severe damage in the event of a major earthquake in these regions. While the need to retrofit these RC frame structures is recognized and different strengthening techniques have been laboratory-tested and applied in practice worldwide, ability to assess the relative merits of different strengthening schemes or to predict the improved performance of a strengthened structure is still lacking. This paper describes the development of experimental-based hysteresis models of unstrengthened and strengthened concrete frames by using the system identification method. The analytical models are validated by comparing the analytical results with results of experiments on strengthened RC frames.

Phan, L. T.; Todd, D. R.; Lew, H. S.
Strengthening Methodology for Lightly Reinforced Concrete Frames-I.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5128; 108 p. February 1993.
Available from National Technical Information Services
PB93-161354

frames; reinforced concretes; analytical; dynamic analysis; experimental; hysteresis models; infilled walls; system identification; multi-variable regression

An analytical method for evaluating the inelastic dynamic structural response of lightly reinforced concrete (RC) frames strengthened by infilled shear walls was developed. This method consists of the development of hysteresis failure models for existing and strengthened RC frames and the incorporation of the models into computer program IDARC for use in analytical study. The hysteresis models were developed by, first using the system identification techniques to characterize the load-deformation histories of fifty-five RC frame tests in terms of the stiffness degradation parameter, the strength degradation parameter, and the pinching parameter. Next, multi-variable regressions were performed to relate as functions of the specimen's material and geometric properties and reinforcement parameters. The empirical expressions resulted from these regressions are the hysteresis failure models. The models were validated by analyzing a one-story, one-bay infilled frame, tested by Aoyama et al., and a three-story, one-bay infilled frame tested by Higashi et al. The results of the analyses showed that (1) hysteresis models developed using one-story, one-bay frames can be incorporated into IDARC for the analysis of frames with more than one-story height, and (2) reasonable predictions of structural behavior, both in terms of ultimate load capacity and in absorbed energy on the per cycle basis, can be achieved using the hysteresis models. Thus, in the present form, the hysteresis models can be used in parameter study to assist in the design of strengthening of RC frame structures.

Phan, L. T.; Todd, D. R.; Lew, H. S.
Strengthening Methodology for Lightly Reinforced Concrete Frames.
National Institute of Standards and Technology, Gaithersburg, MD
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, 25th. May 17-20, 1993, Ibaraki-ken, Japan, 265-272 pp, 1993.

building technology; earthquakes; frames; reinforced concretes; dynamic analysis; hysteresis models; infilled walls; system identification

An analytical method for evaluating the inelastic dynamic structural response of lightly reinforced concrete (RC) frames strengthened by infilled shear walls was developed. The models were validated by analyzing a one-story, one-bay infilled frame, tested by Aoyama et al., and a three-story, one-bay infilled frame tested by Higashi et al. The results of the analyses showed that (1) hysteresis models developed using one-story, one-bay frames can be incorporated into IDARC for the analysis of frames with more than one-story height, and (2) reasonable predictions of structural behavior, both in terms of ultimate load capacity and in absorbed energy on a per cycle basis, can be determined using the hysteresis models.

Pitts, W. M.

Pitts, W. M.
Rayleigh Light Scattering Studies of Turbulent Mixing.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Fall Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 8-16 pp, 1993.

Rayleigh light scattering; turbulent mixing; turbulent combustion; concentration measurement; flow fields; velocity measurement; turbulent jet flames; diffusion flames; axisymmetric jets

Turbulent combustion remains a very active research area. This interest is justified due to the pivotal role it plays in a wide variety of technologically important processes. Development of models for combusting flows is crucial for the more efficient utilization of limited hydrocarbon fuel resources, reduction in environmentally harmful pollutants, more efficient chemical processes, and for the prediction of hazard associated with unwanted fire. An important subset of turbulent combustion is turbulent jet diffusion flames because they are relatively simple to generate, and because they provide an appropriate testbed for the development of more general theories for turbulent combustion.

Pitts, W. M.; Bryner, N. P.; Johnsson, E. L.
Production Mechanisms for Carbon Monoxide in Enclosure Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Central and Eastern States Section. Combustion Fundamentals and Applications. Joint Technical Meeting, 1993. March 15-17, 1993, New Orleans, LA, 102-106 pp, 1993.

carbon monoxide; enclosures; experiments; entrainment; pyrolysis

Roughly two thirds of all deaths resulting from enclosure fires can be attributed to the presence of carbon monoxide (CO), which is known to be the dominant toxicant in fire deaths. The mechanisms responsible for the generation of high concentrations of CO in fires are poorly understood. A long-term program (Carbon Monoxide Production and prediction Priority project) at BFRL is seeking to develop an understanding of and predictive capability for the generation of CO in fires.

Pitts, W. M.; Yang, J. C.; Breuel, B. D.; Cleveland, W.; Gmurczyk, G.
Dynamics of the Release of Alternate Halon Replacement Agents From Pressurized Bottles.
National Institute of Standards and Technology, Gaithersburg, MD
University of New Mexico; New Mexico Engineering Research Institute; Center for Global Environmental Technologies; National Association of Fire Equipment Distributors, Inc.; Halon Alternative Research Corp.; Fire Suppression Systems Assoc.; and Hughes Associates, Inc. Halon Alternatives Technical Working Conference 1993. Proceedings. May 11-13, 1993, Albuquerque, NM, 75-82 pp, 1993.

halons; experiments; halon 1301; military facilities; military aircraft; nacelle fires

Halon 1301 has been widely employed on military and commercial aircraft for fire fighting purposes. Unfortunately, due to the deleterious effects of chlorine and bromine on stratospheric ozone, the manufacture of halon 1301 will be phased out by the end of 1993 under the terms of the Montreal Protocol. As a result, the military services and the Federal Aviation Administration, with the U.S. Air Force coordinating the effort, have initiated a research program to identify effective halon 1301 replacements which are low ozone depleters. As part of this project, a list of eleven potential halon 1301 alternatives have been proposed. The National Institute of Standards and Technology has been tasked to recommend which of the eleven compounds should be tested at full scale. The work reported in this paper is part of this task.

Pommersheim, J.

Pommersheim, J.; Nguyen, T.; Zhang, Z.; Lin, C.
Diffusion of Cations Beneath Organic Coatings on Steel Substrate.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
Xiamen Univ., Fujian, China
NISTIR 5102; 39 p. April 1993.
Available from National Technical Information Services

substrates; steels; diffusion; cations; organic coatings; mathematical models

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

Portier, R. W.

Portier, R. W.
Programmer's Reference Guide to FDMS File Formats.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5162; 42 p. April 1993.
Available from National Technical Information Services
PB93-182038

computers; databases; cone calorimeters; furniture calorimeters

Fire Data Management System, FDMS, is a computer database specifically designed to store and retrieve fire test results. This guide provides detailed descriptions of the current file formats as well as revisions planned for the immediate future.

Puri, R.

Puri, R.; Richardson, T. F.; Santoro, R. J.; Dobbins, R. A.
Aerosol Dynamic Processes of Soot Aggregates in a Laminar Ethene Diffusion Flame.
Pennsylvania State Univ., University Park
Brown Univ., Providence, RI
Combustion and Flame, Vol. 92, No. 3, 320-333, February 1993.
diffusion flames; laminar flames; aerosols; soot; data analysis

Laser scattering/extinction tests on a coannular ethene diffusion flame were analyzed using cross sections for polydisperse aggregates. Using an improved experimental arrangement that allowed simultaneous measurement of light scattering at multiple angles, it was possible to determine the fractal dimension of the aggregates in the flame. The analysis also yields the mean-square radius of gyration, the aggregate number concentration, the average number of primary particles per aggregate, as well as the volume average of the volume-mean diameter as a function of height of residence time along the particle path of maximum soot concentration in this flame. These results lead to the conclusion that soot aerosol dynamic processes in the laminar ethene flame are partitioned into four regions. Low in the diffusion flame there is a region of particle inception that establishes the number of primary particles per unit volume that remains constant along a prescribed soot pathline. In the second region, there is sustained particle growth through the combined action of cluster-cluster aggregation (CCA) accompanied by heterogeneous reactions contributing to monomer-cluster growth. Oxidation processes occur in the third region where CCA continues. If aggregate burnout is not complete in the oxidation region, then smoke is released to the surroundings in the fourth region where reactions cease but clusters continue to grow by CCA. The experiments yield the CCA growth rate within the flame which compares favorably with the theoretical value. The similarities and differences between this data reduction and the traditional analysis based on the use of cross sections for Rayleigh spheres and Mie theory spheres is discussed.

Q

Qian, C.

Qian, C.; Saito, K.
Tubulent Flame Spread on Corner Walls.
University of Kentucky, Lexington
Combustion Institute/Eastern States Section. Chemical and Physical Processes in Combustion. Technical Meeting, 1993. October 25-27, 1993, Princeton, NJ, 338-341 pp, 1993.
combustion; walls; corners; flame spread; ignition; heat transfer

The work reported here is part of a continuing program to establish a reliable database for predicting fire spread on vertical corner walls. In a corner fire, transient three dimensional fire-induced flow causes a complex convection and radiative heat transfer to the corner walls. In our previous work, the fire-induced flow was investigated first, and then an automated infrared imaging system was developed to measure transient wall temperature distributions. Using the IR imaging system the progress of pyrolysis front on corner walls was measured successfully. The motivation for the present study is to characterize the flame spread and heat transfer from flame to the wall surface.

Quintiere, J. G.

Quintiere, J. G.
Canadian Mass Fire Experiment, 1989.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Fire Protection Engineering, Vol. 5, No. 2, 67-78, April/June 1993.

mass fires; energy transfer; forest fires; smoke emissions

Working with Forestry Canada and the Ontario Ministry of Natural Resources, the Defense Nuclear Agency carried out an extensively instrumented experiment of a prescribed burn in forest debris to simulate conditions of a mass fire. In addition to the Canadian team, a multi-institutional US team made both ground and airborne measurements of the fire and smoke conditions. The fire reported on was in Hill Township, Ontario and covered nearly 480 in its overrall burning area. Both flaming and smoldering modes contributed to the energy and combustion products of this fire. Significant quantities measured and determined included estimations of energy release rate, emission factors for smoke particulates and species, ground level wind and temperatures, and aspects of cloud dynamics and cloud particles. The fire caused a capping cloud to form and reach a level of 6.5 km. Rain, snow, hail and lightning were reported along with ground level fire whirls and water spouts on the adjoining lakes. Fire spread rates reached 1 m/s and fire induced winds reached 12 m/s.

R

Raufaste, N. J.

Raufaste, N. J.
Collaborating With Our Customers.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-3; 24 p. August 1993.
Available from National Technical Information Services
PB94-110194
Available from Government Printing Office
SN003-003-03234-4

building research; fire research

The competitiveness of all U.S. industries and the quality of life of all people depend on the quality of the constructed facilities that shelter and support most human activities. Construction also is of great direct economic importance. Annually, in excess of $600 billion is spent in the United States on the design, construction, maintenance, repair, and renovation of constructed facilities, according to statistics from the U.S. Department of Commerce. New construction alone emplys 6 million people. The Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST) is dedicated to the life cycle quality of constructed facilities. NIST's primary mission is to help U.S. industry to strengthen its international competitiveness. BFRL enhances the competitiveness of U.S. industry and public safety through performance prediction and measurement technologies and technical advances that improve the life cycle quality of constructed facilities. Its products are used by those who own, design, construct, supply, and provide for the safety or environmental quality of constructed facilities.

Raufaste, N. J.
Impacts.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-4; 40 p. August 1993.
Available from National Technical Information Services
PB94-113420
Available from Government Printing Office
SN003-003-03232-8

building research; fire research

The Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST) is dedicated to the life cycle quality of constructed facilities. NIST is the only federal technology agency with the specific mission of helping U.S. industry to strengthen its international competitiveness. BFRL is the national laboratory for the building and fire communities. BFRL's mission is to enhance the competitiveness of U.S. industry and public safety through performance prediction and measurement technologies and technical advances that improve the life cycle quality of constructed facilities. The Laboratory performs and supports field, laboratory, and analytical research on the performance of construction materials, components, systems and practices, and the fundamental processes underlying the initial, propagation, and suppression of fires. BFRL produces technologies to predict, measure, and test the performance of construction and fire prevention and control products and practices. This report describes major effects of BFRL's program on building and fire research. Scientific and economic impacts are cited in Section 1; preliminary impacts are cited in Section 2. Although in no instance did BFRL alone accomplish the improvements in building and fire practices, BFRL has played a key role in improvements in building and fire practice producing annual savings amounting to tens of billions of dollars.

Raufaste, N. J.
NIST Building and Fire Research Laboratory Projects, 1993.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-1; 129 p. August 1993.
Available from the National Technical Information Service
PB94-118288
Available from Government Printing Office
SN003-003-03233-6

earthquakes; structural behavior; concretes; coatings; quality assurance; refrigeration; mechanical systems; heat transfer; moisture; air quality; computers; fire research; lighting; fire protection; fire extinguishment; combustion; fire detection; halons; carbon monoxide; mass fires; oil spills

The competitiveness of all U.S. industries and the quality of life of all people depend on the quality of the constructed facilities that shelter and support most human activities. Construction also is of great direct economic importance. Annually, in excess of $600 billion is spent in the United States on the design, construction, maintenance, repair, and renovation of constructed facilities, according to statistics from the U.S. Department of Commerce. New construction alone employs 6 million people. The quality of constructed facilities directly affects the productivity of the U.S. building and fire community and affects the safety and quality of life of all constructed facilities. Over two-thirds of the Nation's fixed reproducible wealth is invested in the constructed facilities.

Raufaste, N. J.
NIST's BFRL.
National Institute of Standards and Technology, Gaithersburg, MD
Military Engineer, Vol. 85, No. 557, 43-45, July 1993.
research facilities

The mission of the National Institute of Standards and Technology (NIST), our nation's premier science and engineering measurement laboratory, is to help U.S. industry improve its competitiveness via new technologies, up-to-date production processes, better quality control and rapid commercialization; to improve public health, safety, and the enviornment; and to conduct research that advances science and engineering.

Rehm, R. G.

Rehm, R. G.; Baum, H. R.; Tang, H. C.; Lozier, D. C.
Finite-Rate Diffusion-Controlled Reaction in a Vortex.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Science and Technology, Vol. 91, No. 1-3, 143-161, 1993.
flame fronts; formulations; equations; diffusion flames

The influence of a vortex on a gaseous diffusion reaction is examined. The vortex is taken to be two dimensional, and the species are initially assumed to occupy adjacent half spaces. In the flame-sheet limit, thermal expansion and the effects of variable diffusion are taken into account. A global similarity solution exists for this problem, and a simple expression for the solution is determined in the asymptotic limit of large Schmidt number. The problem is also analyzed for finite-rate chemistry, appropriate for an isothermal, bimolecular reaction. The problem depends upon three parameters, Reynolds number, Schmidt number and the equivalence ratio, with the Damkohler number equal to the dimensionless time. The structure of the reaction region normal to the flame front is examined as a function of time. The evolution of the reaction to a state relation, dependent only upon the mixture-fraction variable, is demonstrated as the Damkohler number becomes large.

Richards, C. D.

Richards, C. D.; Pitts, W. M.
Global Density Effects on the Self-Preservation Behavior of Turbulent Free Jets.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Fluid Mechanics, Vol. 254, 417-435, 1993.
density effects; turbulent jets; flow fields; turbulent flow

An experimental investigation was designed to test the hypothesis that all axisymmetric turbulent free jets become asymptotically independent of the source conditions and may be described by classical similarity analysis. Effects of initial conditions were studied by varying jet exit boundary conditions and the global density ratio. The exit velocity profile and turbulence level was changed by using both pipe and nozzle flow hardware. Initial density differences were imposed by using three gases: helium, methane, and propane. The scalar field (concentration) in the momentum-dominated regime of the far field (10 to 60 jet exit diameters downstream) of turbulent free jets was characterized using Rayleigh light scattering as the diagnostic. The results show that regardless of the initial conditions axisymmetric turbulent free jets decay at the same rate, spread at the same angle, and both the mean and r.m.s. values collapse in a form consistent with full self-preservation. The means and fluctuations follow a law of full self-preservation in which two virtual origins must be specified. The two displacements are required to account for the effects of a finite source of momentum and different development of the velocity and mass distributions in the near fields of the jets. The memory of the jet is embodied in these two virtual origins.

Rossiter, W. J., Jr.

Rossiter, W. J., Jr.; Denchfield, R. D.
Field Study of the Performance of Polymer-Modified Bitumen Roofing.
National Institute of Standards and Technology, Gaithersburg, MD
Denchfield Corp., Silver Spring, MD
National Roofing Contractors Association. Problems: Issues and Answers. 10th Conference on Roofing Technology, Proceedings. April 22-23, 1993, Gaithersburg, MD, National Roofing Contractors Assoc., Rosemont, IL, 48-58 pp, 1993.

roofs; building technology; field study; low-sloped roofing; membranes; performance; polymer-modified bitumens; standards development

This report presents the results of a field study of polymer-modified bitumen roofing. Observations on in-service performance are beneficial for identifying field problems that require study to attain solutions. Fifty-three roofs, ranging in age from 24 to 131 months and lacated in Washington, DC/Baltimore, MD, Jacksonville, FL, and Dallas, Texas were inspected. The types of asphale modifiers were almost equally distributed between atactic polypropylene (APP) and styrene-butadiene-styrene (SBS) block copolymer. Re-roofing predominated the type of construction and was divided somewhat evenly between tear-off and re-covering. The overall performance of these relatively young roofs was considered to be satisfactory. About 70 percent of the roofs were considered to be satisfactory. About 70 percent of the roofs were considered visually to be in fine condition. Still, about a quarter of the roofs showed some defects that contributed to a lowered performance ranking. The key defects observed with some membranes were surface cracking of both APP and SBS sheets, loss of granules (particularly in ponded water), slippage of SBS sheets, and disbonded lape or relatively extensive repairing of the laps of an APP system. Although limited, the field experiences provide evidence that performance-related standards are needed to evaluate the membrane materials' ability to resist such defects and to minimize future problems.

Rossiter, W. J., Jr.; Denchfield, R. D.
Observations From a Field Study of the Performance of Polymer-Modified Bitumen Roofing.
National Institute of Standards and Technology, Gaithersburg, MD
Denchfield Corp., Silver Spring, MD
NISTIR 4972; 41 p. January 1993.
Available from National Technical Information Services

roofs; building technology; field study; low-sloped roofing; membranes; performance; polymer-modified bitumens; standards development

The use of modified-bitumen membranes for low-sloped roofing in the United States has increased greatly over the last decade. In spite of this growth, voluntary consensus standards to aid in the proper selection and use of these membrane materials are not available. Moreover, few reports describing performance in service have been prepared. The two primary modifiers currently used to produce modified bitumens are: atactic polypropylene (APP) and styrene-butadine-styrene (SBS) block copolymer. This report presents the results of a field study of polymer-modified bitumen roofing. Observations on in-service performance are beneficial for identifying field problems that require study to attain solutions. Fifty-three roofs, ranging in age from 24 to 131 months and located in Washington/Baltimore, Jacksonville, Florida, and Dallas, Texas, were inspected. The types of membrane modifiers were almost equally distributed between APP and SBS polymers. Reroofing predominated the type of construction and was divided somewhat evenly between tear-off and re-covering. The overall performance of these relatively young roofs was considered to be satisfactory. About 70 percent of the roofs were considered visually to be in fine condition. Still, about a quarter of the roofs showed some defects that contributed to a lowered performance ranking. The key defects observed with some membranes were surface cracking of both APP and SBS sheets, loss of granules (particularly in ponded water), slippage of SBS sheets, and unsealed or relatively extensive repairing of the laps of an APP system. Although limited, the field experience provide evidence that performance-related standards are needed to evaluate the membrane materials' ability to resist such defects and to minimize future problems.

Rossiter, W. J., Jr.; Martin, J. W.; Embree, E.; Seiler, J. F., Jr.; Byrd, W. E.; Ream, E.
Effect of Ozone on the Creep-Rupture of Butyl-Adhered EPDM Seam Specimens.
National Institute of Standards and Technology, Gaithersburg, MD
Neidig Roofing Co., York, PA
National Roofing Contractors Association. Problems: Issues and Answers. 10th Conference on Roofing Technology, Proceedings. April 22-23, 1993, Gaithersburg, MD, National Roofing Contractors Assoc., Rosemont, IL, 85-92 pp, 1993.

ozone; creep-rupture; EPDM; seams; roofs; adhesive performance; building technology; low-sloped roofing; single-ply roofing; time-to-failure

EPDM roofing seam specimens, prepared using a commercially available butyl-based adhesive, were subjected to a creep-rupture experiment in peel in the presence of ozone. The times-to-failure of 12 replicate specimens were recorded at five ozone concentrations: ambient (about 0.01-0.03), 0.14, 0.26, 0.50, and 1.0 parts per million. The results of the study indicated that an increase in the ozone concentration significantly reduces the times-to failure over those observed at ambient levels. The shorter times-to-failure at elevated ozone levels were attributed to ozonolysis of the adhesive. The results emphasize the need to minimize incorporating peel stresses into seams of EPDM roofing membranes.

Rothfleisch, P. I.

Rothfleisch, P. I.; Didion, D. A.
Study of Heat Pump Performance Using Mixtures of R32/R134a and R32/R125/R134a as "Drop-In" Working Fluids for R22 With and Without a Liquid-Suction Heat Exchanger.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5321; 62 p. December 1993.
Available from National Technical Information Services

heat pumps; refrigerants; heat exchanger; cooling; drop-in test; liquid suction

A ductless mini-split residential heat pump with a modified indoor coil was utilized to compare the performance of R22 and a mixture of 34% R32/66% R134a by weight. This test was intended to serve as an indicator of "drop-in" performance so the system was optimized for each refrigerant by varying only the charge mass and expansion valve setting. At the 27.8 deg C (82 deg F) cooling test condition the capacity and COP of the mixture were 94% and 90% of the values for R22, respectively. Additional tests were conducted with a liquid-suction intracycle heat exchanger. The modified system was operated with both single-phase and two-phase refrigerant entering the low pressure side of the liquid-suction heat exchanger. The addition of the liquid-suction heat exchanger showed a minimal performance improvement with the performance of the two-phase variation being slightly higher. The best performing liquid-suction heat exchanger variant (two-phase refrigerant on the low pressure side) was also run with a ternary mixture of 30% R32/10% R125/60% R134a, by wieight. The results for this mixture were similar to the binary mixture. To examine how well the drop-in test results reflect the fluids performance potential an ideal cycle computer model was used in conjunction with test data to calculate the total UA per unit capacity for each fluid. These results showed that the combination of this system and test procedure penalized the mixture performance by causing it to have a total UA per unit capacity 18.9% lower than R22. Therefore, these drop-in results are not a true indication of the performance potential of this mixture. The ideal cycle model was also used to show that a pure counterflow air-to-refrigerant evaporator would be beneficial to the performance of a cooling only unit regardless of the heat exchange configuration of the condenser.

S

Saito, K.

Saito, K.
Study of Fire Induced Flow Along the Vertical Corner Wall. Part 2. Final Report.
Kentucky Univ., Lexington
NIST-GCR-93-628; 61 p. April 1993.
Available from National Technical Information Services
PB93-205623

corner tests; walls; building fires; flame height; flame spread rate; heat flux; infrared photography; room fires

This paper describes a new experimental technique with wide application which has been proven for corner fires. To measure the flame spread rate of pyrolysis front along vertically oriented flat and corner walls, it may be necessary to measure transient temperature profiles on the walls. Conventional thermocouple and visual observation methods, however, have limitations due to complexity of implementation and the inherent ambiguity of visual observations due to interference from flames. To overcome these limitations, automated infrared imaging was applied for simultaneously collecting temperature data in a relatively large wall surface area. Results indicate that the infrared system with a band-pass filter successfully avoids the flame interference allowing measurements of temperature distribution on the fire-heated wall, from which the spread rate in any direction can be deduced. The infrared camera without filters also can be used to measure visible flame position as photographic and video camera.

Sanders, P. A.

Sanders, P. A.
Literature Review of Lighting Standards.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5202; 86 p. June 1993.
Available from National Technical Information Services
PB93-208445

building technology; lighting; efficiency; test methods; regulations; systems; lamps; ballasts; luminaires; photometry

Society's dependence on energy and increased concerns about global warming have prompted legislative bodies to implement minimum energy efficiency requirements for architectural lighting systems. The present report reviews and summarizes current Canadian and U.S. federal legislation, U.S. state legislation and model energy efficiency codes with particular attention to describing the minimum conformance standards. Although early state legislation regulates the efficiency of complete lighting systems, more recent Canadian and U.S. federal legislation stipulates minimum efficiencies for individual lighting system components. However, since the minimum component efficiencies are based on testing protocols that do not permit an accurate assessment of the electrical and thermal interactions of components in an installed lighting system and since component requirements are becoming increasingly stringent, the need exists to develop more comprehensive testing procedures. Therefore, the present report also reviews the current national, international, and industry testing procedures identifying inconsistencies and deficiencies which lead to inaccurate performance assessments so that these may be addressed in future testing protocols. Finally, the review outlines a framework for developing more comprehensive test procedures.

Schwartz, L. M.

Schwartz, L. M.; Martys, N.; Bentz, D. P.; Garboczi, E. J.; Torquato, S.
Cross-Property Relations and Permeability Estimation in Model Porous Media.
Schlumberger-Doll Research, Ridgefield, CT
National Institute of Standards and Technology, Gaithersburg, MD
Princeton Univ., NJ
Physical Review E, Vol. 48, No. 6, 4584-4591, December 1993.

model porous media; permeability; diffusive properties; electrical properties; equations

Results from a numerical study examining cross-property relations linking fluid permeability to diffusive and electrical properties are presented. Numerical solutions of the Stokes equations in three-dimensional consolidated granular packings are employed to provide a basis of comparison between different permeability estimates. Estimates based on the lambda parameter (a length derived from electrical conduction) and on dc (a length derived from immiscible displacement) are found to be considerably more reliable than estimates based on rigorous permeability bounds related to pore space diffusion. We propose two hybrid relations based on diffusion which provide more accurate estimates than either of the rigorous permeability bounds.

Simiu, E.

Simiu, E.; Frey, M.
Melnikov Function and Homoclinic Chaos Induced by Weak Perturbations.
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review E, Vol. 48, No. 4, 3190-3192, October 1993.

noise (sound); equations

The effect of noise on the possible occurrence of chaos in systems with a homoclinic orbit (e.g., the Duffing equation) was recently considered by Bulsara, Schieve, and Jacobs and Schieve and Bulsara, who adopted an approach based on a redefinition of the Melnikov function. We show that this redefinition is unsatisfactory and leads to incorrect results.

Simiu, E.; Frey, M.
Spectrum of the Stochastically Forced Duffing-Holmes Oscillator.
National Institute of Standards and Technology, Gaithersburg, MD
Physics Letters A, Vol. 177, 199-202, 1993.

oscillators; spectral density; noise (sound)

The Brundsen-Holmes method of power spectrum estimation for the Duffing-Holmes oscillator is applied to the case of weak quasiperiodic excitation and then extended to weak colored noise excitation with any specified spectral density. A novel model of near-Gaussian noise is introduced to achieve this extension. The results obtained by this approach coincide with and extend those obtained by Stone and Holmes' application of the Fokker-Planck equation. In particular, our results confirm Stone's conjecture that the expression for the mean time between successive maxima in the case of colored noise is similar to that for white noise.

Simiu, E.; Garrett, J. H.; Reed, K. A.
Development of Computer-Based Models of Standards and Attendant Knowledge-Base and Procedural Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Carnegie-Mellon Univ., Pittsburgh, PA
American Society of Civil Engineers (ASCE). Structural Engineering in Natural Hazards Mitigation. Structures Congress '93 Proceedings. April 19-21, 1993, Irvine, CA, ASCE, New York, NY, Ang, A. H. S.; Villaverde, R., Editors, 841-846 pp, 1993.

computer models; standards; expert systems

Existing and new technology can be used to develop a new generation of standards that would allow designers to use complex standards efficiently, help standard-writing bodies to detect and eliminate errors and inconsistencies in standard provisions, facilitate interaction between standard-writing bodies and design professionals, and make effective use of available knowledge, including large data bases. We propose the development of computer-based models of standards, and of knowledge-based and procedural systems to be incorporated in or used in conjunction with such models. Pilot projects should demonstrate the significant potential for improvement in design and construction productivity inherent in such a new generation of standards. Wind loading examples are used for illustration.

Simiu, E.; Grigoriu, M.
Non-Gaussian Noise Effects on Reliability of Multistable Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Cornell Univ., Ithaca, NY
American Society of Mechanical Engineers (ASME). Proceedings of the 12th International Conference on Offshore Mechanics and Arctic Engineering (OMAE) 1993. Volume 2. Safety and Reliability. June 20-24, 1993, Glasgow, Scotland, Soares, C. G.; Baker, M. J.; Labeyrie, J.; Lacasse, S., Editors, 65-71 pp, 1993.

noise (sound); equations; structural stability

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

Smyth, K. C.

Smyth, K. C.; Harrington, J. E.; Johnsson, E. L.; Pitts, W. M.
Greatly Enhanced Soot Scattering in Flickering CH4/Air Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 95, 229-239, 1993.

diffusion flames; soot; laminar flames

Planar images of laser-induced fluorescence from OH radicals and elastic scattering from soot particles are presented in time-varying laminar CH4/air diffusion flames burning in a co-flowing, axisymmetric configuration at atmospheric pressure. Acoustic forcing is used to phase lock the periodic flame flicker to the pulsed laser system operating at 10.13 Hz. For conditions where the tip of the flame is clipped, the intensity of the light scattered by the soot particles increases dramatically (by more than a factor of 7 for the maximum signals at a point) compared to a steady-state, laminar flame with the same mean fuel flow velocity. Comparison of the scattering signals integrated along the flame radius is carried out in the steady-state and time-varying flames as a function of height above the burner. Time-varying flames exhibit a larger range of combustion conditions than observed in corresponding steady-state flames, including different residence times, temperature histories, local stoichiometries, and strain and scalar dissipation rates. Thus, their investigation promises to yield new insights into a wide variety of chemistry-flowfield interactions which are prominent in turbulent combustion.

Snell, J. E.

Snell, J. E.
Elements of a Framework for Fire Safety Engineering.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers. Interflam '93. Fire Safety. International Fire Conference, 6th. March 30-April 1, 1993, Oxford, England, Interscience Communications Ltd., London, England, Franks, C. A., Editor, 447-456 pp, 1993.

fire safety; fire science; safety engineering; decision making; life safety

This paper lays out a framework for fire safety engineering based on scientific tools for fire safety design and decision-making. These tools include computer-based models for fire safety hazard and risk prediction, measurement methods to provide data for such methods, databases and expert systems to provide access to them, and the ultimate integration of these tools with other elements of computer-aided design, construction and conformity assessment. The paper suggests needs, roles and actions required to bring fire safety engineering to the level of sophistication enjoyed in most other areas of engineering practice. The need for international cooperation and public-private collaboration is stressed.

Snell, J. E.
Forum for International Cooperation on Fire Research.
National Institute of Standards and Technology, Gaithersburg, MD
VTT-Technical Research Center of Finland and Forum for International Cooperation in Fire Research. Nordic Fire Safety Engineering Symposium. Development and Verification of Tools for Performance Codes. August 30-September 1, 1993, Espoo, Finland, 1-9 pp, 1993.

fire safety; safety engineering; codes; fire research; technology transfer

This Symposium is about fire safety engineering and the development of performance codes for fire safety. It is the second conference in a series, the first of which was in Sydney, Australia last year. The Australian Symposium was exciting because of the impressive efforts underway there to develop and introduce a performance-based fire code. Not to be outdone, this year's Symposium features another such code, the proposed Nordic Model Performance Code. That's fantastic! Our hats are off to Pentti Loikkanen and the other organizers of this Symposium. We hope this series will extend for a number of years and to a number of countries.

Snell, J. E.
Status of Performance Fire Codes in the USA.
National Institute of Standards and Technology, Gaithersburg, MD
VTT-Technical Research Center of Finland and Forum for International Cooperation in Fire Research. Nordic Fire Safety Engineering Symposium. Development and Verification of Tools for Performance Codes. August 30-September 1, 1993, Espoo, Finland, 1-9 pp, 1993.

fire safety; safety engineering; codes; fire codes; regulations

The purpose of this paper is to report on the status of performance fire codes in the United States. The bottom line is that construction related research and development in the USA are seeking to guide the construction industry through the same transformation manufacturing industry is experiencing. This involves exploiting advances in science and technology, and modern concepts of manufacturing quality to assure life cycle quality and performance. For fire safety, this means engineering fire safety into products and buildings and providing means to assure that a facility is safe in use. This can not be done using traditional regulatory methods, nor accomplished by national edict. Rather, creative partnerships between industry, government and academe are needed to devise new strategies and engineering tools; and international scale research and cooperation are needed for development and implementation of global standards and conformity assessment systems. After briefly describing the context for building and fire safety regulation in the USA, the status of development and implementation of performance-based fire safety engineering practices is discussed. The paper concludes with some observations about critical conditions for success of fire safety engineering and its application to building fire safety regulation.

Snyder, K. A.

Snyder, K. A.; Clifton, J. R.
Calculating Cement Paste and Mortar Diffusivity From Conductivity Measurements: Preliminary Results of a New Method.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5235; 14 p. October 1993.
Available from National Technical Information Services

building technology; conductivity; diffusivity; impedance spectroscopy; service life

A new method to determine the chloride diffusivity of concrete is being developed which is both expeditious and accurate. The method is based upon the Nernst-Einstein equation relating conductivity and diffusivity. Results from a single measurement can be used to calculate the diffusivity for any specified ion, given the "free" diffusivity of that ion. The experimental procedure, along with preliminary results, are reported.

Stone, W. C.

Stone, W. C.
Development of a Fast-Response Variable-Amplitude Programmable Reaction Control System.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5118; 238 p. January 1993.
Available from National Technical Information Services
PB93-158731

active control; amplitude control; cold gas thruster; microprocessor control; piezoelectric stack; pulse width resolution; reaction control system; system identification

This report describes a high speed loading system comprised of: a piezoelectric stack and an associated microprocessor-based programmable DC power source; a low-loss mechanical displacement amplifier; a high pressure spring-loaded axial valve; an integral high pressure valve seat; an expansion nozzle; and a high pressure gas supply. A half square wave voltage signal of varying duration and amplitude was used to drive the piezoelectric stack in such a manner as to produce changing displacements which were subsequently amplified by a monolithically milled hinged anvil. The anvil is connected to a valve core which seats upon, and is normally forced closed upon a specially hardened throat of an expansion nozzle by means of a compression spring. The interior side of the thruster nozzle communicates with a high pressure gas supply. The flow of gas through the nozzle is normally prohibited by the spring loaded valve core. As the piezoelectric stack expands under computer control the valve core is lifted off the nozzle throat permitting gas to expand through the nozzle and create thrust that is directly proportional to the control signal from the microprocessor. The device is designed to operate as a stand-alone unit with a dedicated onboard microcontroller system and onboard energy storage system. Minimum pulse width resolution (base-to-base) was shown to be 0.98 ms with a lag time of 0.37 ms relative to the initiation of the drive pulse. Linear amplitude response was achieved beyond a threshold drive voltage of 80 vdc and was maintained through the limit of testing at 240 vdc. Thrust change rates of 12000 N/s were achieved. The demonstration unit developed for this study produced a peak thrust level of 15 N at operating pressures of 41 MPa.

Stone, W. C.
National Institute of Standards and Technology Conference on Reducing the Cost of Space Infrastructure and Operations. Part 1. Oral Presentations and Discussion.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5255; 203 p. August 1993.
Available from National Technical Information Services
PB94-109683

space infrastructure; cost reduction; unit cost; advanced propulsion; launch insurance; orbital habitats; space suits; space transportation

A conference was held from November 20-22, 1989 at the National Institute of Standards and Technology in Gaithersburg, Maryland for the purpose of discussing methods for reducing the cost of space infrastructure and operations. This was a multi-disciplinary group that included invited speakers from both within and outside of the traditional aerospace community. Specific comparison was made in the case of habitats and extravehicular activity with commercially successful undersea operations on earth which operate daily under more severe environmental conditions and with operating budgets on the order of 1/1000 that of orbital analogs. Other topical areas included chemical and advanced launch systems and institutional aspects including insurance and differences between top-down control and performance-based development of space infrastructure. The proceedings are published in two separate reports. Part 1, Oral Presentations and Dicussion, is contained in the present publication and provides edited transcriptions of the invited lecture presentations and of the discussion which followed each presentation. Part 2, Topical Papers, contains prepared manuscripts which were submitted in advance of the conference and is available as a separate NISTIR report.

Stone, W. C.
National Institute of Standards and Technology Conference on Reducing the Cost of Space Infrastructure and Operations. Part 2. Topical Papers.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5256; 235 p. August 1993.
Available from National Technical Information Services
PB94-113487

space infrastructure; cost reduction; unit cost; advanced propulsion; launch insurance; orbital habitats; space suits; space transportation

A conference was held from November 20-22, 1989 at the National Institute of Standards and Technology in Gaithersburg, Maryland for the purpose of discussing methods for reducing the cost of space infrastructure and operations. This was a multi-disciplinary group that included invited speakers from both within and outside of the traditional aerospace community. Specific comparison was made in the case of habitats and extravehicular activity with commercially successful undersea operations on earth which operate daily under more severe environmental conditions and with operating budgets on the order of 1/1000 that of orbital analogs. Other topical areas included chemical and advanced launch systems and institutional aspects including insurance and differences between top-down control and performance-based development of space infrastructure. The proceedings are published in two separate reports. Part 1, Oral Presentations and Dicussion, contains edited transcriptions of the invited lecture presentations and of the discussion which followed each presentation and is available as a separate NISTIR report. Part 2, Topical Papers, is contained in the present publication and includes prepared manuscripts which were submitted in advance of the conference.

Stone, W. C.; Taylor, A. W.
ISDP: An Integrated Approach to the Seismic Design, Retrofit, and Repair of Reinforced Concrete Structures.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Structural Engineering, [pages unknown], 1993.

reinforced concretes; structures

Limitations of present procedures for the design of reinforced concrete structures to withstand seismic loads are discussed. An integrated seismic design procedure (ISDP) is described which (1) allows the automatic selection and scaling of design ground motions given the earthquake magnitude, epicentral distance, and the type of overlying soil strata; (2) predicts the inelastic behavior of reinforced concrete elements when subjected to random lateral loads up to and including failure; and (3) calculates cumulative damage which can be directly correlated to observed states of damage from laboratory tests of reinforced concrete elements. Techniques for achieving the above capabilities are described and new design criteria are proposed, which are based on acceptable damage indices as functions of earthquake energy content and structural importance. The procedure is demonstrated by means of a practical example involving the seismic retrofit of a spiral reinforced bridge column.

Stone, W. C.; Taylor, A. W.
Seismic Performance of Circular Bridge Columns Designed in Accordance With AASHTO/CALTRANS Standards.
National Institute of Standards and Technology, Gaithersburg, MD
Federal Highway Administration, McLean, VA
NIST BSS 170; 129 p. February 1993.
Available from Government Printing Office
SN003-003-03195-0

bridges (structures); columns; standards; circular bridge columns; damage index; design applications; dynamic analysis; earthquakes; hysteretic damage model; inelastic modeling; reinforced concretes; seismic loads; site specific response; soil amplification; spiral reinforcement

Limitations of present procedures for the design of bridge columns to withstand seismic loads are discussed. An integrated seismic design procedure is developed which 1) allows the automatic selection and scaling of design earthquakes given the earthquake magnitude, the distance from the site to the fault, and the type of overlying soil strata; 2) predicts the inelastic behavior of reinforced concrete bridge columns when subjected to random lateral loads up to and including failure; and 3) calculates cumulative damage which can be directly correlated to observed states of damage in laboratory tests of bridge columns. Techniques for achieving the above capabilities are described and new design criteria, based on acceptable damage indices as functions of earthquake magnitude, distance, and structural importance, are proposed. Using the proposed procedure and criteria the performance of 72 representative bridge columns designed in accordance with 1992 CALTRANS specifications is analyzed. Analysis parameters included earthquake magnitude, distance from epicenter, subsurface soil characteristics, column aspect ratio, and normalized column axial load. Design charts, based on allowable damage index versus earthquake magnitude, are developed and retrofit strategies are discussed for those designs which do not meet the proposed design criteria.

T

Tadros, M. K.

Tadros, M. K.; Einea, A.; Low, S. G.; Magana, R. A.; Schultz, A. E.
Seismic Resistance of a Six-Story Totally 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). Modern Prestressing Techniques and Their Applications Proceedings. Volume 1. FIP '93. October 17-20, 1993, Kyoto, Japan, 99-106 pp, 1993.

seismic behavior; office buildings; high rise buildings; concretes; gravity load; shear walls; structural analysis; structural member design; connections; joints

As a part of the PREcast Seismic Structural Systems (PRESS) program, a research project is underway to investigate the behavior of a six-storey precast concrete office building. 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. Interior and exterior wall panels are the main lateral load resisting elements. Preliminary static analyses and an "experimental" structural element design are conducted. Because current building codes in the United States do not address seismic design of precast concrete specifically, the design process is undertaken to identify areas where research is needed.

Tait, W. S.

Tait, W. S.; Handrich, K. A.; Tait, S. W.; Martin, J. W.
Analyzing and Interpreting Electrochemical Impedance Spectroscopy Data From Internally Coated Steel Aerosol Containers.
S. C. Johnson and Son, Racine, WI
Tait and Associates, Racine, WI
National Institute of Standards and Technology, Gaithersburg, MD
American Society for Testing and Materials. Electrochemical Impedance: Analysis and Interpretation. ASTM STP 1188. American Society for Testing and Materials, PA, Scully, J. R.; Silverman, D. C.; Kendig, M. W., Editors, 428-437 pp, 1993.

containers; spectroscopy; corrosion; electrochemical impedance spectroscopy; Bode magnitude; Bode phase; Nyquist; Chi-square; corrosion resistance extremes

Internally coated steel aerosol container corrosion and coating parameters derived from electrochemical impedance spectroscopy (EIS) data can have a range of values, requiring collection of data from multiple samples on a given coated container/electrolye system. Multiple specimens enable estimation of distribution curve shape, and thus estimation of the fraction of the entire container population that will experience failure at a given time. Three types of EIS curves, (1) Bode magnitude, (2) Bode phase, and (3) Nyquist, should be used to determine how many responses (time constants) are present in an EIS data set. Capacitances are used to determine what type of process is being observed for each responses. Low Chi-square values lead to the conclusion that more accurate estimates of capacitances are obtained from analysis of individual responses, instead of from analyzing an entire data set with a single equivalent electrical circuit.

Tartarini, P.

Tartarini, P.; Liao, Y.; diMarzo, M.
Transient Cooling of a Hot Surface by Droplets Evaporation. Final Report. July 1989-July 1990.
Maryland Univ., College Park
NIST-GCR-93-622; Report 90-6; 104 p. April 1993.
Available from National Technical Information Services
PB93-189421

droplets; evaporation; solid fuels; thermal conductivity; water; vaporization

This report describes the research performed during the period July 1989-July 1990 under a joint research program between the Mechanical Engineering Department of the University of Maryland and the Center for Fire Research of the National Institute of Standards and Technology. The research is conducted by Graduate Research Assistants of the ME Department under the joint supervision of Dr. di Marzo (UMCP) and of Dr. Evans (CFR - NIST). A new experimental set-up for the study of dropwise evaporation in a radiant heat transfer field has been designed, constructed and tested. The various issues of concern such as: steady state solid temperature distribution, radiant heater design and configuration, infrared background noise and post test data manipulation are outlined.

Tartarini, P.; Liao, Y.; Kidder, C.; diMarzo, M.
Transient Cooling of a Hot Surface by Droplets Evaporation. Final Report. July 1990-July 1991.
Maryland Univ., College Park
NIST-GCR-93-623; 169 p. April 1993.
Available from National Technical Information Services
PB94-156957

computer programs; cooling; droplets; evaporation; solid surfaces; water

This report describes the research performed during the period July 1990-July 1991 under a joint research program between the Mechanical Engineering Department of the University of Maryland and the Building and Fire Research Laboratory of the National Institute of Standards and Technology. The research is conducted by Graduate Research Assistants of the ME Department under the joint supervision of Dr. di Marzo (UMCP) and of Dr. Evans (CFR - NIST). This joint research program was initiated in January 1985. The long term objective of the study of droplet-solid interaction is to obtain information applicable to the extinguishment of fire through a droplet array (e.g. spray). The solids of concern include low thermal conductivity materials, typical of fire applications. Several important results were obtained in the first years of research. In particular, the modelling of the boundary condition at the liquid-vapor interface (at the droplet exposed surface) was validated with the data collected for water droplets evaporating on an aluminum block (diMarzo 1986a, 1986b, 1988).

Taylor, A. W.

Taylor, A. W.; Stone, W. C.
Evaluating the Seismic Performance of Lightly-Reinforced Circular Concrete Bridge Columns.
National Institute of Standards and Technology, Gaithersburg, MD
National Earthquake Conference, 1993 Proceedings. Earthquake Hazard Reduction in the Central and Eastern United States: A Time for Examination and Action. Volume 2. Mitigation of Damage to the Built Environment. May 2-5, 1993, Memphis, TN, 543-552 pp, 1993.

bridges (structures); reinforced concretes; columns; seismic performance; hysteretic failure model; equations; regression rate; sensitivity; retrofitting

The ability to analytically predict the inelastic dynamic behavior of reinforced concrete bridge structures during earthquakes is dependent on the availability of appropriate hysteretic failure models. To date, several such models have been implemented in research computer codes. However, little information is available concerning the selection of appropriate parameters for the solution of specific types of reinforced concrete structures. As part of an effort to develop an integrated seismic design procedure (ISDP) for reinforced concrete bridge piers, the National Institute of Standards and Technology (NIST) is conducting extensive studies of hysteretic failure models and laboratory data from tests of bridge columns subjected to cyclic lateral loading. A digital database of load-displacement histories has been established for circular, spirally-reinforced bridge columns. A system identification analysis was performed to determine optimal values of three hysteretic failure model parameters for each test specimen. Subsequent regression analyses were conducted to develop equations correlating the hysteretic failure model parameters to the material and geometric properties of the specimens. The availability of closed form equations for the model parameters permits an a priori inelastic dynamic solution for spirally-reinforced bridge columns. These equations also reveal information about the seismic performance of this class of member. The implications for seismic retrofitting of lightly reinforced circular columns are discussed.

Taylor, A. W.; Stone, W. C.
Jacket Thickness Requirements for Seismic Retrofitting of Circular Bridge Columns.
National Institute of Standards and Technology, Gaithersburg, MD
National Science Foundation and Iowa State University. Practical Solutions for Bridge Strengthening and Rehabilitation. Session 5. Repair and Strengthening Technologies. April 5-6, 1993, Des Moines, IA, Klaiber, F. W.; Sanders, W. W., Jr., Editors, 249-258 pp, 1993.

bridges (structures); seismic retrofitting; columns; steel jacketing

Steel jacketing is a common seismic retrofit strategy for circular, spirally-reinforced concrete bridge piers. With this technique two steel half-cylinders are welded together, encasing the column in a cylindrical jacket. Usually a cement grout is pumped into the annular space between the jacket and the column. The purpose of the steel jacket is to supplement existing lateral reinforcement within the column, providing additional lateral confinement to the concrete in regions of potential seismic damage. Although jacketing is recognized as an effective and relatively inexpensive method for improving column ductility, little guidance is available for determining the required thickness of the jacket. In this study jacket thickness requirements were investigated using a time-step inelastic analysis algorithm which incorporates a hysteretic failure rule and a cumulative damage model. A variety of column designs were subjected to a range of real earthquake acceleration histories, and the resulting damage lvels, or "damage indices" were calculated. These same columns were then re-analyzed with steel jackets of varying thicknesses. It was determined that a relatively thin steel jacket - on the order of a few millimeters in thickness - can dramatically improve the seismic performance of a column. Guidelines are presented for calculating required jacket thicknesses, and practical considerations regarding the installation and performance of jackets are discussed.

Taylor, A. W.; Stone, W. C.; Lew, H. S.
Integrated Approach to Seismic Design of Concrete Bridges.
National Institute of Standards and Technology, Gaithersburg, MD
East Asia-Pacific Conference on Structural Engineering and Construction, 4th Proceedings. September 1993, Seoul, Korea, 1-8 pp, 1993.

bridges (structures); reinforced concretes; seismic design; earthquakes

An integrated seismic design procedure is developed which 1) allows the automatic selection and scaling of design earthquakes given the earthquake magnitude, distance from the site to the fault, and type of overlying soil strata; 2) predicts the inelastic behavior of reinforced concrete bridge columns when subjected to random lateral loads up to and including failure; and 3) calculates cumulative damage which can be directly correlated to observed states of damage in laboratory tests of bridge columns. Techniques for achieving the above capabilities are described and new design criteria, based on acceptable damage indices as functions of earthquake magnitude, distance, and structural importance, are proposed.

Todd, D. R.

Todd, D. R.
Evaluation and Retrofit Standards for Existing Federally Owned and Leased Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
Central United States Earthquake Consortium. Earthquake Hazard Reduction in the Central and Eastern United States: A Time for Examination and Action. National Earthquake Conference Proceedings, 1993. Volume 2. May 2-5, 1993, Memphis, TN, 25-29 pp, 1993.

evaluation; standards; seismic safety; building construction

Public Law 101-64 requires the Interagency Committee on Seismic Safety in Construction to develop "standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government." Congress has directed the President to adopt these Standards by December 1, 1994. This paper describes the process that is being used to develop the standards; presents the results of an Issues Workshop held for potentially affected Federal agencies, at which philosophical and administrative concerns were addressed; and describes the anticipated content of the standard.

Treado, S. J.

Treado, S. J.
Methods for Determining Lighting System Performance and Efficiency.
National Institute of Standards and Technology, Gaithersburg, MD
Lux Europa Proceedings. April 1993, Edinburg, Scotland, 1-7 pp, 1993.

lighting equipment; lame measurement; ballast measurement; fixture; luminaire performance

A research effort has been underway to characterize and quantify the interactions between lighting system components, and to develop standard test procedures and methods for determining both component and lighting system performance. The work has focused primarily on fluorescent lighting systems. This paper discusses the test procedures which have been developed, and the procedure for determining lighting system performance from component characteristics. Sample measurement data are presented to demonstrate the application of the methods, and the accuracy of the performance predictions.

Treado, S. J.; Collins, B. L.
Lighting System Design and Evaluation in Federal Office Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4960; 68 p. March 1993.
Available from National Technical Information Services
PB93-206217

lighting equipment; office buildings; evaluation; ballast; building technology; energy efficiency; fixture; lamp; lighting; luminaire; luminous efficacy; testing procedures

This report describes the results from a research project on developing methods for designing and selecting efficient and effective lighting systems for federal office buildings. It includes a review of current GSA and IES lighting design guidelines and a discussion of relevant testing and rating procedures. A comprehensive procedure for measuring and evaluating lighting components and systems was developed and used to assess the performance of a range of typical office lighting equipment. This procedure accounted for interactions between different components of a lighting system. The measurement results showed a wide range of performance characteristics related to light output and energy efficiency. The T-8 triphosphor lamps and electronic ballasts exhibited the best performance, but some of the more traditional lighting system components also performed well.

U

Urbas, J.

Urbas, J.; Parker, W. J.
Surface Temperature Measurements on Burning Wood Specimens in the Cone Calorimeter and the Effect of Grain Orientation.
Weyerhaeuser Co., Washington, DC
Fire Technology Consultant, Germantown, MD
Fire and Materials, Vol. 17, No. 5, 205-208, September/October 1993.

wood; surface temperature; combustion; cone calorimeters; thermocouples; pyrometers; temperature measurement

Surface temperatures were measured on dry Douglas fir sapwood specimens during Cone Calorimeter tests using thermocouples and an infra-red pyrometer. Good agreement between the thermocouples and the pyrometer was obtained when (1) the emissivity was assumed to be 1.0 and (2) the thermocouples were in good contact with the surface and were not located in the proximity of a fissure. The major fissures were normal to the grain of the wood and the volatiles vented through the fissures. Char oxidation in the region between the vertical fissures resulted in higher surface temperatures.

W

Walton, G. N.

Walton, G. N.
Computer Programs for Simulation of Lighting/HVAC Interactions.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5322; 155 p. December 1993.
Available from National Technical Information Services
PB94-140407

computers; energy calculation; heating; ventilation; air conditioning; lighting; modeling; transient simulation; view factor

This report describes two computer programs developed for the analysis of lighting/HVAC interations: HLITE and VLITE. VLITE is used to compute the coefficients (view factors) describing radiation interchange between surfaces. These coefficients are used in a thermal network model which is solved by HLITE for transient temperatures and cooling loads. These programs are research tools. HLITE is based on a simple finite volume model for heat transfer combined with sufficiently short time steps to permit explicit time integration in most of the simulation. Controls are modeled in a manner emulating the operation of controls in real buildings. The accuracy of the mathematical solution is appropriate to the models used and data available resulting in a fast, flexible simulation tool. The solution time tends to be directly proportional to the number items in the thermal network and inversely proportional to the time step. The simple methods used in HLITE could provide a general approach to modeling building systems.

Walton, W. D.

Walton, W. D.
In Situ Burning of Oil Spills: Mesoscale Experiments and Analysis.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5192; 39 p. September 1993.
Available from National Technical Information Services
PB94-101839

oil spills; crude oil; burning rate; particle size distribution; plumes; fire tests; heat release rate; pool fires; smoke yield

A series of six mesoscale experiments were performed to measure the burning characteristics of Louisiana crude oil on water in a pan. These included one - 6 m square and five - 15 m square burns. Results of the measurements for burning rate and smoke emissions are compared to those from previous burns of various scales. The burning rate as indicated by the regression rate of the oil surface was found to be 0.062 + 0.003 mm/s for both the 6 m and 15 m square pan fires. Smoke particulate yields from both the 15 m square fires were found to be approximately 11% of the oil burned on a mass basis.

Walton, W. D.
In-Situ Burning of Oil Spills: Mesoscale Experiments.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5266; 62 p. November 1993.
Available from National Technical Information Services
PB94-142973

oil spills; burning rate; crude oil; fire tests; heat release rate; particle size distribution; plumes; pool fires; smoke yield; water sprays

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, oil temperature, water temperature, smoke particle size distribution, smoke plume trajectory, and smoke particulate yeild are provided. The burning rate as indicated by the regression rate of the oil surface was found to be 0.055 + 0.005 mm/s and smoke particulate yeilds were found to be approximately 0.13 of the oil burned on a mass basis.

Walton, W. D.; Evans, D. D.; McGrattan, K. B.; Baum, H. R.; Twilley, W. H.; Madrzykowski, D.; Putorti, A. D.; Rehm, R. G.; Koseki, H.; Tennyson, E. J.
In Situ Burning of Oil Spills: Mesoscale Experiments and Analysis.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Research Institute, Tokyo, Japan
Minerals Management Service, Herndon, VA
Environment Canada. Arctic and Marine Oil Spill Program Technical Seminar, 16th. Volume 2. June 7-9, 1993, Edmonton, Alberta, Canada, Environment Canada, Ottawa, Ontario, 679-734 pp, 1993.

oil spills; experiments; crude oil; water; instruments; burning rate; particle size distribution; temperature; carbon dioxide; plumes; visibility; mathematical models; equations

A series of six mesoscale and one large laboratory fire experiments were performed to measure the burning characteristics of Louisiana crude oil on water in a pan. These included one - 6 m square and five - 15 m square mesoscale burns and one - 1.2 m diameter laboratory burn. Results of the measurements for burning rate and smoke emissions are compared to those from previous burns of various scales. The burning rate as indicated by the regression rate of the oil surface was found to be 0.062 + 0.003 mm/s for both the 6 m and 15 m square pan fires and 0.046 mm/s for the 1.2 m diameter fire. Smoke particulate yields from both the 15 m square and 1.2 m diameter fires were found to be approximately 11% 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 are presented. 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.

Walton, W. D.; Notarianni, K. A.
Comparison of Ceiling Jet Temperatures Measured in an Aircraft Hangar Test Fire With Temperatures Predicted by the DETACT-QS and LAVENT Computer Models.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4947; 35 p. January 1993.
Available from National Technical Information Services

computer models; ceiling jets; temperature; aircraft hangars; building technology; detector response; fire models; fire plumes; fire tests; pool fires; response time; sprinkler response

Prediction of the DETACT-QS and LAVENT computer fire models are compared to temperature measurements made during the calibration of the fire detection system in a military aircraft hanger. Two 3.34 m2 isopropyl alcohol pool fire tests of 60 second duration were conducted in the 37 m by 40 m by 14 m high main hanger bay. Brass disks with a known thermal response time index (RTI) were used to simulate the thermal element in a sprinkler or heat detector. Measurements were made of centerline plume temperatures, and ceiling jet gas and disk temperatures at radial distances of 0, 2.7, 5.5, 8.2, and 11.0 m from the centerline of the fire, 380 mm below the ceiling. At a radial distance of 5.5 m, measurements of ceiling jet gas temperatures were also made 150 and 610 mm below the ceiling. Comparisons of predictions and measurements demonstrate some of the strengths and weakness of DETACT-QS and LAVENT for this fire scenario.

Wilson, M. R.

Wilson, M. R.
Time Dependent Vector Dynamic Programming Algorithm for the Path Planning Problem.
Clemson Univ., SC
NIST-GCR-93-636; 53 p. December 1993.
Available from National Technical Information Services

computer programs; building fires; egress; escape; fire models; fire research

Dynamic programming is a modeling technique used for the decision making process. This method can be used to find the set of nondominated paths in a network with time dependent vector costs. In this report a dynamic programming algorithm and its implementation are discussed. An application to a fire egress problem is also included.

Wright, R. N.

Wright, R. N.
Infratechnologies: Tools for Innovation.
National Institute of Standards and Technology, Gaithersburg, MD
Civil Engineering, Vol. 63, No. 11, 68-69, November 1993.

construction; technology utilization; industries

What's ahead for the U.S. construction industry? Many technologies that promote innovation and competitiveness have a single theme: providing information that supports decisions about a constructed facility over its entire life cycle.

Wright, R. N.
Lessons From the Loma Prieta Earthquake.
National Institute of Standards and Technology, Gaithersburg, MD
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, 25th. Technical Memorandom of PWRI No. 3217. May 17-20, 1993, Ibaraki-ken, Japan, 796-786 pp, 1993.

earthquakes; buildings; earthquake engineering; earthquake hazard reduction; geotechnical engineering; lifelines; public policy; seismology; structural engineering

The Loma Prieta, California earthquake (LPE) of October 17, 1989, has had profound influence on both policies and practices for earthquake hazards reduction in the United States. Special Federal funds were allocated for studies to learn from the earthquake how to improve policies and practices for earthquake hazards reduction. The President issued an Executive Order requiring Federal agencies to apply appropriate seismic design and construction practices for new Federal buildings and new Federally-assisted or regulated buildings. The order also provided impetus for improvement of the State and local government building codes that govern non-Federal construction. Major changes were made in the legislation governing the National Earthquake Hazards Reduction Program (NEHRP); research, development and technology transfer activities in NEHRP responded to the legislation. Thus, this paper describes lessons in public policy as well as those in earth, engineering and social sciences and practices resulting from the earthquake.

Wright, R. N.
Structural Analysis in Context.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers (ASCE). Structural Engineering in Natural Hazards Mitigation. Structures Congress '93 Proceedings. Volume 2. April 19-21, 1993, Irvine, CA, Am. Soc. of Civil Engineers, New York, NY, Ang, A. H. S.; Villaverde, R., Editors, 1657-1662 pp, 1993.

structural analysis; structural engineering; structural behavior

The issues of what students should learn about structural analysis and how it should be taught are explored considering the purposes of structural analysis in engineering practice and the motivation of structural engineering students. Structural analysis is considered to be the process by which the structure and its environment are modeled to predict structural response. Structural analysis is addressed as a process linked integrally to professional responsibilities such as design, review for safety and serviceability, construction, condition assessment of existing structures, performance investigations, modification and renovation.

Y

Yamashita, H.

Yamashita, H.; Baum, H. R.; Kushida, G.; Nakabe, K.; Kashiwagi, T.
Heat Transfer From Radiatively Heated Material in a Low Reynolds Number Microgravity Environment.
Nagoya Univ., Japan
National Institute of Standards and Technology, Gaithersburg, MD
Osaka Univ., Japan
Journal of Heat Transfer, Vol. 115, 418-425, May 1993.

heat transfer; reynolds number; microgravity; mathematical models; vapor phases; equations; fluid flow

A mathematical model of the transient three-dimensional heat transfer between a slowly moving ambient gas stream and a thermally thick or thin flat surface heated by external radiation in a microgravity environment is presented. The problem is motivated in part by fire safety issues in spacecraft. The gas phase is represented by variable property convection-diffusion energy and mass conservation equations valid at low Reynolds numbers. The absence of gravity and low Reynolds number together permit the flow to be represented by a self-consistent velocity potential determined by the ambient velocity and the thermal expansion in the gas. The solid exchanges energy with the gas by conduction/convection and with the surroundings by surface absorption and re-emission of radiation. Heat conduction in the solid is assumed to be one dimensional at each point on the surface as a consequence of the limited times (of order of 10 seconds) of interest in these simulations. Despite the apparent simplicity of the model, the results show a complex thermally induced flow near the heated surface. The thermal exchange between the gas and solid produces an outward sourcelike flow upstream of the center of the irradiated area and a sinklike flow downstream. The responses of the temperature fields and the associated flows to changes in the intensity of the external radiation and the ambient velocity are discussed.

Yancey, C. W. C.

Yancey, C. W. C.
Hollow Clay Tile Prism Tests for Martin Marietta Energy Systems: Task 2 Testing.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5328; 318 p. November 1993.
Available from National Technical Information Services

hollow clay tile units; compressive strength; compression testing; modulus of elasticity; masonry prisms

Forty-one Hollow Clay Tile prisms were tested in monotonic, uniaxial compression to failure as the second task in a two-task prism test program for the Department of Energy (DOE). Twenty prisms were nominally 330 nm (13 in) thick and twenty-one were nominally 200 nm (8 in) thick. Twenty-one prisms were tested with the compressive load applied normal to the axis of the hollow cores and the other twenty were subjected to compressive load acting parallel to the axis of the cores. The objectives of the Task 2 test series were to: 1) obtain the compressive strength, 2) determine the modulus of elasticity in compression, 3) determine Poisson's ratio for the prisms, 4) study and understand the behavior of this type of masonry prism, 5) determine whether workmanship during construction of the prisms significantly affects the strength and 6) compare the results of using load control versus displacement control while loading the prisms. Test results are presented in tabular form to report the gross and net area compressive strengths, and Secant Modulus of Elasticity on the gross and net areas. Load-displacement plots are presented to graphically report the output from vertical and horizontal Linear Variable Differential Transformers attached to the prism faces.

Yang, J. C.

Yang, J. C.
Heterogeneous Combustion.
National Institute of Standards and Technology, Gaithersburg, MD
Environmental Implications of Combustion Processes. Chapter 4, CRC Press, Boca Raton, FL, Puri, I. K., Editor(s), 97-137 p., 1993.

heterogeneous combustion; droplets; sparys; coal; smoldering combustion

The term "heterogeneous" in this chapter is used loosely to refer to systems in which there are two phases. Under this classification, the subject of heterogeneous combustion is so broad that it is impossible to cover every aspect of it in this chapter. Therefore, only a limited selection of topics will be discussed: liquid droplet combustion, spray combustion, combustion of coal and coal-slurry particle, and smoldering combustion. As a reflection of the author's interest, emphasis will be on liquid droplet combustion and combustion of coal and coal-slurry particles. Discussions on other topics of heterogeneous combustion (e.g., combustion of metal particles, fixed-bed combustion, and fluidized-bed combustion) will not be included because of the voluminous amount of materials to be covered in this chapter.

Yang, J. C.; Breuel, B. D.; Grosshandler, W. L.
Solubilities of Nitrogen and Freon-23 in Alternative Halon Replacement Agents.
National Institute of Standards and Technology, Gaithersburg, MD
University of New Mexico; New Mexico Engineering Research Institute; Center for Global Environmental Technologies; National Association of Fire Equipment Distributors, Inc.; Halon Alternative Research Corp.; Fire Suppression Systems Assoc.; and Hughes Associates, Inc. Halon Alternatives Technical Working Conference 1993. Proceedings. May 11-13, 1993, Albuquerque, NM, 107-114 pp, 1993.

halons; nitrogen; thermodynamic properties; solubility

As part of the USAF-sponsored halon replacement project, solubility measurements of nitrogen and Freon-23 in eleven potential halon replacement agents and evaluations of the thermodynamic properties of the agents are currently being conducted at NIST. The eleven agents proposed by the USAF are: FC-31, FC-318, HCFC-124, HFC-227, HFC134a, FC-218, HCFC-22, HFC-125, HFC-236, FC-116, and HFC-32/HFC-125 azeotrope. The determination of the solubility of nitrogen or Freon-23 (HFC-23) in the replacement agents is essential because nitrogen or Freon-23 is being considered as a pressurization gas; nitrogen is currently used in existing halon 1301 bottles. 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.

Yang, M. H.

Yang, M. H.; Puri, I. K.; Hamins, A.
Extinction of Inhibited, Stretched and Diluted Counterflowing Flames.
Illinois Univ., Chicago
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Institute/Central and Eastern States Section. Combustion Fundamentals and Applications. Joint Technical Meeting. March 15-17, 1993, New Orleans, LA, 56-60 pp, 1993.

flame research; methodology; kinetics; flame extinguishment

It has been shown that a criteria for flame extinction can be described by the Damkohler Number which is the ratio of a characteristic flow or diffusion time to a characteristic chemical reaction time. As the Damkohler Number is reduced the fuel burning rate gradually decreases until a critical value is attained when the flame will abruptly extinguish. The objective of this study is to investigate differences in the detailed chemical mechanisms which control the kinetics of non-premixed flames as they approach extinction by stretch, inhibition, and dilution.

Yeomans, S. R.

Yeomans, S. R.
Considerations of the Characteristics and Use of Coated Steel Reinforcement in Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5211; 46 p. July 1993.
Available from National Technical Information Services

building technology; reinforced concretes; corrosion; coated steel reinforcement; hot dip galvanized steel; fusion bond epoxy coated steel; accelerated corrosion testing; weight loss; chlorides; half-cell potentials; zinc coating loss

The corrosion of steel reinforcement in concrete, due in part to the inability of the concrete mass to protect the embedded steel, is a worldwide problem of massive propertions. The damage that results from corrosion, mainly cracking and delamination of the concrete, may significantly reduce the serviceability and structural integrity of reinforced concrete if early repair and rehabilitation is not carried out. These procedures are often quite expensive. While the provision of an adequate cover of a dense impermeable concrete is clearly the best means of protecting reinforcing steel, the use of additional methods of protection in concrete construction are now commonplace. One such method involves the use of coatings on the reinforcement, the two most common of which are epoxy coating and galvanizing. A review is presented of important considerations in the manufacture, specification and performance of coated steel reinforcement. The coating itself, which can be broadly classified as metallic or non-metallic in nature, provides barrier type protection by isolating the steel from corrosive elements in the local environment. In addition, some coating metals which are more anodic than steel afford sacrificial protection in the event that the coating is damaged and the steel substrate is exposed. In the first instance, the physical integrity of the coating, as well as its low reactivity with the environment to which it is exposed, is thus vital to the success of non-metallic coatings such as paints and fusion bonded powders, as well as to noble metal coatings on steel. On the other hand, active metal coatings on steel such as zinc, provide both primary barrier protection and, where the coating is damaged and the substrate exposed, secondary cathodic protection. The long term performance of active metal coatings on steel also depends on the reactivity of the coating metal in the environment to which it is exposed.

Yokel, F. Y.

Yokel, F. Y.
Effect of Subsurface Conditions on Earthquake Ground Motions.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4769; 93 p. January 1993.
Available from National Technical Information Services

earthquakes; dynamic soil properties; earthquake engineering; ground motion; shear wave propagation; response spectra; soil dynamics; wave mechanics

A revised version of the SHAKE program was prepared and used to study the effects of subsurface conditions on the earthquake ground motion in the Loma Prieta earthquake. Preliminary soil profile data from the sites of the Oakland Outer Harbor Wharf and Apeel 2 strong motion stations are used to calculate ground motions, which are then compared with the recorded ground motions using response spectra calculated for a 5% damping ratio. Parameters affecting the amplitude of the calculated ground motion are examined. Response Spectra for recorded and calculated ground motions are compared with recommended design spectra (NEHRP, 1988). It is shown that for periods less than 1.4 s the response spectra for recorded far source earthquake motions at Oakland Wharf and Apeel 2 fall outside the envelope of the applicable design spectra, and that response spectra for deeper soil profiles calculated for near source conditions exceed the design spectra by a considerable margin. Design spectra for the San Francisco Bay region, recently proposed in a USGS study, are reasonably close to the calculated near source spectra for deeper soil profiles for periods less than 1 s, but they are conservative for the bedrock motion, and extremely conservative for longer period structures.

Z

Zarr, R. R.

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
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 (CCI3F) 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 abour 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.

Zhang, X.

Zhang, X.; Ghoniem, A. F.
Computational Model for the Rise and Dispersion of Wind-Blown, Buoyancy-Driven Plumes. Part 2. Linearly Stratified Atmosphere.
Massachusetts Institute of Technology, Cambridge
NIST-GCR-93-637; 47 p. December 1993.
Available from National Technical Information Services
PB94-143427

buoyant flows; computation; entrainment; fire phases; large fires; simulation; urban fires; wildland fires; wind effects

A multi-dimensional computational model of wind-blown, buoyancy-driven flows is applied to study the effect of atmospheric stratification on the rise and dispersion of plumes. The model utilizes Lagrangian tranpsort elements, distributed in the plane of the plume cross section normal to the wind direction, to capture the evolution of the vorticity and density field, and another set of elements to model the dynamics in the atmosphere surrounding the plume. Solutions are obtained for a case in which atmospheric density changes linearly with height. Computational results show that, similar to the case of a neutrally stratified atmosphere, the plume acquires a kidney-shaped cross section which persists for a long distance downstream the source and may bifurcate into separate and distinct lumps. Baroclinic voricity generated both along the plume boundary and in the surroundings are used to explain the origin of the distortion experienced by the plume and inhibiting effect of a stratified atmosphere, respectively. The vorticity within the plume cross section forms two large-scale coherent eddies which are responsible for the plume motion and the entrainment. Prior to reaching the equilibrium height, the computed plume trajectory is found to follow the two-thirds law, when extended to include the initial plume size, reasonably well. The entrainment and the added mass coefficients, 0.49 and 0.7, respectively, are obtained from the numerical results over a wide range of the buoyancy ratio, defined as the ration between the plume buoyancy and the degree of background stratification. In the case of strong stratification, the plume trajectory shows weak, fast decaying oscillations around the equilibrium height. The origin and decay of these oscillations are explained using a simple analytical model.

Zhou, L.

Zhou, L.; Fernandez-Pello, A. C.
Turbulent, Concurrent, Ceiling Flame Spread: The Effect of Buoyancy.
California Univ., Berkeley
Combustion and Flame, Vol. 92, No. 1-2, 45-59, 1993.

flame spread; ceilings; air flow; polymethylmethacrylate; turbulence; air; buoyancy; flame fronts

Experiments have been conducted to study the effects of forced air flow velocity and grid-generated turbulence on the flow-assisted flame spread over a flat solid combustible surface in a ceiling configuration. The tests are conducted with thick PMMA sheets as fuel, and air as oxidizer. Flame spread rate, flame length, surface heat flux, and products composition are obtained for air flow velocities ranging from 0.25 to 4.5 m/s and turbulence intensities the 1% to 15%. It is found that for all turbulence intensities the ceiling flame spread rate increases with the flow velocity, and that the flow turbulence retards the flame spread for flow velocities larger than 1 m/s and enhances it at lower velocities. The flame length and the surface heat flux exhibit power law correlations with the fuel pyrolysis length, and the flame spread rate data can be correlated with an expression deduced from a simplified heat transfer analysis of the process. In order to determine the effect of buoyancy on the flame spread processes, data from the ceiling configuration experiments are compared with data from floor tests conducted previously. The experimental results indicate that in ceiling spread, buoyancy has two main competing effects. One is an enhancement of the heat transfer from the flame to the solid surface because the flame stands closer to the surface, the other is an incomplete (larger than 1 m/s), the enhanced heat transfer is found to be dominant and results in a faster flame spread in the ceiling than in the floor. For small flow velocities, the incomplete combustion becomes more important and the opposite result is observed. The species concentration data show that in general the combustion reaction is less complete in ceiling spread than in floor spread, and that significant amounts of CO and unburned hydrocarbons are produced in ceiling flame spread.

2. AUTHOR INDEX

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