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U.S. DEPARTMENT OF COMMERCE

TECHNOLOGY ADMINISTRATION

National Institute of Standards and Technology

BUILDING & FIRE RESEARCH LABORATORY

ACTIVITIES, ACCOMPLISHMENTS & RECOGNITIONS

1997

U.S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary

Technology Administration
Gary R.Bachula, Acting Undersecretary for Technology

National Institute of Standards and Technology
Raymond G. Kammer, Director

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Developed by Andrew J. Fowell
Building and Fire Research Laboratory

Design Consultant: Susan Permut

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The Building and Fire Research Laboratory web site is http://www.bfrl.nist.gov

Technical Publications

Building and Fire Research Laboratory's 1996 publication abstracts are found in *Publications 1996*, NIST SP838-12. Full text, tables and figures are available on 2 CD-ROM's, NIST SP 914. Also, summaries of BFRL's research are available as *1997 Project Summaries*, NIST SP 838-13. This material is available from BFRL's Office of Cooperative Research Programs, National Institute of Standards and Technology, Gaithersburg, MD 20899, Facsimile (301) 975-4737.

Left: The launch of STS-94 on 1 July 1997

Director's Foreword

Staff of the Building and Fire Research Laboratory

We in the Building and Fire Research Laboratory (BFRL) are pleased to present to our clients and collaborators this 1997 report of our activities, accomplishments and recognitions. As one of the National Institute of Standards and Technology's Measurement and Standards Laboratories, we provide performance prediction methods, measurement technologies and technical advances needed to assure the life cycle quality and economy of constructed facilities. These include residences, commercial and institutional buildings, industrial facilities, public works and utilities. We are enthusiastic about our work, conducted in close collaborations with industry, government and academia, because of its importance to the productivity and competitiveness of all U.S. industry and everyone's quality of life.

The thrusts of our program are high performance materials and systems, automation in construction and constructed facilities and reduction of losses from fire and natural hazards. Examples of our principal accomplishments described herein are:

- Developed with industry, understanding of mechanisms of and effectiveness measures for, a new generation of silicon-based fire retardants (to provide environmentally friendly, fire-resistant products).

- Completed a model capable of the efficient computation of the fire environment in multistory buildings (for the commercialization by industry of advanced fire modeling in computer aided design).

- Completed the draft international standard, Plant Spatial Configuration, to support automatic exchange of information in the design, construction and use of process plants (an important export area for U.S. manufacturers, designers and constructors and a good start for the wide application of automatic information exchange in the life cycle of constructed facilities in general).

- Developed a new simulation model for refrigeration cycle evaporators (to provide industry the basis for design of heat pumps, air conditioners and refrigerators effectively using advanced, environmentally friendly refrigerants).

- Developed a three dimensional model for simulation of cement hydration and microstructure development in cement paste (to provide the ability to design concrete for economical attainment of desired properties for placement, strength and durability).

- Developed for standardization the modified compression field theory for the shear resistance of reinforced concrete beams that use high strength concrete (to help preclude the occurrence of sudden, brittle shear failures which would be fatal to the beneficial use of high strength concrete).

- Produced the beta test version of the methodology for assessing the life cycle economic and environmental performance of building products (a rational and systematic approach for balancing economic and environmental performance).

- Initiated the state, local and federal government and industry program Streamlining the Building Regulatory Process (to address the great barrier to innovation and cost-effective construction provided by slow and redundant regulatory reviews, but without reducing protection of public safety, environmental quality and property values).

This report gives further information on these and other accomplishments and sources for more detailed information.

Looking ahead to 1998, we are focusing the majority of our resources on six major products that appear to have early benefits to the industry. They are:

- Partnership for High Performance Concrete Technology
- Performance Standards System for Housing
- Cybernetic Building Systems
- Computer Integrated Construction Environment
- Fire Safe Materials and Composites and
- Fire Safety Performance Evaluation System

We look forward to your inquiries and to our continued and strengthened collaborations.

Richard N. Wright
Director, BFRL

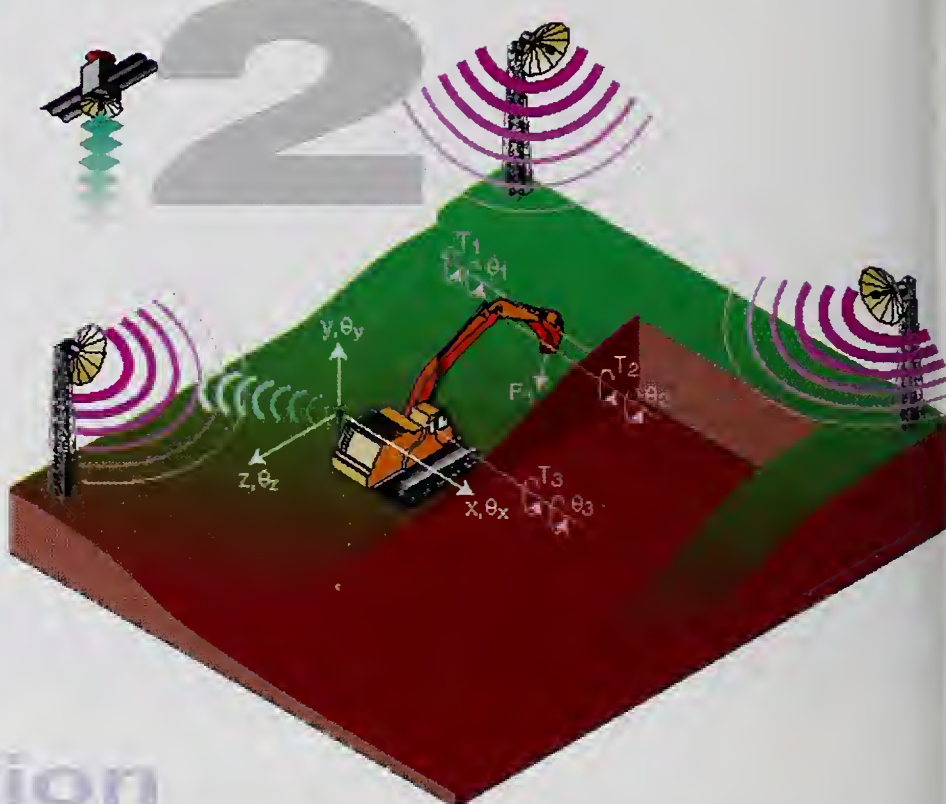
Performance

1

Advanced photodegredation device capable of exposing polymeric materials to a highly, spatially uniform ultraviolet radiant flux.

Automation

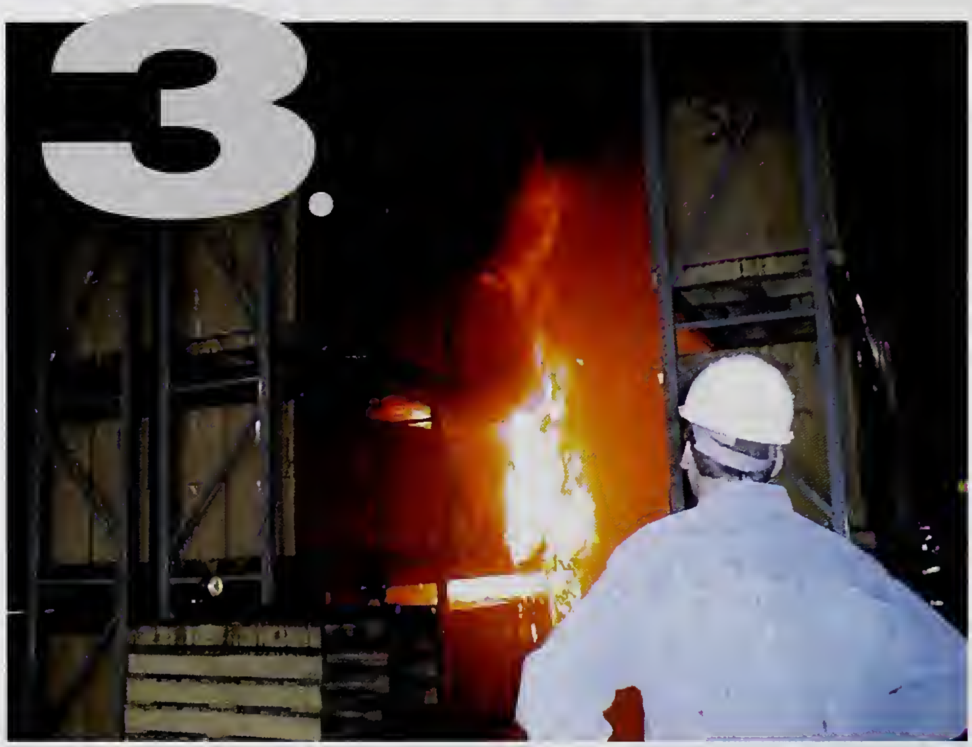
2



Simulation of computer automation at the construction site

Loss Reduction

3.



Fire Test of interaction of sprinklers, draft curtains and heat and smoke vents

Mission

The Laboratory's mission is to enhance the competitiveness of U.S. industry and public safety by developing performance prediction methods, measurement technologies and technical advances needed to assure the life cycle quality and economy of constructed facilities.

Programmatic Thrusts

NIST's Building and Fire Research Program focuses on three thrusts: High Performance Materials and Systems for Constructed Facilities, Automation in Construction and Constructed Facilities and Loss Reduction. In addition, NIST is supporting cooperative private and public activities to streamline regulatory processes for constructed facilities and improve mechanisms for the evaluation and acceptance of innovative products and services.

1 High Performance Materials and Systems for Constructed Facilities

provides for U.S. leadership in high performance materials and systems for constructed facilities by developing performance criteria and evaluation as well as measurement and test methods for structural, enclosure, mechanical and fire protection materials, components and systems. These are aimed at opening the marketplace to innovative materials and systems for which product-specific standards do not exist. Attention is given to life cycle performance including functionality, economy, durability, maintainability, recycling and fire safety.

2 Automation in Construction and Constructed Facilities

provides for U.S. leadership in construction processes and constructed facilities by developing technical bases for integrated open systems for automation and robotics in design, construction, operations, maintenance and renovation. Intelligent systems offer great potential for supporting decisions and providing automatic diagnosis and adaptive control.

3 Loss Reduction

provides for reduction of intolerable U.S. losses of lives, property, and production due to fires, earthquakes, extreme winds, explosions and hazardous materials spills. This effort also supports reduction of construction costs and U.S. leadership in products and services for disaster-resistant constructed facilities. BFRL develops criteria for the actions of extreme environments, methods for predicting, measuring and assessing the performance of new and existing facilities and recommendations for standards providing cost effective reliability of constructed facilities.

1 High Performance Materials and Systems for Constructed Facilities

It is estimated that increased energy usage due to moisture is approximately $150 million dollars per year.

Mold and mildew as a result of poor moisture control

1.1 MOIST 3.0

Douglas Burch of the Building Environment Division has completed and released an enhanced version of MOIST, a personal computer program that predicts the transfer of heat and moisture in walls, flat roofs and cathedral ceilings. MOIST 3.0 represents a significant advancement over the previous DOS based version. MOIST 3.0 utilizes an easy to use graphical user interface that allows the user to construct virtual building assemblies and quickly assess the resulting thermal and moisture performance.

The program contains an extensive heat and moisture property database for building materials and hourly weather data for 51 cities within the United States and Canada. Unlike the previous version of MOIST, MOIST 3.0 incorporates algorithms that predict the indoor relative humidity of the building being analyzed rather than assuming a fixed relative humidity. This capability is useful in determining if ventilation strategies provide a means of achieving acceptable moisture performance.

The program is used by building practitioners to: 1) determine if vapor retarders are needed in cold climates and if so where they should be placed; 2) predicting surface relative humidity at the construction layers in hot and humid climates, thereby determining the potential for mold and mildew growth; 3) determine the drying rates for materials containing original construction moisture; and 4) to investigate the moisture performance of cold refrigeration storage rooms. Moisture analysis makes it possible to design building constructions that perform with considerably less moisture-induced material degradation.

It is estimated that increased energy usage due to moisture is approximately $150 million dollars per year. If through the use of MOIST, moisture accumulation in 20 percent of the affected roofs and walls was eliminated, an annual savings of $30 million per year would result. Proper moisture analysis and construction would also decrease the enormous expenditure of funds required to replace moisture damaged building materials and coatings as well as reduce the litigation associated with moisture-related damage.

The previous DOS-based MOIST is being used by over 1,200 building practitioners. It is anticipated that the new release will be in greater demand due to its ease of use and enhanced analysis capabilities.

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1.2 Ventilation and Indoor Air Quality Model

Andrew Persily of the Building Environment Division has developed the CONTAM simulation program for multi-zone airflow and indoor air quality analysis. Poor indoor air quality is a major national problem based on the impacts on health care expenses, the costs associated with reduced productivity of building occupants and the impacts on the performance of students in educational buildings. The latest version of the CONTAM program, CONTAM96, can perform airflow and contaminant dispersal analysis on a wide variety of complex multi-zone building systems. The program employs an element assembly approach to describe a building as a series of well-mixed zones connected by airflow elements such as doorways and mechanical ventilation system airflows. Additional elements are used to describe contaminant sources, sinks and air filters. The most significant elements in CONTAM96 are the inclusion of a ventilation system model and the ability to estimate occupant exposure to airborne contaminants. The program can be used on a PC-compatible system and can analyze the performance of a building for an entire year in only a few minutes of run-time. CONTAM96 will be used by researchers and the design community responsible for building ventilation and airflow, such as smoke control system designers. CONTAM96 is described in detail in its user's manual, NISTIR 6056 CONTAM96 User Manual and is available at ftp.nist.gov under the CONTAM directory.

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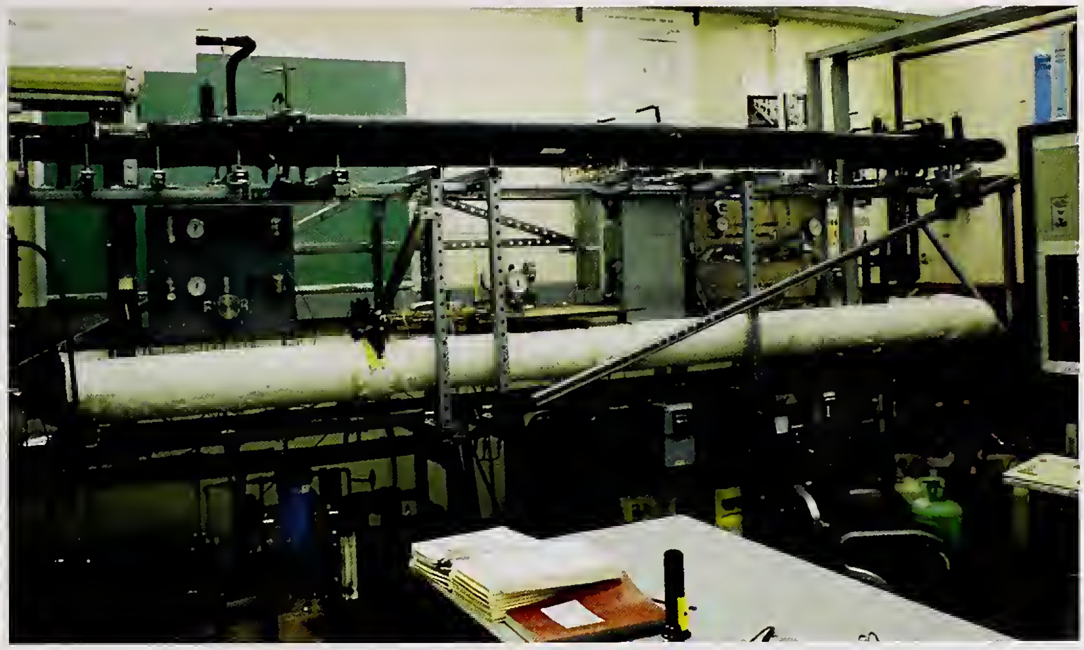

Instrumented and unique test rig measures the local convective condensation heat transfer coefficients of alternative refrigerants

1.3 Convective Condensation of Alternative Refrigerants

Mark Kedzierski and Joaquim Goncalves developed correlations to predict micro-fin tube condensation heat-transfer coefficients and pressure drops for ozone-safe R22 alternative refrigerants. The heat transfer and pressure drop measurements were made in an apparatus that was specially designed for a wide variation in flow parameters. The measured convective condensation Nusselt numbers for all of the test refrigerants were correlated to a single expression of dimensionless properties. The pressure drop correlation is a modified form of a well accepted pressure drop correlation for smooth tubes. The correlations provide the designer of heat pump condensers with a simple means to size the alternative refrigerant condenser for given duty and pressure drop requirements. Both the pressure drop and heat transfer correlations are based on the hydraulic diameter of the tube. Consequently, the correlation may be successfully extrapolated to predict the performance of micro-fin tubes with a variety of number of fins and fin shapes.

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CONTAM96, can perform airflow and contaminant dispersal analysis on a wide variety of complex multi-zone building systems.

Placing tape-bonded seam specimens in the chamber prior to conducting a creep-rupture test

1.4 Predicting Service Life of Chloride-Exposed Steel-Reinforced Concrete

Dale Bentz, James Clifton and Kenneth Snyder have developed a prototype computer-integrated knowledge system (CIKS) for predicting the service life of steel-reinforced concrete exposed to chloride ions, as in a concrete bridge deck treated with de-icing salt. Starting from the mixture proportioning process, the system proceeds to predict chloride diffusivity coefficients and, finally, to predict the ingress profiles and time to corrosion initiation for a reinforced concrete exposed in a specific environment. Apart from its intrinsic value as a tool for designers, the system demonstrates the potential for disseminating knowledge on specific topics in concrete technology to the construction industry through the World Wide Web.

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1.5 Evaluation of New Technology for Seams in Elastomeric Roofing

Elastomeric roofing membranes based on EPDM rubber have excellent weather-resistance and are one of the main types of membrane used on low-slope roofs. A critical element of elastomeric roofing membranes is the seams which are generally formed in the field. The liquid-applied butyl adhesives which have been extensively used in forming EPDM roofing seams since the mid-1980s have been successful. However, these adhesives contain a large fraction of volatile organic solvents, which could be a problem for the roofing industry if environmental regulations become more restrictive. An alternative that has been proposed is butyl tape systems which contain lesser amounts of solvent. To evaluate the reliability of adhesive joints made with tape systems, a NIST-led consortium of individual companies and two trade associations has been studying the tape adhesives for two years. The statistically-designed experiments have investigated the times-to-failure of seams under various loads and under various environmental conditions. The results to date suggest that seams made with tape adhesives perform at least as well as those made with liquid-applied butyl adhesives and that they may be considered a viable alternative.

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1.6 Knowledge System for Protective Coatings for Steel

Organic coatings provide a versatile, cost-effective means for protecting steel structures against adverse environmental conditions, but decisions about coating system selection are often difficult to make. Currently, users of coating systems must rely on information presented in many different forms. These include manuals, guides, photographs and drawings, videos, databases and other sources. In addition, a human expert's advice may be needed to reach a decision, or the needed knowledge may not be accessible. To provide a comprehensive, easily-accessible source of reliable information, BFRL has worked with the SSPC (formerly the Steel Structures Painting Council and now renamed the Society for Protective Coatings) to develop the Coatings Expert

Advisory system, COEX-I, which contains some of NIST's coatings data, together with much data from other sources. The COEX-I system was well-accepted by the coatings community and an improved version, COEX-II, has been developed to provide an even better advisory system.

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1.7 Electronic Monograph on the Structure and Properties of Concrete and Other Cement-Based Materials

BFRL was a pioneer in the computational materials science of concrete and is one of the world's main centers for this new field. Edward Garboczi and Dale Bentz, with collaborators from several other laboratories, have developed models of microstructure and properties on all length scales of interest. These have been linked together to give overall predictions for concrete properties as a function of mixture design, curing and environmental exposure. As part of the development of a computer-integrated knowledge system (CIKS) for building materials, a monograph, *An Electronic Monograph: Modeling the Structure and Properties of Cement-Based Materials* (available at URL: http:\\ciks.cbt.nist.gov\garboczi), has been developed to summarize and make available the current state of knowledge of the computational materials science and engineering of concrete.

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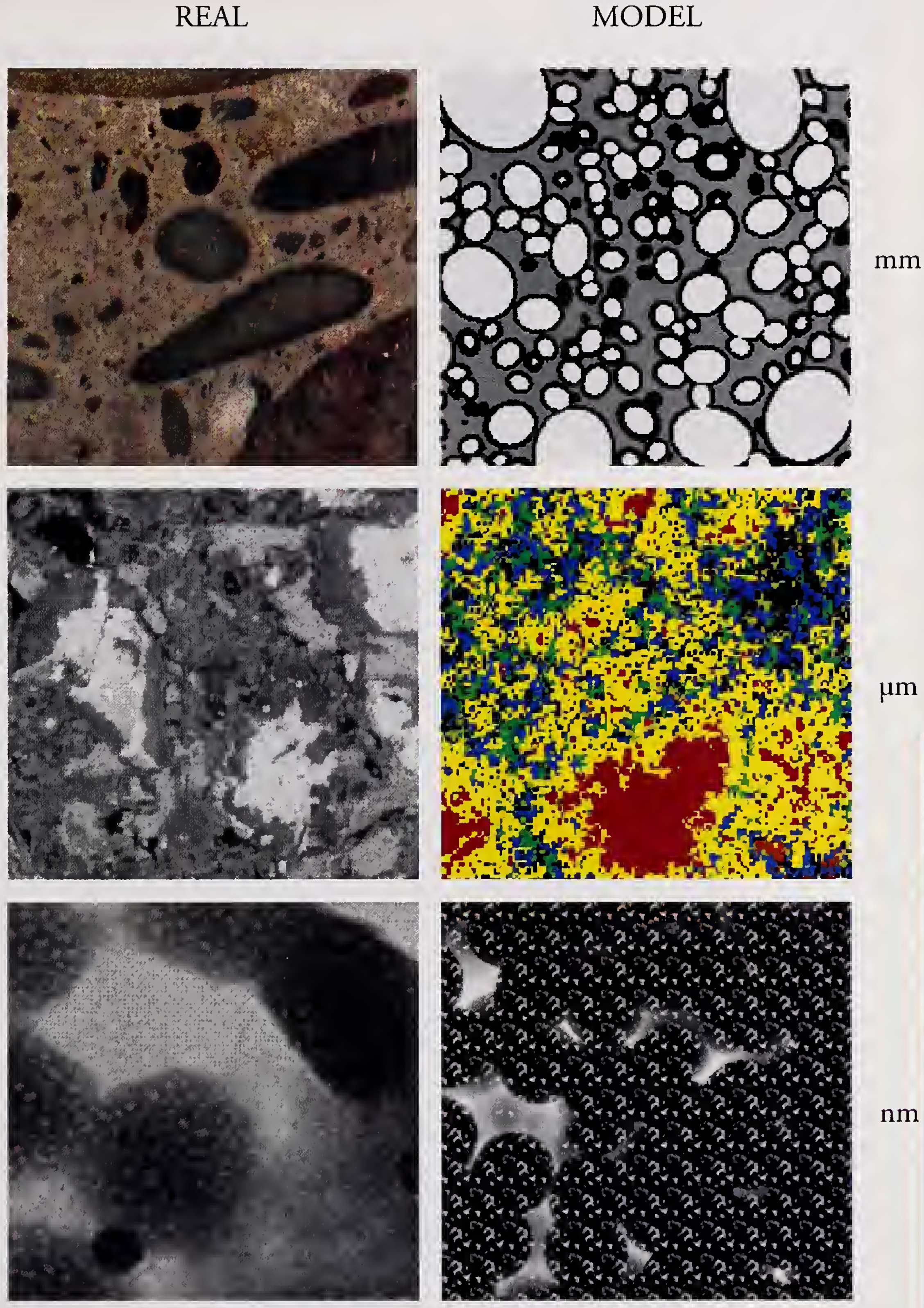
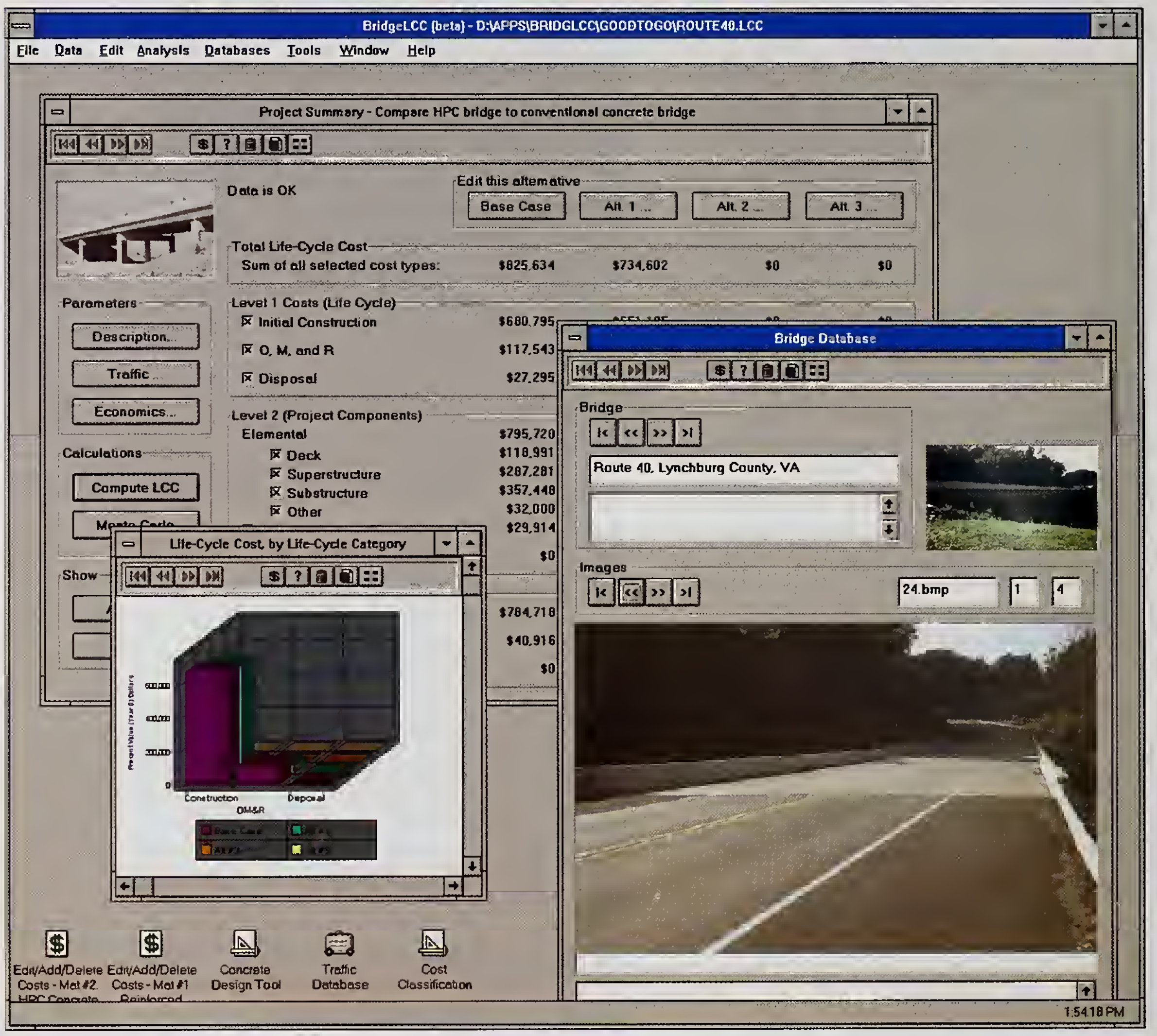


Comparison of model and experimental images of concrete microstructure at different length scales



BridgeLCC calculates the life-cycle costs of bridges built from competing alternative materials

1.8 Economic software for Assessing the Life-Cycle Costs of High-Performance Bridge Materials

Mark Ehlen, an engineer in BFRL's Office of Applied Economics, has completed the alpha version of BridgeLCC, user-friendly Windows-based software for evaluating the life-cycle costs of highway bridges. Based on an economic model developed by Ehlen and Harold Marshall, BridgeLCC is specifically designed to analyze the life-cycle costs of new construction materials such as high-performance concrete, high-performance steel and fiber-reinforced-polymer composites. The software includes a BFRL-developed concrete service life tool, a Monte Carlo module for analyzing uncertain costs and a standard bridge elemental classification under joint development by BFRL and industry. Ehlen is working with the Federal Highway Administration to implement the beta version at state departments of transportation, giving them an evaluation tool to help them reduce the life-cycle costs of building and repairing bridges by using new, higher-performance materials.

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1.9 New Proficiency Sample Programs for Masonry Materials

BFRL's ASTM-sponsored Cement and Concrete Reference Laboratory (CCRL) has initiated three new proficiency sample programs for masonry materials in consultation with ASTM Committees C12 on Mortars for Unit Masonry and C15 on Manufactured Masonry Units. The programs were developed in consultation with the National Concrete Masonry Association and the Brick Institute of America. These programs include a Masonry Mortar Program based on ASTM C270, a Concrete Masonry Unit Program based on ASTM C140 and a Facing Brick Program based on ASTM C67. They are in addition to existing CCRL Proficiency Sample Programs for portland cement, portland cement concrete, blended cement, masonry cement and pozzolans.

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Concrete Reference Laboratory has initiated three new proficiency sample programs for masonry materials

Materials handling equipment used to prepare CMRL proficiency samples

1.10 ASTM ISR Reference Soils Project

BFRL's AASHTO Materials Reference Laboratory (AMRL) sponsored by the American Association of State Highway and Transportation Officials (AASHTO) is supporting the ASTM Institute of Standards Research Reference (ISR) Soils and Testing Program. The purpose of this program is to prepare precision statements for 13 ASTM test methods and have a stockpile of four soil types to benefit the engineering community. The soil samples can be used by laboratory accreditation systems, quality control and quality assurance activities and standards development. AMRL has processed more than 41,000 kg of the four soil types into samples ready for shipment to laboratories, provided statistical support in conjunction with the NIST Information Technology Laboratory and participated on the project management team.

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1.11 Implementation of Strategic Highway Research Program Technology

AMRL is continuing to support implementation of results from the Strategic Highway Research Program (SHRP). AMRL has assisted the AASHTO Subcommittee on Materials in drafting and processing more than 60 provisional standards based on SHRP technology. AMRL has added SHRP performance graded binder and hot-mixed asphalt samples to its Proficiency Sample Program and inspects laboratories who perform related test methods as part of its Laboratory Inspection Program. AMRL is also supporting SHRP implementation through its technical support of the AASHTO Accreditation Program. Private industry laboratories testing asphalt binders are required to be accredited by the year 2000. Haleem Tahir is serving on five National Cooperative Highway Research Program panels that guide the follow-on research on SHRP technology dealing with aggregates and asphalt mix design. He also helped develop the concept of the AASHTO Lead States Program, which was developed to ensure that practical, real world experience is gained in the early application of SHRP technology. This program has been instituted and is considered to be a most successful program in technology transfer.

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1.12 Fire Performance of High-Strength Concrete

High-Strength Concrete (HSC) is presently being used more and more for structural applications owing to its many advantages over normal strength concrete (NSC) and its easy availability nowadays at many concrete plants. However, recent studies have revealed that HSC possesses some undesirable performance characteristics when subjected to elevated temperatures. These include significantly shorter fire endurance time compared with NSC, markedly higher losses in mechanical properties and more importantly, high susceptibility to sudden explosive spalling at temperatures in the 300° to 6500°C range. These differences have design consequences and give rise to the question of whether the existing U.S. fire design provisions, which were developed using data from high temperature testing of NSC, are applicable when HSC is used.

In response to these technical challenges, BFRL initiated an effort to address the above fire performance issues with aims to accurately predict the behavior of fire-exposed HSC structures and to mitigate HSC's undesirable fire performance characteristics. Early results of this ongoing effort include the publication of a systematic review of relevant technical data that established the current baseline knowledge concerning the fire performance of HSC and identified technical issues in need of research.

Also published were the proceedings of the International Workshop on Fire Performance of HSC in which experts in this field from various laboratories and agencies worldwide participated. The results of this study will provide the needed solutions to the critical issues concerning the fire performance of HSC, thus promoting safe and increased use of HSC in the construction industry.

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Recent studies have revealed that HSC possesses some undesirable performance characteristics when subjected to elevated temperatures

2

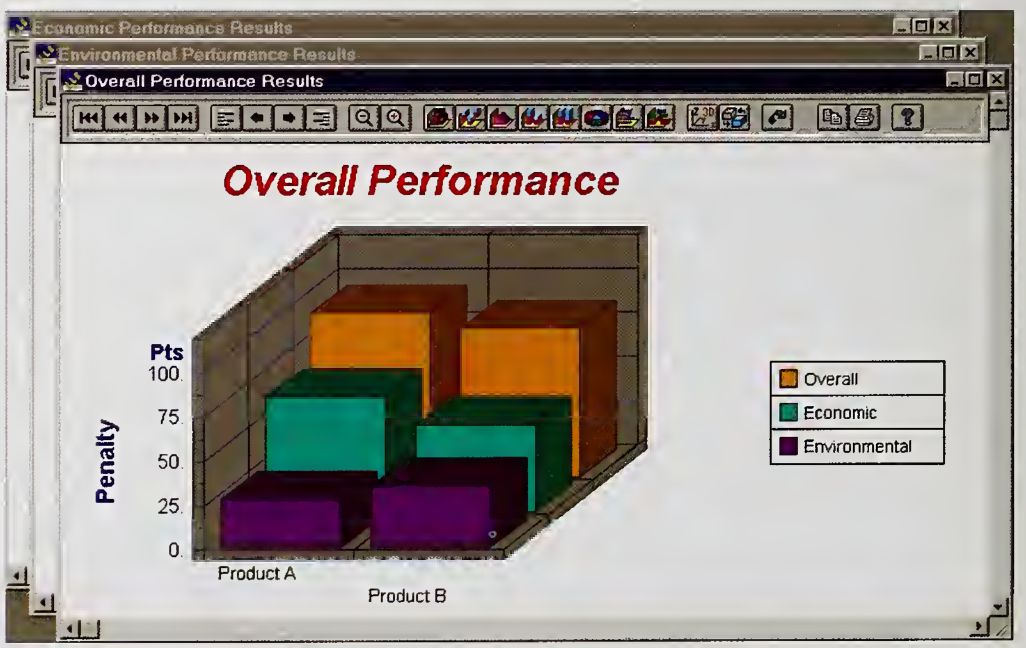
Automation in Construction and Constructed Facilities

2.1 BEES

Under Barbara Lippiatt, of the BFRL Office of Applied Economics, the BEES (**B**uilding for **E**nvironmental and **E**conomic **S**ustainability) project has developed a powerful technique for balancing the environmental and economic performance of building products. Implemented in Windows-based decision support software aimed at designers, builders and product manufacturers, the tool includes actual environmental and economic performance data for a number of building products. After incorporating comments received during a 1997 beta test by over 125 reviewers worldwide, the first version of the tool, BEES 1.0, will be published in January 1998. The intended impact is lowered building-related contributions to environmental problems at minimum cost.

The intended impact is lowered building-related contributions to environmental problems at minimum cost

BEES measures the environmental performance of building products using the environmental life-cycle assessment approach specified in the latest versions of ISO 14000 draft standards. The approach analyzes all stages in the life of a product, including raw material acquisition, manufacture, transportation, installation, use and recycling and waste management. Economic performance is measured using the ASTM standard life-cycle cost method. The technique includes the costs over a given study period of initial investment, replacement, operation, maintenance and repair and disposal. Environmental and economic performance are combined into an overall performance measure using the ASTM standard for Multi-Attribute Decision Analysis.



The BEES methodology is being refined and expanded over the next three years under sponsorship of the EPA Environmentally Preferable Purchasing (EPP) Program. The EPP program is charged with carrying out Executive Order 12873, "Federal Acquisition, Recycling and Waste Prevention," which directs Executive agencies to reduce the environmental burdens associated with the $200 billion in products and services they purchase each year, including building products. BEES is being further developed as a tool to assist all Federal procurement agents in carrying out the mandate of Executive Order 12873.

For each alternative product, the BEES software computes an environmental performance score (based on a synthesis of scores for six environmental attributes) and an economic performance score (based on life-cycle costs). The environmental and economic performance scores are then combined into an overall performance score based on importance weights for environmental versus economic performance entered by the user.

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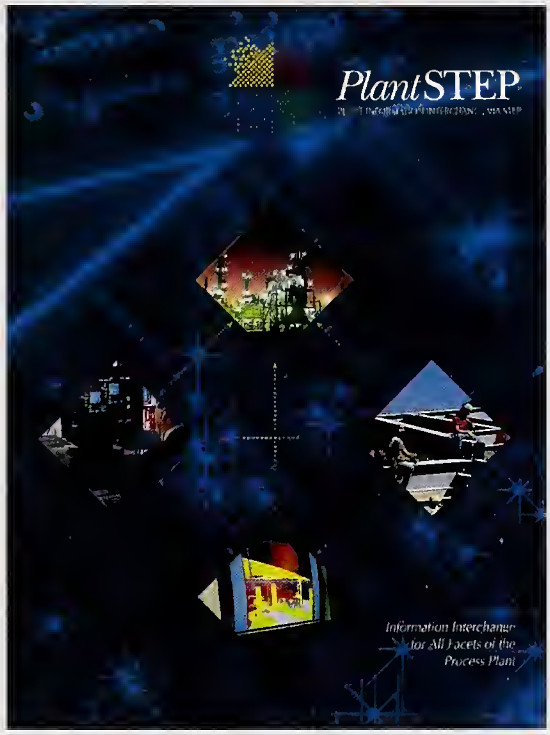
2.2 International Standard for Exchanging Plant Engineering Information

The Computer Integrated Construction Group is working with industry to deliver effective data exchange standards to advance the international competitiveness of U.S. engineering, construction, process and CAD/CAE industries.



PlantSTEP brochure

In the international world of process plant design, construction and operation, the rapid and accurate exchange of technical information among owners, designers, equipment suppliers, fabricators and others is critical. Incompatible data exchange formats can lock corporations out of profitable national and international process plant projects.

Working with PlantSTEP, Inc. (see page 34) and other leaders from the process plant industries, the CIC Group completed the Draft International Standard, ISO 10303-227: Plant Spatial Configuration. This standard, commonly referred to as STEP Application Protocol 227, will enable the automatic exchange of plant engineering information, including 3D models of plants and the detailed engineering of piping systems.

In parallel with developing the standard, the CIC Group provided an experimental testbed for assessing prototype implementations of the draft standard. During 1997, demonstrations of AP 227 implementations were conducted at international conferences in Houston and Tokyo. These demonstrations were the first examples of exchanging complex plant models among all of the major plant design software packages using a neutral, international standard. The Draft International Standard of STEP AP 227 is out for international ballot and approval by the members of ISO. Industry is beginning to include the use of AP 227 for new process plant engineering contracts. This standard is an important step for the wide application of automatic information exchange in the life cycle of constructed facilities in general.

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This standard is an important step for the wide application of automatic information exchange in the life cycle of constructed facilities in general

Preliminary demonstrations have been made to industry participants showing the ability to track a full-scale 30-ton bridge crane (one component of NCAT) and the components it is maneuvering in 3D in real-time and to display the status of the job site to a remote management center

2.3 Visual Test Shell for BACnetP

Visual Test Shell (VTS), a software tool developed by NIST for testing building control products for conformance to ASHRAE Standard 135-1995, BACnet, was released in 1996. BACnet is a communication protocol standard that enables the interconnection of building control products made by different manufacturers. This standard creates the opportunity for building owners to bid control system projects competitively and to integrate traditionally stand-alone building services such as energy management, fire detection, security and building transportation. It will also play an important role in interactions between building control systems and a deregulated utility industry. VTS is now being used by manufacturers who are developing BACnet products. The testing procedures implemented in VTS have become the basis for a draft addendum to the BACnet standard that defines a conformance test suite. VTS will continue to develop as the standardization process proceeds. The goal is for VTS to become the tool used to implement an industry-run certification program for BACnet products.

The emergence of building control products that utilize the BACnet protocol has significantly increased the interest in BACnet outside of the United States. BACnet has been adopted as a pre-standard in the European Community (ENV 1805-1) and has been adopted as the working draft for an ISO standard by ISO/TC 205/WG 3 Building Control System Design. BACnet has been included in the specifications for the new German Parliament complex at the Reichstag in Berlin. The Reichstag project is one of the most high profile construction projects in Europe today. There are now at least 2,500 BACnet systems installed worldwide and they can be found in at least 14 countries.

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2.4 NIST National Construction Automation Testbed: Developing Interface Data Standards for Real-Time Construction Site Metrology

An exciting collaborative effort is under way between the Building and Fire Research Laboratory (BFRL), the Manufacturing Engineering Laboratory (MEL) and the U.S. construction industry to develop the information infrastructure that will lead, ultimately, to the general use of automated metrology systems and semi-automated machinery on the average construction job site.

A multi-disciplinary team has been formed within NIST, drawing expertise in the fields of CAD/CAE information systems and data exchange standards, real-time construction site metrology; wireless data telemetry; VR world modeling; and intelligent systems design. The first product of this collaboration, the National Construction Automation Testbed (NCAT) is "under construction" at NIST for test and validation of proposed open architecture data exchange and protocol standards; real-time construction site metrology techniques, including seamless hand-off between metrology systems; and the development of standard component identification protocols for barcode, smart chip and RFID tags. Preliminary demonstrations have been made to industry participants showing the ability to track a full-scale 30-ton bridge crane (one component of NCAT) and the components it is maneuvering in 3D in real-time and to display the status of the job site to a remote management center (the National Advanced Manufacturing Testbed laboratory, approximately 600 m distant from NCAT). There, a 3D construction simulation system has been developed to display a virtual replica of the construction site that not only recognizes the actual, instant, changes taking place in the crane position, but also in the location and orientation of the components it is moving. The NCAT team hopes to demonstrate within the following two years the seamless tracking of the delivery of a semi-tractor trailer load of process plant components to the parking lot adjacent NCAT; the automatic unloading of that cargo using an instrumented fork truck; and the delivery of the components to the crane for automated assembly of the process plant sub-unit. All of this will take place under the umbrella of four different positioning systems — GPS, an internal Pseudolite range; fanning laser systems; and traditional total stations. The system is being designed to determine automatically which metrology system supplies the strongest, most recent signal with the least error as machines and components move about the site.

It will then automatically shift control to the appropriate system when, for example, the fork truck enters the NCAT facility and loses GPS satellite contact but picks up a fanning laser lock. It is anticipated that this approach will revolutionize component tracking and placement on construction sites.

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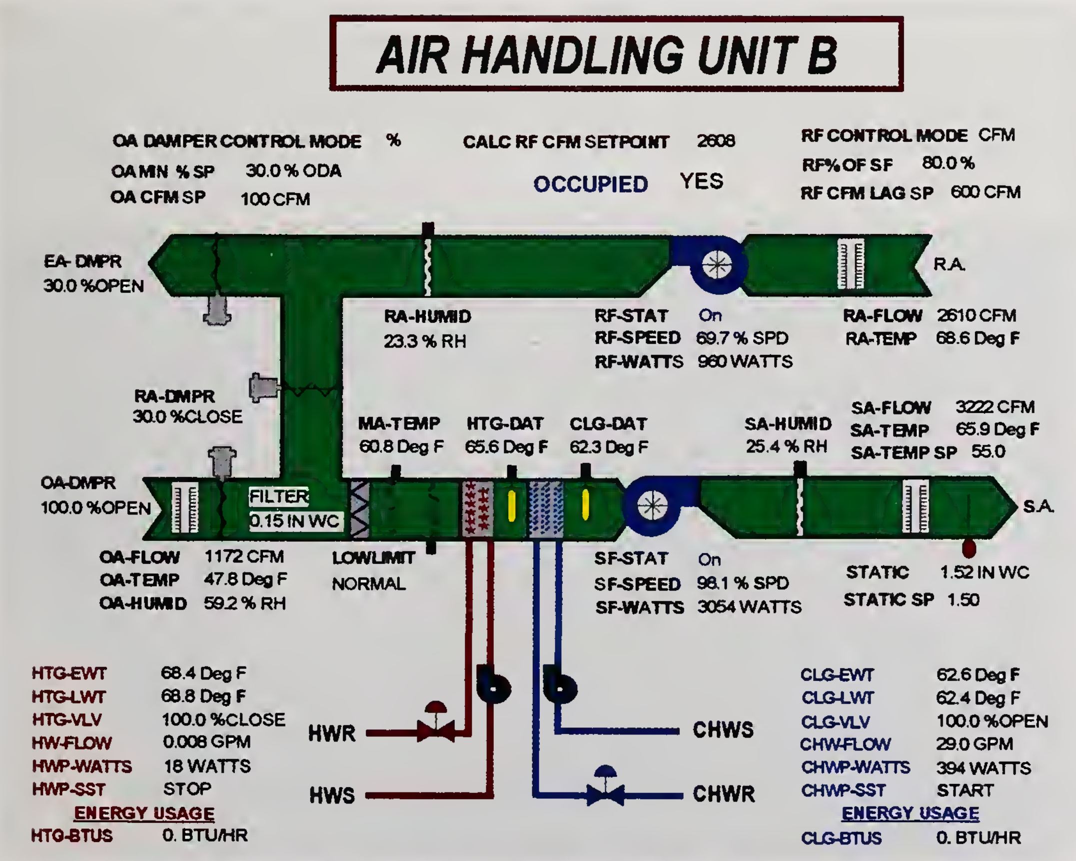
2.5 Improved Variable-Air-Volume Air-Handling Unit Control

BFRL staff have participated in two separate "annexes" of the International Energy Agency where researchers from several countries have collaborated to develop and implement methods to detect and diagnose faults in Heating, Ventilating and Air Conditioning Systems (HVAC). The staff made a significant improvement in control technology for one specific application as a result of this participation.



Schematic of air-handling unit at the Iowa Energy Center used for testing new control system

Outdoor air entering an air-handling unit through the exhaust air outlet has the potential to adversely affect indoor air quality if the exhaust air outlet is located near a pollution source, such as a truck loading dock. Engineers George Kelly and John House were instrumental in the discovery and analysis of conditions that can lead to this phenomenon in variable-air-volume air-handling units. Subsequent research on the problem was performed under a CRADA with Johnson Controls, Inc. and led to the development of a new damper control system that helps alleviate the problem.

The reverse airflow problem has been observed and studied in variable-air-volume air-handling units that control the return fan to maintain a constant volumetric flow difference between the supply and return airflow rates. In such systems, dampers in the outdoor, return and exhaust air ducts are traditionally controlled such that as the return air damper opens, the outdoor and exhaust air dampers close. The reverse airflow phenomenon has typically been observed when the exhaust and outdoor air dampers are less than 30% open. The new damper control system is identical to the traditional control system except that the outdoor air damper is set to 100% open during periods when a building is occupied. Simulations, laboratory experiments and field tests at the Iowa Energy Center, Energy Resource Station have demonstrated that the new control system will reduce the range of conditions for which the reverse airflow problem occurs. The new damper control system represents a straightforward solution to a problem with potentially serious health effects.

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Dr. John M. House, (301) 975-5874, john.house@nist.gov

3

Loss Reduction

3.1 New Class of Fire Retardants

As materials evolve to a higher degree of functionality and safety, new types of formulations are needed to meet fire safety standards. BFRL scientists Jeffrey W. Gilman and Takashi Kashiwagi, working with Emmanual Giannelis of Cornell University, have been examining novel materials formed by reacting a host organic resin with special fine clay particles. At low clay additions (under 10% by mass) a polymer layered silicate nanocomposite is formed. The team has shown that these materials also offer a new means for achieving a high degree of fire retardancy. Prior NIST research has shown that the rate of heat release during a fire is the principal property controlling fire growth and thus fire loss. Reacting nylon-6 with only 5% of this clay results in a product whose peak rate of heat release is reduced by a factor of 3. The mechanism that results in this significant improvement in fire safety is different from that in simple mixtures and is leading to approaches for other resins. The results have attracted international attention and a consortium of U.S. polymer and polymer product manufacturers is being formed to accelerate this technology.

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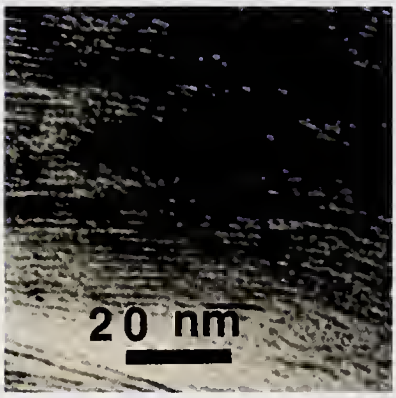
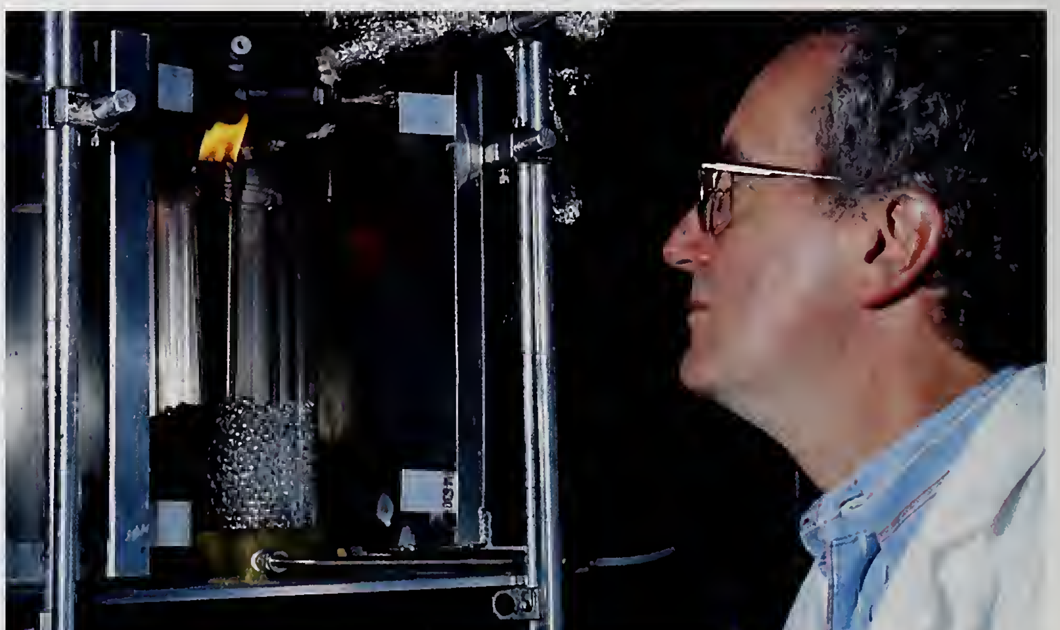


Transmission electron micrograph of char from combustion of nylon-6 silicate nanocomposite

3.2 Suppression of Electrical Fires

A fire in a telecommunications facility can have such a severe impact on service that it is important to effect fire suppression while keeping the equipment functioning. For years, halon 1301 (CF_3Br) has been the chemical agent used to accomplish this. However, this chemical is a significant depleter of stratospheric ozone, with international restrictions on its production and use. Working with the 3M Company, William Grosshandler and Emil Braun are determining the fire suppressant criteria for controlling fires in energized electrical equipment. Current standards presume that the needed concentration of fire suppressant will be the same as for non-electrical fires. Tests by 3M had shown that as much as twice the agent may be needed. BFRL staff have now conducted a series of tests to measure analogous ratios for suppressing and preventing re-ignition of the radiation-enhanced burning of a rod of solid fuel. The required concentrations of two inert gases and four halocarbon agents were



Dr. William Grosshandler, Leader, Fire Sensing and Extinguishment Group, is developing a new test method in cooperation with 3M to quantify the impact of the radiant flux from an electrical heater (seen as the truncated cone) on the minimum concentration of a gaseous agent necessary to extinguish a burning plastic specimen.

Pre-fire detection systems for range-top cooking are feasible without undue disruption of attended cooking

measured as the radiant flux on the sample was increased up to 40 kW/m^2. Test showed that increasing surface temperatures lead to a need for an increased amount of agent to avoid ignition of premixed gasified fuel and air and that even modest radiant fluxes can double the amount of agent required to control a burning plastic.

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3.3 Combustion Mechanisms of Silicone Fires

Polydimethylsiloxanes, or silicones, burn differently and less vigorously than ordinary hydrocarbons. For over three years, BFRL researchers, led by Takashi Kashiwagi, have worked with Robert Buch of Dow Corning to unravel the basis for this behavior. The knowledge could lead to a new generation of fire-resistant products. Perhaps the most important aspect of this burning is the process by which the liquid polymer produces combustible vapor. The team has simulated the exposures to fires of different sizes by exposing samples of the silicone fluids to radiant fluxes of 20 kW/m^2 to 70 kW/m^2. The fluids, siloxane polymers of different chain length, had viscosities from 0.65 cS to 60,000 cS. The measurements included mass loss rates, fluid temperatures, trapped volatile products and fluid residues, all measured throughout the gasificationprocess. A detailed energy balance was conducted to determine the global heat of vaporization including absorption of incident (flame) radiation by the volatile products, reradiation losses from the heated fluids and heat losses to the substrate. The gasification of the siloxanes was found to occur via two modes: (1) volatilization of molecular species native to the polymer and

Foam-like residue of silicone with 1% silica after 50kW/m^2 exposure in a nitrogen atmosphere

(2) volatilization of cyclic molecules that result from thermally induced degradation of the polymer via siloxane bond rearrangement. The former process dominates for low molecular weight siloxanes (<10 cS) and the latter for high molecular weight compounds (> 1,000 cS).

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3.4 Cooking the Food but not the House

A significant portion of residential fires begin at the kitchen stove, most often arising from unattended cooking and being oil or grease-fed. Ideally, many of these fires could be avoided if the stovetop "knew" a fire was pending and turned itself off. It is recognized that there are indicators of impending ignition for several foods being cooked on range surfaces: elevated temperatures and emission of smoke particulates and hydrocarbon gases. However, their reliability in sensing all fires and their discrimination against non-fires has not been determined. Rik Johnsson, working under the sponsorship of the Consumer Product Safety Commission (CPSC), investigated the feasibility of a pre-ignition detection device sensing one or more of these environment characteristics. He conducted experiments using typical ranges and food types, making a variety of measurements: smoke particulates, carbon monoxide, carbon dioxide and total organic vapors, as well as temperatures near the food and in the vicinity of the range and range hood. While no single sensor performed faultlessly in recognizing all the pending fires without false alarming, logically combined signals with simple pairs of sensors were effective. Thus, pre-fire detection systems for range-top cooking are feasible without undue disruption of attended cooking. The CPSC will include this key finding in their overall evaluation of approaches to ameliorating this fire problem.

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Range-top fire test

3.5 Fire in Space

Gregory Linteris, NIST's first astronaut, has completed two flights as a payload specialist on the Space Shuttle Columbia. STS-83 was the first Microgravity Science Laboratory mission. Launched in April 1997, its goal was to focus on materials and combustion research in microgravity. The mission was curtailed after only a few days due to mechanical problems with the spacecraft. However, on July 1, 1997, Dr. Linteris and the rest of the STS-83 crew were launched into space as part of mission STS-94 to complete the experimentation considered vital by NASA management.

The results exceeded everyone's expectations, providing fundamental new knowledge in the scientific fields of combustion, biotechnology and materials processing. More than 200 fires, or combustion experiment runs were conducted on MSL-1. A study of the phenomena of soot resulted in discovery of a new mechanism of flame extinction caused by radiation of soot. Scientists found that the flames emit soot sooner than expected. These findings have direct impact on the theories predicting the formation of soot, a major factor as a pollutant and in the spread of unwanted fires.

A second combustion study on spherical flame structures or flameballs, resulted in the weakest flames ever burned either in space or on Earth and the longest ever ignited in space. This provides new information for models of weak combustion processes needed to develop cleaner, more fuel-efficient internal combustion engines. In a third combustion study, individual and paired droplets of fuel were ignited and information collected on the burn rates, flame shape and radiation emitted. The resulting information will improve theoretical models of combustion of atomized fuels, such as experienced in engines and spray fires.

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Dr. Gregory Linteris, mechanical engineer and NASA payload specialist is performing materials and combustion science research in the orbiting STS-94 Microgravity Space Science Laboratory

Damaged port facilities in Kobe, Japan caused by liquifaction

3.6 Methods for Predicting Liquefaction Potential

Liquefaction of loosely deposited granular soils is a major cause of damage in earthquakes. With the technical input of experts from the private and public sectors who participated in a January 1996 workshop sponsored by the National Center for Earthquake Engineering Research (NCEER) and in collaboration with the University of Texas at Austin, BFRL has made significant improvements to the methods for predicting liquefaction potential using shear wave velocity. The improvements, which are summarized in a report of the workshop, are based on field performance data from 20 different earthquakes and in-situ measurements of shear wave velocity at 50 sites. One advantage of using shear wave velocity is measurements are possible in soils that are hard to sample, such as gravely soils and at sites where borings may not be permitted, such as capped landfills. To further improve the accuracy of the methods and establish guidelines for their use, additional case histories will be compiled and a probabilistic analysis will be performed on the expanded database in fiscal year 1998.

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3.7 Welded Steel Moment Frame (WSMF) Buildings Studies

Many welded steel buildings have been built in recent years to take advantage of the ductility of steel when subject to earthquake ground shaking. However, post-earthquake investigations following the 1994 Northridge earthquake revealed many unsuspected failures of welded joints in over 100 welded steel moment frames (WMSF) buildings. Similar damage was also observed in the 1995 Kobe earthquake. BFRL has been carrying out a multi-year comprehensive research program for the development of methods for repair and retrofit of steel frame buildings. In this effort, BFRL is closely coordinating with the SAC (SEAOC, ATC and CUREe) program.

Experimental investigation of welded haunched retrofit

Working with practicing engineers and university researchers in the past three years, BFRL carried out both analytical and experimental studies. The program has produced the following early products: the proceedings of a workshop on the seismic performance of steel frame buildings during the Northridge earthquake; the results of a detailed survey of WSMF buildings damaged in the Northridge earthquake; a report on the analysis and characterization of actual failed section of beam-column connections from buildings damaged in the Northridge earthquake; the results of derailed investigation and analysis of two steel frame buildings which suffered extensive damage in the same earthquake; a report on the development of computer models for analyzing WSMF buildings; and the test results of large-scale testing of retrofitted steel moment confections.

Findings from these experimental studies, combined with results from the SAC program, are being used in the development of guidelines for the modifications of existing WSMF buildings to improve their seismic performance. This effort is being carried out jointly with the American Institute of Steel Construction.

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Damaged Interior of the Albertsons store in Williamson County, Central Texas after being hit by the F-3 Cedar Park Tornado

3.8 BFRL Survey of Damage Due to the May 27, 1997, Central Texas Tornadoes

On May 27, 1997, a system of severe thunderstorms developed in the afternoon hours over Central Texas and moved southwesterly across this region. A series of tornadoes were spawned from this system and caused a significant number of deaths (28) and extensive damage to properties in four Central Texas counties (more than 280 homes and commercial buildings destroyed). The most deadly tornado, which was designated as an F-5 on the Fujita scale following the early damage survey, was the one that struck Jarrell, located between Waco and Austin, Texas.

Under the coordination of the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM), members of BFRL and the National Weather Service (NWS) jointly conducted ground and aerial surveys to document the tornadoes' ground tracks, including estimates of their lengths and widths and the associated structural damage. Like many tornadoes in the past, the intensities of the Central Texas tornadoes were estimated and reported by comparing the physical damage to structures and objects in the affected region with the descriptive damage outlined by the F-scale. Since the F-scale also provides a range of wind speed for each intensity scale, inaccurate assignment of an F-scale could result in over- or underestimation of the tornado rotational wind speed. This in turn, could have a significant impact in the design profession. The observed structural damage documented by the NIST-NWS damage survey team provided a unique opportunity for comparing probable wind speed with that associated with the F-scale.

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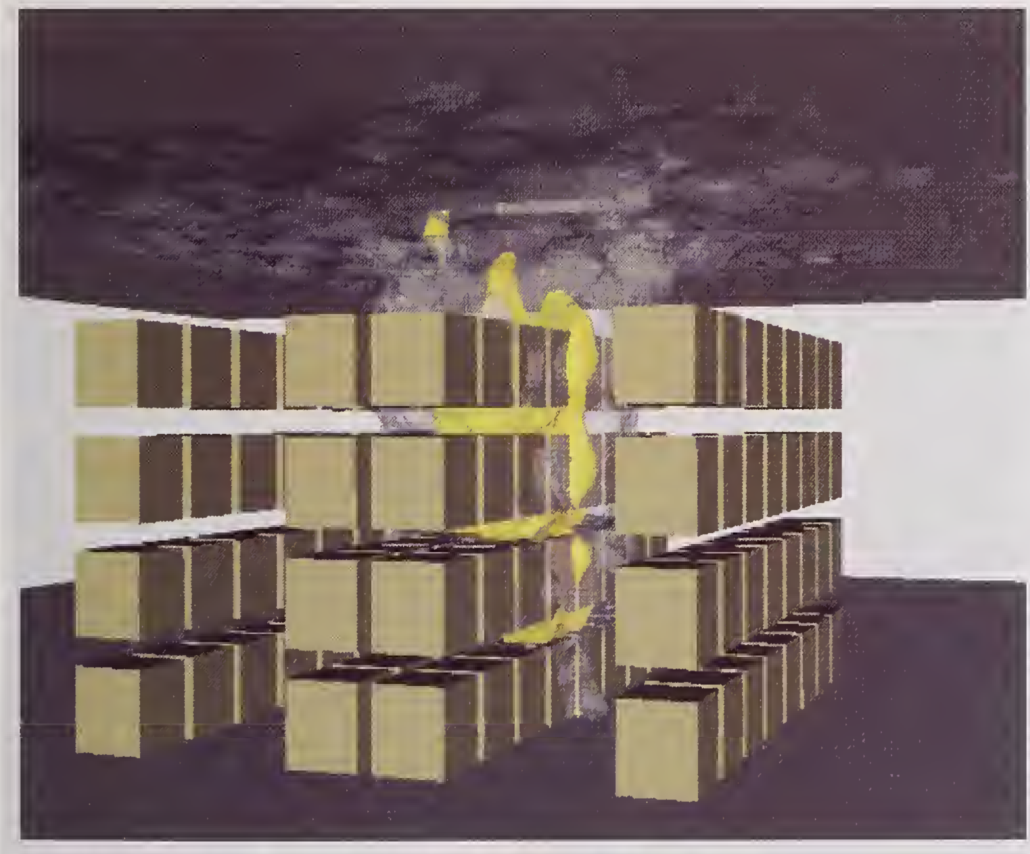
3.9 BFRL Industrial Fire Simulation (IFS) Computer Model Used to Plan Large Scale Fire Tests

The National Fire Protection Research Foundation assembled eight interested industrial partners to support the evaluation of the BFRL Industrial Fire Simulation (IFS) model. The problem being investigated was the interaction of sprinkler, draft curtains and heat and smoke vents in industrial storage facility fires. Data from the tests, which included five full scale high piled commodity and 32 controlled heat release rate gas fire tests, provided additional data to complement previous testing and evaluation data for the model. Each of the tests was planned with the benefit of insight from model calculations so that maximum benefit could be gained from the limited testing budget available for these studies. The model was improved based on findings from the tests. It was successful in predicting actuation times of multiple sprinklers produced by the controlled gas fires. The model was less successful in predicting the details of the commodity tests that were unfortunately not wholly repeatable in themselves. The data and model results from this study should help to determine the conditions under which vents and draft curtains are beneficial and under what conditions they are detrimental to the performance of fire sprinkler systems. To assist industry in this effort, Kevin McGrattan has provided simulations of the full scale high piled storage fires used to evaluate the performance of the fire protection systems installed in the Underwriters Laboratories test facility in Northbrook, Illinois. The high resolution IFS model utilizes large eddy simulation technology to provide prediction of fire driven gas flows in the facility. Supporting sub-models, developed by Glenn Forney for sprinkler sprays, Anthony Hamins for burning boxes and industry standard models for thermal response of sprinklers and vents are integrated with the gas phase calculations to produce a full test simulation. Results can be studied as graphical presentations of selected quantities or as full motion video simulations of the tests constructed from the predictions.



Computer simulation of industrial storage facility fire.

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3.10 Fire Hazard Analysis for Trains

In real world situations, these high performance materials help slow the spread of fire, allowing more time for passengers to safely leave a burning train car.

When a fire starts in an enclosed space, like a passenger train compartment, time for evacuation is of the essence. Everything about the design of the compartment – from the materials used for curtains, seats and carpets to the number of exits and the width of aisles – determines whether passengers will have enough time to exit a train car safely. As part of a three-year study of passenger train fire safety requirements for the Federal Railroad Administration (under the direction of the Volpe National Transportation Systems Center), Richard Peacock conducted full-scale tests in the BFRL large-scale fire research facility. Using bags of trash collected from in service trains, NIST researchers measured heat release rates to better understand the behavior of realistic fires. Peacock and his colleagues used these measurements with computer models to simulate how fires might spread in actual trains. Because these simulations take materials interactions and the size and arrangement of railway cars into account, they can often produce more realistic predictions of fire spread than materials testing alone. Even when exposed to very intense, direct flames, the train seats in the test charred rather than igniting and feeding the fire. In real world situations, these high performance materials help slow the spread of fire, allowing more time for passengers to safely leave a burning train car.

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Fire protection engineer David Stroup explores the use of an infrared camera to determine details of fire spread and burning of the trash fire set near train seats

Fire test on oil spill containment boom

3.11 Development of a Method for the Evaluation of Fire-Resistant Oil Spill Containment Boom

Intentional burning is emerging as one of the accepted methods of mitigating oil spills at sea, particularly in remote areas. Intentional burning requires that a portion of the oil spill be corralled in a fire-resistant oil spill containment boom to control the burn. Presently there is no standard method for evaluating the performance of fire-resistant oil spill containment booms when subjected to both fire and waves. Under sponsorship of the U.S. Coast Guard and the Minerals Management Service of the U.S. Department of Interior, researchers, led by William Walton, in the Fire Safety Engineering Division have designed a wave tank capable of evaluating a 15 m section of boom by subjecting it to a 5 m diameter fire with 0.3 m high waves. The unique wave tank was constructed at the U.S. Coast Guard Fire and Safety Test Detachment in Alabama. Walton's team has developed a draft test protocol based on guidelines from the ASTM (American Society for Testing and Materials) committee responsible for oil spills. The team evaluated the protocol using five typical fire-resistant oil spill containment booms selected by the sponsors. The evaluation was a success; however, a few areas in need of refinement were identified. Although pass-fail criteria have not been finalized, the fire-resistant boom manufacturers were able to gain insight into the performance of their products under realistic conditions. The results of the evaluation will be presented to the ASTM committee responsible for oil spills.

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Presently there is no standard method for evaluating the performance of fire-resistant oil spill containment booms when subjected to both fire and waves

3.12 Protecting Fire Fighters

Over the past 20 years the protective clothing worn by firefighters has improved dramatically, giving the individual firefighter greater protection from fire, heat and moisture. Yet firefighters continue to suffer burns at a stubbornly constant rate. With support from the U.S. Fire Administration, BFRL's Fire Safety Engineering Division is examining the thermal environment of firefighters' protective clothing under stage and attack conditions of structural firefighting. The causes of these burn injuries are being elucidated by an improved understanding of the relationships among three factors. The critical factors are: the thermal environments surrounding firefighters when the injuries occur, the performance of the protective clothing itself and the activities and tactics of the firefighters that may contribute to the burn injuries. James Randall Lawson is leading the research effort aimed at developing the measurement tools and techniques needed to determine the performance of firefighters' protective clothing. Initially, Lawson examined the broad range of fire conditions and events that lead to burn injuries. Much fire research has focused on structural fires related to the design of buildings, their materials and contents, whereas little research has examined the thermal environment around firefighters while they are attacking a structural fire.

Fire Fighter turnout gear damaged during a fire that resulted in burn injuries

Firefighters avoid contact with the flaming envelope – that area bounded by the flame's edge. Many firefighter burn injuries are not caused by flame contact, but by factors such as contact with hot surfaces, excessive exposure to high thermal radiation and/or insufficient protection provided by protective clothing. In one scenario, a firefighter was burned even though the firefighter's protective clothing was wet on the inside from perspiration and on the outside from the splattering of the fire hose. Lawson has developed detailed recommendations for improving protective clothing including reducing and controlling the moisture inside the clothing. The report is specific about the need to inform and train firefighters about the performance limits of their clothing and strongly urges that firefighter training and tactics avoid placing the firefighter in an environment where the limit of the protective clothing is challenged.

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3.13 Foams Used to Halt Wildland/Urban Fires

The 1991 Oakland Hills fire destroyed 2,889 homes in a wildland/urban conflagration with devastating consequences. Unprotected homes were consumed by the fire, but some homes that were in the path of the fire were saved because fire fighters or homeowners continually sprayed water on them while the building was threatened. However, this action required that the individuals protecting the structure stay with the home during a very dangerous situation. Researchers, led by Daniel Madrzykowski in the Fire Safety Engineering Division, are testing the use of water-based, compressed air foams to cover the exteriors of buildings. Called "durable agents," these protein-based foams and water thickeners (known as gelling agents) could be applied to building exteriors, especially in areas where fires tend to begin, such as in corners or under eaves. The research team conducted an investigation to test the capability of these durable agents to protect a building's exterior materials from ignition. Two-1.2m by 2.4m walls were built in a laboratory to form a corner with an attic assembly positioned over the walls in typical residential construction. Experiments were conducted with durable agents sprayed on the exterior surfaces and without the agents. Results were favorable, demonstrating that the application of durable agents reduced the chance of ignition and flame spread under laboratory conditions. Yet much work remains, especially in keeping the agent on the exterior surface under hot, dry and windy conditions.

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Results were favorable, demonstrating that the application of durable agents reduced the chance of ignition and flame spread under laboratory conditions

Fire fighters from the York Beach Fire Dept., Maine protecting a building exposed to an adjacent building fire

1997 NIST Bronze Medal

Ms. Geraldine S. Cheok was awarded the NIST bronze medal for pioneering experimental research which resulted in the development of hybrid-moment-resisting precast concrete beam column connections.

The Bronze Medal Award recognizes work that has resulted in more effective and efficient management systems and the demonstration of unusual initiative or creative ability in developing and improving methods and procedures and/or for significant contributions affecting major programs, scientific accomplishment within NIST, and superior performance of assigned tasks for at least five consecutive years.

1997 Distinguished Young Engineer Award

Dr. Gregory T. Linteris was selected by the Maryland Science Center as one of four to receive the 1997 Distinguished Young Engineer Award. A member of the NIST staff since 1992, Dr. Linteris was cited for his research on advanced fire suppressants and flame inhibition mechanisms. His work, as part of an international community of scientists and engineers, is concerned with finding alternatives to the ozone-depleting chemical halon 1301, upon which the modern world has depended for ensuring fire protection in industry, transportation, communications and defense systems.

Fire Protection Person of the Year – Automatic Fire Alarm Association

Mr. Richard Bukowski was presented with the Automatic Fire Alarm Association Fire Protection Person of the Year Award. This award is presented annually to the person who, in the opinion of AFAA's Board of Directors, has made a significant contribution to the Association's goal of advancing life safety in America. Mr. Bukowski received the award "In recognition of your countless hours of research in the fire detection field; efforts throughout your career to make the world safer through the use of smoke detection and fire alarm systems; dedication to finding the best way to apply detection principles for life safety in buildings; and work through the codes and standards process to ensure the proper use of detection and alarm systems."

1997 ACI Structural Research Award

Dr. William C. Stone and Ms. Geraldine S. Cheok are recipients of the ACI Structural Research Award in 1997 for their paper (Performance of Hybrid Moment-Resisting Precast Beam-Column Concrete Connections Subjected to Cyclic Loading) describing tests on and developing guidelines for precast moment frames using mild steel and post-tensioned tendons to develop the connections.

Federal Laboratory's Consortium Technology Transfer Award

Dr. Hunter Fanney and Mr. Brian Dougherty, received the Federal Laboratory's Consortium Award for excellence in technology transfer. This award recognized Federal laboratory employees who have accomplished outstanding work in the process of transferring laboratory developed technology. Fanney and Dougherty received the award for their patented research work related to solar photovoltaic hot water systems. The award was presented at the Federal Laboratory Consortium's National Technology Transfer Meeting in April 1997.

NIST Measurement Service Award

Mr. Robert Zarr received NIST's Measurement Service Award for Standard Reference Material (SRM) 1453 on thermal resistance expanded polystyrene board. The 1992 Energy Policy Act requires that all windows be labeled to give consumers the ability to compare products. SRM 1453, having known thermal transmission properties, will be used to calibrate the window testing apparatuses.

NIST Equal Employment Opportunity Award

Dr. Sivaraj Shyam Sunder was awarded the NIST Equal Employment Opportunity Award for leading a comprehensive review of NIST's diversity policy and activities which resulted in significant revision and strengthening of the NIST diversity program.

The Equal Employment Opportunity Award recognizes significant contributions to EEO that was performed in an exceedingly outstanding manner by an NIST employee.

NIST Safety Award

Mr. Gary L. Roadarmel and Mr. Laurean A. DeLauter were awarded the NIST Safety Award for conducting more than 500 large-scale fire experiments over the past three years efficiently and without injury.

The Safety Award for Superior Accomplishment recognizes unusually significant contributions on the NIST Occupational Safety and Health program activities.

ASME Best Paper Award

Dr. Hunter Fanney, Mr. Brian P. Dougherty and Mr. Kenneth P. Kramp received an ASME best paper award for their paper, "Field Performance of Photovoltaic Solar Water Heating Systems", which was presented by Fanney at the Solar Energy Forum in Washington, D.C. Fanney and Dougherty are researchers within the Building Environment Division. Kramp, currently a graduate student at Virginia Tech, assisted in the research during his tenure as an undergraduate cooperative education student. The Solar Energy Forum, attended by over 1,100 people, was sponsored by the American Society of Mechanical Engineers, the American Solar Energy Society, the American Institute of Architects, the Solar Energy Industries Association and the U.S. Department of Energy.

Outstanding Presentation Award

Ms. Joannie Chin received the Outstanding Presentation Award from ASTM Committee D30 on Composite Materials for her paper "Effects of Environmental Exposure on FRP Materials used in Construction." The paper was published in the *Journal of Composites Technology and Research,* Vol. 19, No. 4, pp 205-213, October 1997.

Best Publication Award for 1997 — Federation of Societies for Coatings Technology

Dr. Tinh Nguyen received the Best Publication Award for 1997 from the Coatings Committee of the Federation of Societies for Coatings Technology in recognition of the best corrosion-related article published in *Journal of Coatings Technology,* "Unified Model for the Degradation of Organic Coatings on Steel in a Neutral Electrolyte" Vol. 68, No. 855, pp 45-56.

Award of Excellence – International Appliance Technical Conference

Dr. Natascha Castro received one of three awards of excellence for a technical paper at the International Appliance Technical Conference held May 12-14, 1997 in Columbus, Ohio. Her paper, entitled "Energy and Water Consumption Testing of a Conventional Dishwasher and an Adaptive Control Dishwasher", showed that because the current DOE Test Procedure for dishwashers does not effectively test equipment under real world conditions involving soiled dishes, it significantly overestimates the energy performance of adaptive control dishwashers. Using the existing test procedure, the water heating energy, which represents approximately 80% of the total energy consumed by a dishwasher, was found to be 35% less for an adaptive dishwasher when compared with a conventional model. However, in tests conducted with a soiled load, the water energy for the adaptive control dishwasher was slightly higher than the conventional model. This points out the need for revisions in the DOE dishwasher test procedure to obtain energy factors that consumers can rely on for making purchase decisions.

1996 Harry C. Bigglestone Award for Excellence in Communication of Fire Protection Concepts

Working under a grant from the NIST Fire Research Program, Drs. James Milke and Thomas McAvoy of the University of Maryland were recognized for their paper "Analysis of Signature Patterns for Discriminating Fire Detection with Multiple Sensors," which appeared in the NFPA journal, *Fire Technology.* They developed a

prototype of an intelligent method for effectively detecting various smoldering and flaming fires in the presence of interfering sources common to residential-type settings. When perfected, such a system would go
a long way toward eliminating the false alarm problems which can plague the current generation of fire and smoke detectors.

Patent for Heat Pump Performance Enhancing Device

The Building Environment Division has received a patent on a device to improve the cold weather performance of residential and light commercial air-source heat pumps. The device was invented by Mr. Peter Rothfleisch of the Thermal Machinery Group. Fundamentally, heat pumps utilize electrical power to extract heat contained in the outside air to heat the dwelling. However, the rate at which the heat pump is able to bring this heat energy into the house is directly proportional to the outside temperature. Consequently, on a cold day, heat pumps are unable to pump enough heat to match the heat loss of the dwelling. For this reason, heat pumps are equipped with auxiliary electric resistance heaters, which are turned on automatically when needed. This resistance heating is expensive for the homeowner and often causes a peak demand problem for the utility. The patented device is a distillation column that when utilized with a zeotropic refrigerant mixture is capable of changing the refrigerant mixture composition. By controlling the mixture composition, the heat pump capacity can be modulated in response to changes in the outdoor temperature. Thus, the distillation column enables the heat pump to maintain acceptable performance over a much wider temperature range and reduces the need for resistance heating. An additional benefit of the device is that the necessary zeotropic refrigerant mixture can be formulated from environmentally acceptable components.

ASME Fellow

Dr. William L. Grosshandler was named a Fellow of ASME International, formerly the American Society of Mechanical Engineers. The election to Fellowship recognizes the person's outstanding contribution to the technical community, as well as the support of organizations such as NIST to the profession. Dr. Grosshandler developed a research team and leads a world-class effort in the advanced technologies needed to identify new fire suppressants, obtain accurate flammability data for new refrigerants and help the U.S. fire detection industry succeed in global competitiveness.

Department of Defense Program Manager

Dr. Richard G. Gann has been named the first Technical Program Manager of the Department of Defense's Next-Generation Fire Suppression Technology Program (NGP). Supported by the Office of the Secretary of Defense, the 8-year, $46 million program has as its goal to develop and demonstrate, by 2004, halon 1301 alternative technologies that are easily retrofittable into current aircraft, ships and land combat vehicles. The new technologies will be applicable to a broad range of critical civilian applications as well. In addition to his position as Chief of the BFRL Fire Science Division, Gann will oversee projects conducted at university, industry and government laboratories.

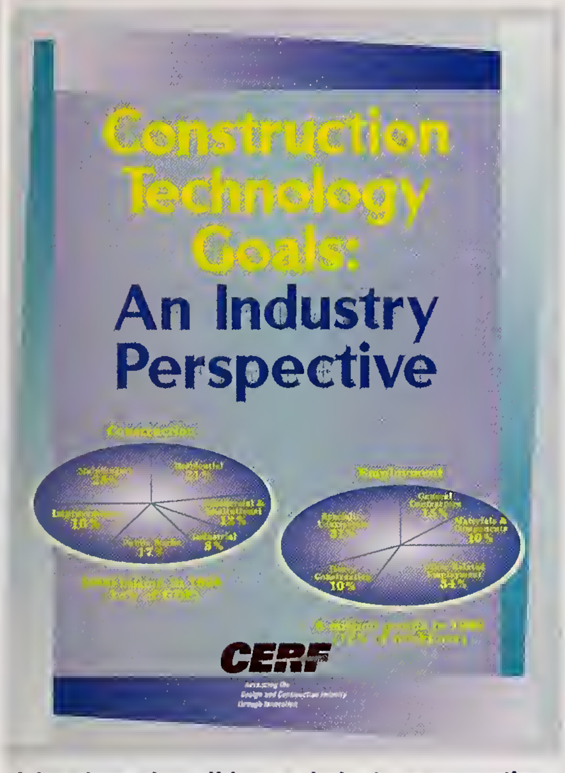
Keynote Speaker at National Conference on Wind Engineering

Dr. Emil Simiu of the Structures Division was a keynote speaker at the 8th U.S. National Conference on Wind Engineering, Baltimore, MD, June 5-8, 1997. His talk "Toward a New Generation of Standard Provisions for Wind Loads" described innovative NIST activities conducted in collaboration with industry to improve significantly the risk-consistency and economy of structural design for wind.

Chair of NFPA's Committee on Alternative Approaches to Life Safety

Mr. David Stroup, of the Fire Safety Engineering Division has been selected to chair the National Fire Protection Association's Technical Committee on Alternative Approaches to Life Safety. This committee is responsible for developing NFPA 101A, Guide on Alternative Approaches to Life Safety. This guide consists of a number of different methodologies for evaluating life safety in buildings, each independent system is meant to be used in conjunction with NFPA 101, Code for Safety to Life in Buildings and Structures. Many of the systems described in the guide are derived from the Fire Safety Evaluation System developed at NIST in the late 1970's. The role of this committee is expected to grow as fire and building regulations in the United States shift from being compliance oriented to performance based.

NSTC Subcommittee on Construction and Building



A brochure describing an industry perspective on the National Construction Goals

The activities of the National Science and Technology Council (NSTC) Subcommittee on Construction and Building (C&B) have profound effects on the BFRL program. BFRL co-chairs and maintains the secretariat of C&B. NSTC, a cabinet-level group charged with setting federal technology policy, coordinates R&D strategies across a broad cross-section of public and private interests. C&B defines priorities for federal research, development and deployment related to the industries that produce, operate and maintain constructed facilities, including buildings and infrastructure. These priorities and related collaborations with industry and government guide the focus of the Laboratory's programs. The 14 Federal agencies that participate in C&B include those with responsibilities as owners and operators, regulators and researchers.

The Mission of C&B

To enhance the competitiveness of U.S. industry, public and worker safety and environmental quality through research and development, in cooperation with U.S. industry, labor and academia, for improvement of the life cycle performance and economy of constructed facilities. C&B addresses Administration goals to:

- forge partnerships with industry to strengthen America's industrial competitiveness and create jobs.
- make environmental protection, safety and energy efficiency fully consistent with other business objectives.

The C&B program Goals

To be accomplished by 2003, based on 1994 business practices and endorsed by industry leaders are:

- 50% reduction in delivery time
- 50% reduction in operation, maintenance and energy costs
- 30% increase in productivity and comfort
- 50% fewer occupant related illnesses and injuries
- 50% less waste and pollution
- 50% more durability and flexibility
- 50% reduction in construction work illnesses and injuries

Industry Strategies

A brochure, "Construction Industry Goals: An Industry Perspective", published in 1997 for C&B by the Civil Engineering Research Foundation (CERF), describes the industry perspective on the goals and summarizes the differing sector strategies for implementation offered by the National Association of Homebuilders Research Center (residential), the Construction Industry Institute (industrial), National Institute of Building Sciences (commercial/institutional) and the American Public Works Association (public works). This input is used to plan a BFRL research program that responds to industry needs.

C&B Activities in 1997

Creation and Development of the Partnership for Advancing Technology in Housing (PATH)

These superinsulated duplexes look normal but they use only half the space heating energy of conventional houses, saving their owners about $200 each year

The Partnership for Advancing Technologies in Housing is being designed to bring together government and industry to develop, demonstrate and deploy housing technologies, designs and practices that can significantly improve the quality of housing without raising the cost of construction. The partnership, which will be made up of industry leaders who are willing to commit time and resources of their companies to help achieve the goals, has started with a core group of industry leaders to establish goals and define commitments from industry. The partnership will be housed in the Department of Housing and Urban Development (HUD). C&B will coordinate federal agency support for the organization and development of the partnership by holding meetings and identifying Federal experts and agency capabilities that can be used in the development of PATH goals and plans. The PATH program will include pilot developments at sites around the country where homes that meet the goals will be constructed and sold. C&B will also coordinate federal R&D effort in support of PATH goals and industry priorities and identify technologies that can be used in PATH pilot homes. C&B will play a key part in the development of a public outreach and publicity program for PATH.

Working with Industries of Construction

In 1997 the Subcommittee on Transportation Infrastructure was integrated with C&B. C&B is now exploring the possibility of a broader program on civil infrastructure involving more than transportation. Two elements are likely to be part of this broader program; the Partnership for the Advancement of Infrastructure and its Renewal (PAIR), a partnership between government and industry, proposed by the Civil Engineering Research Foundation; and the Institute for Civil Infrastructure Systems (ICIS), a forum for addressing infrastructure issues planned by the National Science Foundation.

The CONMAT Council was formally established to implement the high-performance CONstruction MATerials and systems program designed to create a new generation of constructed facilities. The Council consists of 12 different material groups (aluminum, coatings, concrete, fiber-reinforced composites, geo-synthetics, masonry, plastics, roofing materials, smart materials, stainless materials, steel and wood) as well as liaison members from public and private agencies, with CERF acting as secretariat. These groups have joined forces in a $250 million effort to plan and implement a national program of research development and deployment. CONMAT provides an excellent mechanism to align federal R&D with industry programs for advanced construction materials and systems. The use of high performance materials is a key factor in achieving many of the National Construction Goals.

C&B is working with the American Society of Mechanical Engineers to develop a joint government/industry program for mechanical and electrical systems industries similar to CONMAT. It is expected that this program would involve organizations representing heating and air-conditioning systems, security systems, fire alarm systems, electrical systems and elevators and escalators.

C&B is supporting a National Academy of Sciences study to document the relationships between the workplace environment and worker productivity.

C&B held a joint workshop with members of the Construction Industry Institute to identify for the private sector ongoing and planned research that is being conducted in Federal laboratories and for the Federal laboratories identify the needs of the private sector. C&B will continue to define a program of breakthrough research and stimulate Federal agencies to include elements of the program in their plans.

Streamlining Regulation

Industry identified one of the barriers to reducing delivery time as the process of complying with a multiplicity of Federal, state and local regulations, some of which are in conflict. C&B is supporting the National Conference of States on Building Codes and Standards in a project to assemble, from participating organizations and Federal, state and local governments, processes, procedures and enabling legislation "that work". These model processes, procedures and legislation are being tailored to accommodate different types of state/local authority and submitted to relevant national public and private sector organizations for endorsement and promotion for use by relevant Federal, state and local authorities. This project is part of the U.S. Innovation Partnership focus on regulatory innovation.

A number of C&B member agencies sponsored the formation of the National Evaluation Service Building Innovation Center (NES/BIC) which will provide an enhanced evaluation service for new and innovative products. Panels of experts in certain areas will develop the criteria for evaluation and data submitted by manufacturers will be reviewed for suitability and conformance to the criteria.

Coordinating Federal R&D

To explore opportunities for collaboration and avoid any duplication, C&B member agencies present their programs at C&B meetings. To reflect this coordination, a C&B web site was developed in fiscal year 1997 and will be updated on a regular basis.

A project to identify data that can provide baseline measures of current practice with respect to the National Construction Goals has been started by BFRL's Office of Applied Economics. The effort will provide baseline measures for construction technology goals.

Representatives from NIST (Building Materials Division and Polymers Division), Department of Energy (DOE), Army Research Laboratory (ARL), National Science Foundation (NSF), Federal Highway Administration (FHWA) and Navy (NAVSEA and NSWC) have formed the Federal Working Group on Composite Materials. The primary mission of this group is to provide a forum for communication, networking, sharing of technical information and interagency collaboration.

Outreach

The Laboratory has made a concerted effort to improve communication with the building and fire communities through printed and electronic media. To provide detailed information on our technical programs and products, three special publications have been released, *Project Summaries, Publications and Impacts.* These documents have been produced annually, so BFRL also publishes a full color quarterly newsletter *Research Update,* which is mailed to about 5000 recipients.

For more than three years BFRL has had a site on the World Wide Web and is redesigning its organization to include more news items such as those appearing in *Research Update* and provide easier access to items of interest to users. In addition to the Web site BFRL maintains an intranet on its local area network for use by BFRL staff only. This intranet improves communications within the laboratory and makes more information easily available to staff in an electronic format.

Collaboration with Industry

The Building and Fire Research Laboratory's "strategy for success" is to build on the ties that have been developed to identify research needs and to focus our program on the development of products that will meet those needs. Direct research under Collaborative Research and Development Agreements (CRADA's) with individual companies or consortia is the most direct method of meeting the needs of industry.

Industry Consortia

NIST works with industry consortia in a number of areas including the demonstration of a standard communication protocol for building automation and control systems (BACnet), application protocol for the process plant industries (PlantSTEP), the prediction of the service life of coatings, the development of a methodology for evaluating seams of rubber roofing membranes and advanced environmentally-friendly and fire-safe materials.

NIST has expanded its cooperative research and development agreement to include 22 partners to develop interoperable building control equipment that communicates using the BACnet protocol. The objective of the consortium is to assist the member companies in developing products that conform to the BACnet standard and to develop conformance testing tools and procedures that can be used to establish an industry-run certification program. It will also provide a way to interconnect traditionally stand-alone building control systems such as HVAC, fire, lighting and security. NIST has developed test methods and software testing tools and provided facilities for member companies to bring their prototype products together for testing. The following partners make up the BACnet consortium: Alerton Technologies andover Controls, Automated Logic, Auto-Matrix, Carrier, Cimetrics Technology, Cornell University, Delta Controls, Honeywell, Johnson Controls, KMC Controls, Landis and Stafea, McQuay International, Orion Analysis, Phoenix Controls, PolarSoft, Siebe Environmental Controls, Simplex, Teletrol, Systems, Trane and York.

NIST worked with industry to establish PlantSTEP, Inc., an industry consortium supporting the development of information exchange standards for the process, power and construction industries. PlantSTEP membership (20 companies as of December 1997) includes companies that own, operate, engineer, construct, or supply materials for process plants and over 90% of the vendors of 3D plant design systems. In collaboration with PlantSTEP, NIST developed the Plant Spatial Configuration AP (AP 227) which supports the 3D design and engineering of process plants, with an emphasis on piping design. The PlantSTEP/NIST team completed the Draft International Standard version of AP 227 and ISO circulated AP 227 for ballot in September 1997. Consortium members are: Bechtel, Black & Veatch, Eastman Chemical, E. I. DuPont & Co., H.B. Zachry, Merck & Co., Air Products & Chemicals, Autodesk, Bentley Systems, CADCentre, Computervision, Dassault Systems of America, EA Systems, Hitachi, Intergraph, Jacobus Technology, John Brown Systems, Rebis, Shaw/Sunland and Toshiba.

The NIST-led Consortium on Service Life Prediction of Coatings has completed its third year and plans for a second three-year phase are now being drawn up. Apart from NIST, its members are Atlas Electrical Devices, Courtaulds International, Dow Chemical, DuPont, Duron, Eastman Chemical, National Renewable Energy Laboratory, PPG, Rhom and Hass, South Florida Test Sites and the Federal Highway Administration.

The NIST-led Consortium on Tape-Bonded Seam for EPDM Roofing Membranes has been successful in showing that adhesive tapes perform at least as well as liquid-applied adhesives under the conditions investigated so far. The work will be completed in fiscal year 1998. Apart from NIST, the members are Firestone Rubber Company, Carlisle-Syntec, Ashland Chemical, the National Roofing Contractors Association and the Roofing Consultant Institute.

NIST has joined industry to develop new tools for industry to design and make materials with better fire performance. Fire Safety Division researchers, led by Dr. Takashi Kashiwagi, are developing a theoretical model to describe the thermal behavior of polymer chains in the presence of flame retardant additives, various approaches to designing flame retardant materials and new methodology to measure material flammability and the relationship to fire performance. Industrial partners in the consortium are: P.Q., FMC, Akzo Nobel and Sekisui American.

Cooperative R&D Agreements

In addition to the above agreements signed with consortia, NIST has cooperative research and development agreements (CRADA's) with:

American Association of State Highway and Transportation Officials	Testing of Materials for Construction of Transportation Systems
Dow Chemical Company	Evaluate Thermal Performance of Advanced Insulation Panels
Enermodal Engineering Limited	Two-Dimensional Heat and Moisture Transfer Model
Electric Power Research Institute	The Measurement of Evaporative Heat Transfer Coefficients of Refrigerant Mixtures
Johnson Controls, Inc.	Advanced Controls for VAV Air Handling Systems
Aladdin Industries	Thermal Test Methods for Advanced Insulation Systems
The LORRON Corporation	Development of Fire CAD using the NIST CFAST Computation Engine as a basis and LORRON's CAD-Based Topological Modeling Technology
Simulation Technologies Incorporated	Incident Management System (Fireground)
National Elevator Industry, Inc.	Water Flow in Elevator Hoistways
Dow Corning Corporation	Flame Retardant Mechanism of SI Additives in Polyethylene
Duke Scientific Corporation	Measurement of Monosized Polymer Micro-Spheres less than 125 nm Diameter
General Motors Corporation	Post-Crash Automobile Fire Studies
Structural Composites, Inc.	Fire Performance of Composite Materials
Dow Corning Corporation	Combustion of Silicone

Codes and Standards

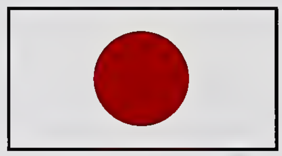
Standards and codes are critical components in the processes of programming, planning, designing, procuring, constructing, equipping, operating, maintaining and recycling the built environment. Standards and codes set the framework effecting the health, safety, functionality, quality and commercial context of the built environment. Through active membership and participation in a number of Standards Development Organizations, BFRL staff contribute significant time and technical expertise to the process of developing national and international standards. Some of the specific organizations within which BFRL works include the American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHREA), American Institute of Steel Construction (AISC), National Fire Protection Association (NPFA), American Society for Testing and Materials (ASTM) and International Organization for Standardization (ISO). In ASTM alone, BFRL is active on Committee C009-Concrete and Concrete Aggregates; Committee D001-Paint and Related Coating Materials; Committee D004-Road and Paving Materials; Committee D008-Roofing, Waterproofing and Bituminous Materials; Committee E05-Fire Standards; and Committee E06-Performance of Buildings. In addition, BFRL is a member of the American National Standards Institute's (ANSI) Construction Standards Board and the International Code Council's (ICC) Industry Advisory Committee. Through its involvement with ANSI, BFRL is supporting the development of a strong U.S. position in regional and international standards activities and through a strengthening relationship with the ICC, BFRL is supportive of the efforts to create a single set of national building codes.

Canada

BFRL and the Institute for Research in Construction (IRC) of the National Research Council of Canada (NRCC) signed an agreement in October 1997 to identify areas for collaborations that will increase each laboratory's productivity and effectiveness, improve the performance and economy of constructed facilities and increase the productivity and competitiveness of the industries of construction. Areas for collaborations include: 1) laboratory, field and analytical research; 2) measurement and test methods; 3) recommendations for national and international standards; 4) conducting workshops with industry, academia and government agencies; 5) laboratory visits and exchanges of staff; 6) exchanges of information and 7) joint planning.

The Building Environment Division and IRC are completing a three-year research project (1995-1997) that developed a computer program for promoting acceptable indoor air quality in the design and operation of buildings. The computer program predicts ventilation performance and contaminant levels in a building before construction and analyzes ventilation and indoor air quality in existing buildings.

Robert Zarr of the Building Environment Division, Eric Lagergren of ITL's Statistical Engineering Division and M. Kumaran of the IRC performed conductivity measurements from an international interlaboratory study for glass-fiber board and fibrous alumina silica. The measurements were determined using guarded hot plate apparatuses at BFRL and the IRC. North America manufacturers of thermal insulation must satisfy the thermal performance requirements promulgated by the U.S. and Canada to market their products in both countries. This interlaboratory study was initiated in 1993 and completed in 1997.



Japan

U.S.-Japan Cooperative Program in Natural Resources

The U.S.-Japan Cooperative Program in Natural Resources (UJNR) was created in January 1964; one of three programs comprising the U.S.-Japan Cooperative Science Program. BFRL co-chairs two of the 19 Panels.

Fire Research and Safety Panel

The Fire Research and Safety Panel explores the chemistry and physics of fires. It encourages, develops and carries out the exchange of information and data in fire and smoke physics, toxicity, chemistry and risk and hazard evaluation; promotes cooperative research in areas of fire safety and combustion toxicity; encourages innovations in the development of risk assessment methods, fire test methods and design standards; establishes multinational consensus of computer-based fire modeling; develops the basis for performance fire codes; and develops new fire protection and prevention technology appropriate to modern products and design. The 13th joint meeting of the panel was held at NIST in March 1996; its 14th meeting will be held in Japan later this year.

U.S.-Japan collaborative research has enabled staff to maximize the strengths of each country's laboratory facilities. The panel has advanced fire science and technology in areas such as fire-smoke toxicity; fire detection; microgravity combustion; thermal degradation of polymers; intumescent polymer burning; wall fire modeling; smoke flow in buildings; building fire modeling; and rate of heat release measurements. Collaborative research has led to a new option for housing; a new method for testing fire smoke toxicity; the formation of an international fire safety science association; and access to unique fire research facilities in both countries. In its 22-year history, the members have exchanged more than 40 guest researches in fire research and safety.

The panel co-chairs are: Dr. Jack Snell, U.S.-side panel, Deputy Director, Building and Fire Research Laboratory and Dr. Tsutoma Shimazaki, Japan-side panel, Director-General, Building Research Institute.

Wind and Seismic Effects Panel

The Wind and Seismic Effects Panel promotes exchanges of technology for the reduction of damages caused by strong winds, earthquakes and storm surge and tsunamis. Through the panel, U.S. and Japanese researchers jointly develop and share seismic and high-wind measurement records and technical data, as well as information on the performance, design and construction of lifelines, buildings and other constructed facilities. The 29th Joint Meeting was held in Japan, May 1997; the 30th meeting will be conducted at NIST, May 1998. Research exchanges have advanced technology development in areas such as the effects of seismic and wind loads on steel, concrete and masonry structures; liquefaction risk analysis; smart materials; and composite and hybrid structures. Joint collaborative research programs have produced improved design and construction practices for both countries. Eight joint programs have been completed; two are on-going. Joint post disaster investigations are performed immediately following the disaster.

Panel activities have improved building and bridge standards and codes and aided structural design and construction and emergency management in Japan and the United States. Panel members created and exchanged digitized earthquake, wind and storm surge records; shared earthquake and wind engineering information and strong-motion measurement techniques with other countries; produced database systems for improved measurement and prediction methods; and verified mathematical models of phenomena such as storm surge and tsunamis, severe weather and performance of constructed facilities. The panel offers key perspectives on developments important to the U.S. and Japanese design and construction community, emergency planning and preparedness managers, public health officials and manufacturers and developers of products for the construction industry. Valuable insight is gained into each country's disaster preparedness methods, wind and seismic measurement techniques, building and public works design and construction projects and standards and code systems.

Since its creation 30 years ago, more than 200 guest researchers have been exchanged and their findings have improved standards and building codes. During its two-week annual meeting, panel researchers visited more than 10 major technical sites such as public works projects to discuss innovative techniques, research laboratories to observe unique tests and discuss measurement capabilities and structures designed with modern technologies that better resists wind and seismic forces. These visits enhance research, design, construction and emergency management procedures used by Japan and the United States. They provide opportunities to observe development and implementation of new technologies that advance U.S. and Japan's research and practice in wind and earthquake science and engineering. Panel research in areas of earthquake and wind science, engineering and emergency management contributes to both countries' research programs. The data produced by this joint effort influence ongoing research, development of new research and improvements in Japanese and U.S. practices and standards.

The panel Co-chairs are Dr. Richard N. Wright, U.S.-side panel, Director, Building and Fire Research Laboratory and Mr. Seizo Tsuji, Japan-side panel, Director-General, Public Works Research Institute.

Common Agenda's Natural Disaster Reduction

The Common Agenda is an agreement between the President of the United States and the Prime Minister of Japan to join policy level officials and technical specialists from the United States and Japan to identify earthquake research and policy issues and seek agreement on cooperative projects to mitigate their impact through improved monitoring and by strengthening research and response countermeasures. BFRL participates in two thrusts of the Natural Disaster Reduction Initiative.

Earthquake Policy Symposium

The second Earthquake Policy Symposium was conducted in September 1997, Kobe Japan. BFRL played a major role in planning the first and second symposium. Two central themes ran through the symposium:

- research is required to address the long term nature of earthquakes as they confront both countries and
- effective disaster information deployment methods are needed to share research findings and disaster-reduction policy information with government and academic laboratories and with the public.

In realizing these themes, the U.S. and Japan members agreed to confront three topics by exchanging:

- real-time seismic information systems for use in disaster-prevention and response policy,
- loss estimation models in emergency prevention, preparedness and response and
- post-earthquake response and recovery policies for prevention of future losses.

Both countries will develop a plan to address these topics within a year. In preparation for this venture, they will seek linkages with appropriate U.S.-Japan programs such as the UJNR Panels (see above) and with appropriate respective agency programs to coordinate and focus related work.

Earthquake Disaster Mitigation Partnership

Also, in September 1997, the U.S.-Japan Earthquake Disaster Mitigation Partnership met in Kobe to review proposed joint cooperative research projects. The priority areas for cooperation include quantifying future earthquake potential; strengthening loss estimation methods; testing basic theories of the earthquake source; understanding near source motions; geological effects and structural response; reducing seismic risks posed by steel buildings; strengthening, evaluating and retrofitting of existing and damaged buildings and infrastructure; developing performance-based design methods; developing real-time seismic information systems; and controlling post earthquake fires.

Forty-three joint research projects were endorsed. NIST is responsible for seven projects that center in BFRL's Structures Division and Fire Safety Engineering Division. Mechanisms for carrying out the Partnership included relying on the UJNR Panels (see above) and on other bilateral linking methods available in the participating agencies; symposia and workshops that address specific topics under the Earthquake Policy Symposium; and other methods identified by the collaborators. The U.S. and Japan sides will convene respective agency meetings throughout the year to initiate work on their respective projects. An annual report on the mission and activities of the partnership will be developed by March 1998. The next full meeting of the U.S.-Japan Partnership will be held with the Earthquake Policy Symposium High Level Forum scheduled in the fall of 1998.

Microgravity Experiments

Takashi Kashiwagi conducted microgravity experiments in the Japan Microgravity Center (JAMIC) drop tower with scientists from NASA and JAMIC. This work was coordinated with the microgravity experiments performed on space shuttle Columbia.

Kingdom of Saudi Arabia

Joel Zingeser leads a joint BFRL and Technology Services program aimed at helping Saudi Arabia develop and adopt a building code based on U.S. practices. This bilateral work will help the U.S. construction industry in major developing markets to avoid technical barriers to trade and to promote the application of U.S. technology in international construction markets through the development and adoption of appropriate building and construction practices, codes, specifications and standards. Work with the Kingdom of Saudi Arabia is being conducted under a Memoranda of Understanding between NIST/BFRL and the National Conference of States on Building Codes and Standards and NIST and the Saudi Arabia Standards Organization (SASO). The SASO team leaders, including representatives of the Royal Commission of Jubail and Yanbu, Aramco and the Ministry of Defense visited the U.S. and participated in an orientation program to better acquaint them with U.S. building code development and enforcement processes. A resource document comparing the Saudi-Aramco building code with recent editions of the Uniform Building Code has been prepared by NIST and is being reviewed by SASO in preparation of a Saudi Building Code workshop, February 1998, Riyadh with U.S. and SASO technical experts.

Korea

In September 1995, an Implementing Agreement was signed between NIST and the Korean Institute of Energy Research of the Republic of Korea. The agreement is for a period of five years and its purpose is to exchange scientific and technological knowledge and to encourage the joint research in the field of energy technology. The first two years of this agreement involved conducting joint research and exchanging of personnel to develop methods for the automated real-time performance optimization, fault detection and diagnosis of thermal systems, especially HVAC processes to improve energy efficiency, increase safety and reliability and reduce operating cost.

Poland

James R. Clifton of the Building Materials Division is NIST's principal investigator of a three-year project on developing performance tests and criteria for polymer concrete as a repair material. The project commenced in 1996 under the sponsorship of the Madame Curie Program. The research has resulted in several presentations given at international conferences which were published in conference proceedings.

Piotr Domanski of the Building Environment Division co-authored a technical paper with K. Maczek, J. Muller and K. Wojtas from the Technical University of Cracow (TUC), Poland. The paper, "A Ternary Zeotropic Mixture with CO^2 Component for R-22 Heat Pump Application" was presented at the CLIMA 2000 conference in Brussels, Belgium, August 30 through September 2, 1997. The reported results were obtained from a joint NIST/TUC research project sponsored by the Maria Sklodowska-Curie Fund administrated by the U.S.-Polish Joint Commission.

Switzerland

The Ecole Polytechnique Federale da Lausanne selected BFRL's Consolidated Model of Fire Growth and Smoke Transport (CFAST) for use in safety design calculations for automobile and train tunnels in Switzerland. CFAST was developed by the Fire Modeling and Applications Group (864). It is a zone type fire model that predicts the environment in a structure subjected to a fire.

Multilateral Activities

The Process Industry Executive for Achieving Business Advantage using Standards of Data Exchange (PIEBASE) is an international umbrella organization for process industry active development of Standard for the Exchange of Product model data (STEP) and other standards for industrial data. Mark Palmer of the BFRL Computer Integrated Construction Group participates in the PIEBASE executive group and leads the PIEBASE Working Group 2 on process plant engineering activity models.

C System Performance: The Practical Application of Fault Detection and Diagnosis Techniques in Real Buildings. Ten countries participate in the Annex. Members of the U.S. team, in addition to NIST, include Johnson Controls Inc., the Honeywell Center, MIT, Purdue University and Field Diagnostic Services, Inc. The objective of Annex 34 is to work with control manufacturers, industrial partners and/or building owners and operators to demonstrate the benefits of on-line performance evaluation in real building applications. The fault detection and diagnostic (FDD) methods developed in Annex 25 are to be combined into robust performance evaluation systems and incorporated into a future generation of smart building control systems.

International Committee Participation

International Council for Building Research and Documentation (CIB)

BFRL is a member of CIB and actively participates in many of its task groups and working commissions. CIB is concerned with fostering international cooperation and information exchange in building construction and research as well as technology development and documentation and as such provides an important channel for international pre-standardization activity in this field. Jack Snell serves on the Board of Directors and the Program and Administrative Committees of CIB. Current CIB priorities include sustainable development, performance based standards, construction process re-engineering, better service to its members in the Americas and Asia and in expanding its role as a pre-standardization body.

Organization for Economic Cooperation and Development (OECD)

Barbara Lippiatt of BFRL's Office of Applied Economics was an invited member of the U.S. Delegation to the OECD conference on Greener Public Purchasing held in Switzerland. Lippiatt presented the Building for Environmental and Economic Sustainability (BEES) methodology at the conference. Lippiatt published the BEES methodology in January 1998 as Windows-based decision-support software for the Federal procurement community for selecting products that achieve the most appropriate balance between life-cycle environmental, economic and technical performance. This work was sponsored in part by the Environmental Protection Agency.

International Organization for Standardization (ISO)

James Gross is a member of ISO's Technical Advisory Group (TAG) 8 on Buildings. TAGs are established by ISO's Technical Management Board to advise the Board on matters of international standardization, developments in building technology and the needs for new work. The TAG 8 membership consists of representatives from seven European countries, Japan and the United States.

Geoffrey Frohnsdorff of the Building Materials Division is the chair of ISO/TC 59/SC 3/WG 9, Design Life of Buildings. This Working Group, created in 1994, is being elevated to subcommittee status in ISO/TC 59. The objective is to develop standards for assuring that the designed life of a building under the anticipated environmental actions will be achieved and to provide a basis for maintenance management. The committee is producing a standard on "Planning of and Management for, Service Life of Buildings." As of October 1997 there are fourteen countries participating in the committee.

Technical committee (TC)86, Refrigeration and Air-conditioning, of the International Organization for Standardization (ISO) is composed of eight subcommittees that address such topics as safety and testing and rating methods for several categories of equipment. NIST participates as a member of the U.S. Technical Advisory Group for ISO TC 86. This participation provides NIST a means for staying abreast of the range of activities undertaken within the eight subcommittees. A NIST representative is also a member of two working groups, WG1 and WG5, within Subcommittee (SC)6, Factory-made air-conditioning and heat pump units. WG1 is working to revise testing and rating standards that apply to unitary air conditioners and heat pumps. WG5 is developing testing and rating standards that cover three categories of multi-split air conditioners and heat pumps.

James Pielert of the Building Materials Division is chairman of ASTM Subcommittee C09.92 on International Activities which is the United States Technical Advisory Group (TAG) for ISO TC71 Subcommittee 1 on Testing of Concrete. The role of the TAG is to coordinate reviews of draft ISO standards and to submit U.S. standards for consideration by ISO. For the latter, ASTM concrete aggregate and admixture standards have been submitted to Israel, the secretariat of Subcommittee 1.

Steven Bushby of the Building Environment Division is convener of ISO TC 205 WG 3 Building Control System Design. The objective of this working group is to develop a multi-part international standard that addresses several issues related to building control systems including control system functionality, communication protocols, system specifications and project management.

International Union of Testing and Research Laboratories for Materials and Structures (RILEM)

James Pielert is the United States delegate to RILEM and is a member of the management committee of RILEM. RILEM's purpose is to promote progress in the design, testing, manufacture and use of building materials. Its membership includes specialists from 80 countries involved with construction and research. Construction technology being developed within RILEM technical committees can be used to the benefit of the U.S. construction industry.

Walter Rossiter of the Building Materials Division is the chair of the International Union of Testing and Research Laboratories for Materials and Structures (RILEM/CIB) Joint Committee on Roofing Materials. The committee has two objectives: to develop a methodology for assessing the condition of in-place low-sloped roofing membranes and to determine the state-of-the-art in design, application and maintenance of sustainable low-sloped roofing systems.

Mark Kedzierski of the Building Environment Division was an invited lecturer at the Oij International Seminar. "A New Approach Toward Low-Temperature and Air-Conditioning, Engineering Without Fluorocarbon Refrigerants" was presented at Tomakomai, Japan, September 16-19, 1997.

Mark Nyden of the Fire Science Division was an invited participant in the 3rd Australian Molecular Modeling Workshop. The papers covered a range of topics including protein structure and function, computational chemistry, materials science, drug design and bioinformatics. Nyden was the expert whose paper addressed modeling thermal reactivity in polymers as they burn.

The International Conference on Service Life Prediction of Coatings was held in Breckenridge, CO, on September 14-19, 1997. The conference was chaired by Jonathan Martin, who also chaired the organizing committee.

Major Conferences, Seminars and Workshops

Forum for International Cooperation on Fire Research (FORUM)

The Forum for International Cooperation on Fire Research (FORUM) comprises heads of public and private sector fire research laboratories and organizations sponsoring fire research around the world. Jack Snell is the chair of the Forum and Richard Bukowski is the secretary. The group meets annually to discuss mutual interests, encourage cooperative undertakings and promote the advancement of fire safety engineering. Typically, the FORUM sponsors a two-day workshop with the host member to highlight some important issue or aspect of fire safety engineering in the host's nation. The fiscal year 1996 meeting was held in Norway and the symposium focused on issues associated with development and implementation of a performance based standard in that country. The fiscal year 1997 meeting in Tainjin, China addressed issues of fire research and testing and the codes and standards processes in China.

International Workshop on the Fire Performance of High-Strength Concrete (HSC)

An international workshop on the fire performance of high-strength concrete (HSC) was sponsored by BFRL in February 1997 in collaboration with Mobil Technology Company, Dupont Engineering and Portland Cement Association. The workshop focused on identifying the technical challenges associated with the performance HSC under fire conditions and the research needed to provide solutions for those challenges. The workshop brought together leading researchers, representatives of trade organizations, government regulators from nine different countries, including Canada, Finland, France, Germany, Norway, Sweden, Taiwan, United Kingdom and the United States. The workshop commenced with technical presentations by various researchers, followed by four concurrent working group sessions addressing topics of material testing, element testing, analytical studies and codes and standards for fire-exposed HSC. A workshop proceedings, which includes technical papers and recommended research needs, is now available.

International Workshop on Seismic Design Methodologies

H.S. Lew of the BFRL co-organized the International Workshop on Seismic Design Methodologies for the Next Generation of Codes that was sponsored jointly by the US-Slovene Joint Board for Scientific and Technological Cooperation, Office of International and Academic Affairs/NIST and the National Science Foundation.

International Conference on Roofing Technology

The 4th International Conference on Roofing Technology was held at NIST on September 17-19, 1997. The conference was sponsored by NIST, the National Roofing Contractors Association and several other organizations. It was attended by about 450 persons from 22 countries. Walter Rossiter served on the planning committee.

Green Building Conference

NIST, as represented by the Building Environment Division, join with the U.S. Green Building Council, the American Institute of Architects and the San Diego Gas and Electric Company to sponsor the "Third International Green Building Conference". Green buildings are defined as those designed, constructed, operated and demolished in ways that have a minimum impact on their global neighborhood and internal environments. The conference, held in San Diego, CA, November 17-19, 1996, brought together experts in the field of green buildings. Approximately 300 people attended this conference, including representatives from industry, academia and government. International professionals presented the latest information on sustainable practices, materials and technologies. The proceedings from the conference are published in NIST Special Publication 908, *"Third International Green Building Conference and Exposition – 1996"*.

ASHRAE/NIST Refrigerants Conference

Refrigerant options for air-conditioning and refrigeration industry in response to ozone depletion and climate change were the topic of the third refrigerant conference jointly organized by the American Society of Heating, Refrigerating and Air-Conditioning Engineers and the National Institute of Standards and Technology. The conference entitled "Refrigerants for the 21st Century" took place on October 6 and 7 at NIST. While the first two conferences organized in 1989 and 1993 were related to ozone depletion, the latest conference included global warming considerations. Climate change is the next global environmental problem. The parties to the U.N. Framework Convention for Climate Change held their third meeting in Kyoto, Japan, in December 1997, to negotiate global preventive measures.

The conference program was based on 16 invited presentations which were given by international experts. The covered topics included contemporary and future fluorochemicals, "natural fluids" including hydrocarbons, carbon dioxide and air, secondary loop systems using ammonia and other chemicals and not-in-kind technologies. The opening speaker was D. Albriton of the National Oceanographic and Atmospheric Administration who provided a status report on atmospheric science. NIST's contributors included D. Didion (BFRL) and M. McLinden (Chemical Science and Technology Laboratory) who co-authored two papers and P. Domanski (BFRL) who chaired the conference steering committee. The conference provided a forum for presenting different points of view on the best refrigerant options for the future. The need for this dialog will increase as a result of the intensifying international climate change negotiations.

Second Computer-Integrated Knowledge System Network Workshop

The second Computer-Integrated Knowledge System Network Workshop, held at NIST on September 24-25, was co-sponsored by the Civil Engineering Research Foundation, the CONMAT Council and ASTM. In addition to keynote presentations on topics in information technology, working groups on specific groups of construction materials discussed how their communities might exploit the CIKS network concept.

First Annual NGP Research Conference

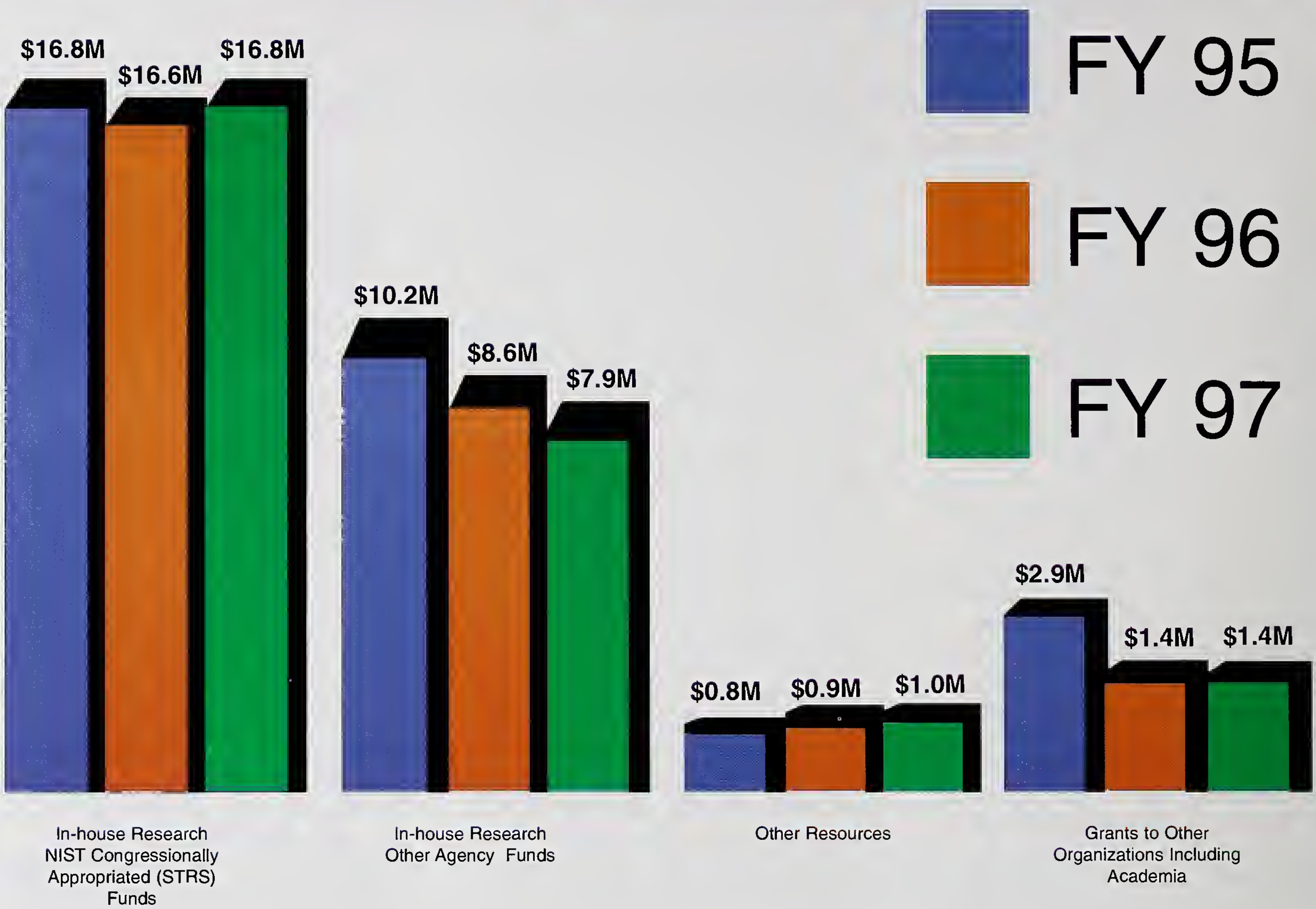
NIST organized and chaired the first meeting of principal investigators under the Department of Defense Next-Generation Fire Suppression Technology program (NGP). Twenty-two experts in the field of fire suppression discussed the early results from the program which is aimed at the development of new processes, techniques and fluids for replacing halon 1301 for firefighting.

The topics included:

- types of fires faced by DOD,
- mechanisms of fire suppressants,
- new fire suppressant chemicals,
- improvements for using water sprays,
- new test method for measuring fire suppressant efficiency,
- effect of obstructions on fire suppressant effectiveness,
- advanced instrumentation for full-scale fire suppression experiments.

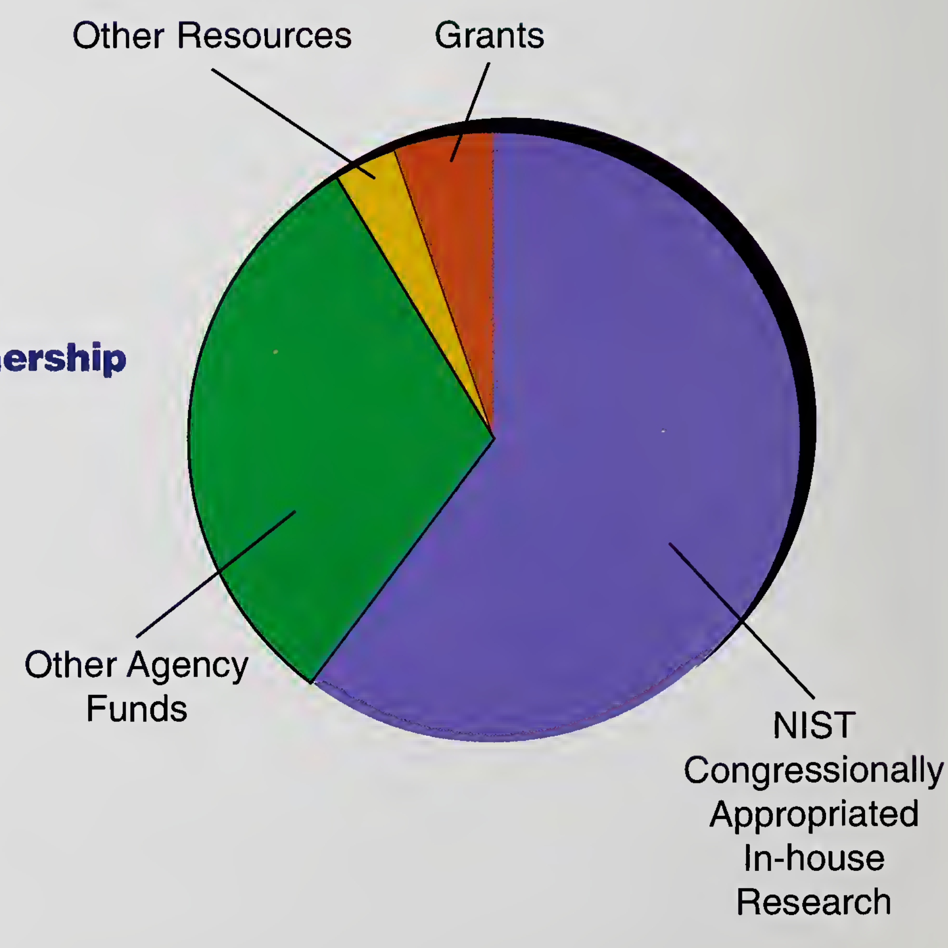
International Firefighting Robot Competition

BFRL, along with Connecticut Natural Gas, Trinity College and Watts Industries, co-sponsored the 4th Annual Firefighting Home Robot Contest at Trinity College in Hartford, CT. Over 60 entrants from the United States, Canada and abroad were entered, making it the largest robotics competition in the United States that is open to enthusiasts of any age, ability or affiliation. The objective is to build a self-propelled, autonomous robot that navigates a 2.4 m x 2.4 m maze and detects and extinguishes a candle in the shortest time. The robot must fit within a 31 cm cube. The contest encourages the development of new approaches to object- and fire-sensing systems, as well as creative approaches to flame suppression. The founders' intent is to stimulate the eventual development of commercial firefighting robots. The over 1,000 spectators saw robots of highly variable visage complete their task in as little as 10 seconds. First prize in the Senior Division (college age or older) went to a team from the Pennsylvania State University at Abington; first prize in the Junior Division was earned by a high school team from Kitchener, Ontario.



Note – Other resources include:

Advanced Technology Program
Manufacturing Extension Partnership
Standard Reference Materials
Expense and Income



BFRL Organization

Building and Fire Research Laboratory

Director
R.N. Wright

Deputy Director
J.E. Snell

Applied Economics
H.E. Marshall

Standards & Code Services
J. P. Zingeser

Construction & Building
A.J. Fowell

Cooperative Research
N.J. Raufaste

Structures Division
S. S. Sunder, Chief

- Structural Evaluation
- Earthquake Engineering

Building Materials Division
G. J. Frohnsdorff, Chief

- Organic Materials
- Inorganic Materials
- Construction Materials Reference Laboratories

Building Environment Division
J.E. Hill, Chief

- Thermal Machinery
- Mechanical Systems & Controls
- Heat Transfer
- Computer - Integrated Construction
- Indoor Air Quality

Fire Safety Engineering Division
D.D. Evans, Chief

- Fire Modeling & Applications
- Large Fire Research

Fire Science Division
R.G. Gann, Chief

- Smoke Dynamics Research
- Materials Fire Research
- Fire Sensing & Extinguishment

Provides the national laboratory concerned with enhancing the competitiveness of U.S. industry and public safety by developing performance prediction methods, measurement technologies, and technical advances needed to assure the life cycle quality and economy of constructed facilities; performs and supports laboratory, field and analytical research on the performance of construction materials, components, systems and practices; and the fundamental processes underlying initiation, propagation and suppression of fires; produces technologies to predict, measure and test the performance of construction and fire prevention and control materials, components, systems and practices and to assist the construction and fire safety communities in achieving the benefits of advanced computation and automation; provides research results which are widely used and adopted by governmental and private sector organizations with standards and codes responsibilities, but does not promulgate building or fire safety standards or regulations; and conducts fire research mandated by the Federal Fire Prevention and Control Act of 1974, research for the improvement of seismic design and construction practices as assigned by the Earthquake Hazards Reduction Act of 1977, as amended and structural failure investigations mandated by the NIST Authorizing Act of FY 1986.

Building and Fire Research Laboratory

The functional statements of the Building and Fire Research Laboratory and the Offices, Divisions and Groups in the laboratory are as follows:

BUILDING AND FIRE RESEARCH LABORATORY OFFICE

Responsible for planning, directing and implementing the scientific, technical and administrative programs of the Laboratory through scientific, administrative and support personnel.

OFFICE OF APPLIED ECONOMICS: Supports the BFRL research and BFRL technology deployment to government agencies and construction and fire-related industries; provides standardized economic methods, economic models, training programs and materials and expert technical consulting in support of resource allocation decisions; and uses techniques such as benefit-cost analysis, life-cycle costing, multi-criteria decision analysis and econometrics to evaluate new technologies, processes, government programs, legislation and codes and standards to determine efficient alternatives.

OFFICE OF COOPERATIVE RESEARCH: Facilitates the transfer of scientific and technical output of the Building and Fire Research Laboratory to the user community; manages the cooperative building and fire research programs with other federal agencies and national and international private organizations; and develops cooperative research programs with other federal agencies and agencies of foreign governments.

STRUCTURES DIVISION (Chief: Dr. S. Sunder 301-975-6713)

Increases the productivity and safety of building construction by providing technical bases for improved structural and earthquake design criteria; conducts laboratory, field and analytical research in structural engineering which includes: investigation of important structural failures, characterization of normal and extreme loads on buildings occurring during construction and in service, associated structural response and methods for providing desired reliability, development of design criteria for reduction of risks from natural hazards, evaluation methods and criteria for safe and economical construction practices, engineering properties of soils and foundations and nondestructive evaluation methods and criteria for increasing structural properties.

STRUCTURAL EVALUATION GROUP: Conducts laboratory, field and analytical research in structural engineering when activities include: development of nondestructive evaluation methods and criteria for assessing structural properties; development of methods for the identification of dynamic response characteristics of flexible members and structural networks; development of technical criteria and methodologies for the strengthening and repair of structural members and systems; characterization of normal and extreme loads on buildings during construction and in service; and investigation of important structural failures.

EARTHQUAKE ENGINEERING GROUP: Provides research data and technical support for the development and application of seismic design and construction practices for new and existing buildings and lifelines when activities include: laboratory and analytical studies needed for improving codes and standards pertaining to new construction; the development of criteria regarding the repair and strengthening of existing structures; the development of procedures to evaluate the response of structural systems to seismic loading; post-earthquake investigations to ascertain the effectiveness of design and construction practices in actual earthquakes; and technical support to the National Earthquake Hazards Reduction Program (NEHRP).

Building and Fire Research Laboratory

BUILDING MATERIALS DIVISION (Chief: Dr. Geoffrey J. Frohnsdorff, 301-975-6706)

Advances construction materials science and technology and disseminates improved techniques and data for making decisions concerning construction materials; conducts analytical, laboratory and field research which includes methods of measurement and prediction of service life, bases for improved criteria and standards for evaluation, selection, use and maintenance of construction materials and improved tools to aid the making of decisions concerning construction materials; provides technical support to national and international standards-writing organizations such as the American Society for Testing and Materials (ASTM) and the International Standards Organization (ISO); and conducts cooperative programs with other research organizations, professional societies, standards-writing groups, testing laboratories and educational institutions.

ORGANIC BUILDING MATERIALS GROUP: Carries out analytical, laboratory and field research on the performance of organic building materials such as paints and coatings, roofing materials and sealants and adhesives; provides technical bases for improved criteria and standards for evaluation, selection and use of these materials; and disseminates improved techniques and data for making decisions on organic building materials, including methodologies for predicting service life.

INORGANIC BUILDING MATERIALS GROUP: Carries out analytical, laboratory and field research on the performance of cement and concrete and other inorganic building materials such as building stone; provides technical bases for improved criteria and standards for evaluation, selection and use of these materials; and disseminates improved techniques and data for making decisions on inorganic building materials, including methodologies for predicting service life.

CONSTRUCTION MATERIALS REFERENCE LABORATORIES: Provides technical support for improvement in the quality of construction materials testing, the development of national and international standards and the advancement of construction materials technology; manages the AASHTO and ASTM-sponsored research associateship programs which (1) provide laboratory inspection and proficiency sample programs, (2) conduct studies to aid in the understanding and improvement of standard methods of test and (3) support the development of standards by national and international organizations such as ASTM and ISO.

BUILDING ENVIRONMENT DIVISION (Chief: Dr. James E. Hill, 301-975-5851)

Reduces the cost of designing and operating buildings and increases the international competitiveness of the U.S. building industry by providing modeling, measurement and test methods needed to use advanced computation and automation effectively in construction and to improve the quality of the indoor environment and the performance of building equipment; conducts laboratory, field and analytical research on building mechanical and control systems; develops data, measurement methods and modeling techniques for the performance of the building envelope, its insulation systems, building air leakage, the release, movement and absorption of indoor air pollutants; and develops software performance criteria, interface standards and test methods needed for the Nation's building industry to make effective use of modern computer-aided design hardware and software and database management systems.

THERMAL MACHINERY GROUP: Identifies and characterizes new atmospheric-safe refrigerants and refrigerant mixtures that contribute to energy-efficient refrigeration applications; works cooperatively with the Thermophysics Division of NIST in determining the thermophysical properties of the new refrigerants to support industrial design of equipment using these refrigerants; and evaluates alternate refrigeration cycles, systems and components that will operate efficiently with new refrigerants.

MECHANICAL SYSTEMS AND CONTROLS GROUP: Improves and lowers the cost of building services by fostering the development and use of more intelligent, integrated and optimized building mechanical systems; develops design tools, diagnostic procedures and performance evaluation techniques for quantifying the performance of such systems; develops standard communication protocols for exchanging information between building management and control systems (BCMS); and develops the technical bases for advanced building controls which will optimize whole building performance.

HEAT TRANSFER GROUP: Develops basic data and simulation models for heat, air and moisture transfer through building envelope components and assists consensus standards organizations in the development of appropriate test methods.

COMPUTER INTEGRATED CONSTRUCTION GROUP: Removes technical barriers faced by the construction industry as it integrates its activities using computer technology; provides information interface and performance measurement technologies that support industry development and the use of automated products and services in an integrated environment; develops interface standards, test methods and performance criteria for integrated project information and control systems; and develops methodologies and computer-aids for implementing building standards, specifications and building technology knowledge bases in computer usable forms.

INDOOR AIR QUALITY AND VENTILATION GROUP: Develops measurement and testing procedures, technical data and comprehensive indoor air quality models to assist in improved indoor air quality and ventilation in buildings.

Building and Fire Research Laboratory

FIRE SAFETY ENGINEERING DIVISION (Chief: Dr. David Evans, 301-975-6863)

Performs research on and develops engineering methods for fire safety engineers, manufacturers and other Federal agencies to predict the behavior of fire and smoke and assess various means to mitigate the impact of fire on people, property and the environment. This includes developing and demonstrating the application of analytical tools to building fire problems; developing analytical models for the quantitative prediction of the threats to people and property from fires and the means to assess the accuracy of those models; developing techniques to predict, measure the behavior and mitigate the impact of large fires; and operating the Fire Research Information Service and the Fire Research large-scale fire test facility.

LARGE FIRE RESEARCH GROUP: Performs research on and develops techniques to measure, predict the behavior of and mitigate large fire events. This includes: understanding the mechanisms in large fires that control the gas phase combustion, burning rate, thermal and chemical emissions and transport processes; developing techniques for computer simulation; developing field measurement techniques to assess the near- and far-field impact of large fires and their plumes; performing research on the use of combustion for environmental cleanup; predicting the performance and environmental impact of fire protection measures and fire fighting systems and techniques; and developing and operating the Fire Research Program large-scale experiment facility.

FIRE MODELING AND APPLICATIONS: Performs research, develops and demonstrates the application of analytical models for the quantitative prediction of the consequences of fires and the means to assess the accuracy of those models. This includes: developing methods to assess fire hazard and risk; creating advanced, usable models for the calculation of the effluent from building fires; modeling the ignition and burning of furniture, contents and building elements such as walls; developing methods of evaluating and predicting the performance of building safety design features; developing a protocol for determining the accuracy of algorithms and comprehensive models; developing data bases to facilitate use of fire models; and operating the Fire Research Information Service which serves as a central source of information for the fire community.

FIRE SCIENCE DIVISION (Chief: Dr. Richard G. Gann, 301-975-6864)

Performs research on and develops scientific and engineering understanding of fire phenomena and metrology for fire research; produces principles, metrology, data and predictive methods for the formation/evolution of smoke components in flames and for the burning of polymeric materials; and develops science and predictive methods to enable high-performance fire detection and suppression systems.

SMOKE DYNAMICS RESEARCH GROUP: Produces scientifically sound principles, metrology, data and predictive methods for the formation/evolution of smoke components in flames for use in understanding and predicting general fire phenomena which includes: research on the effects of within-flame and post-flame fluid mechanics on the formation and emission of smoke, including particulates, aerosols and combustion gases; understanding the mechanistic pathway for soot from chemical inception to post-flame agglomerates; and developing calculation methods for the prediction of the yields of CO (and eventually other toxicants) as a function of fuel type, availability of air and fire scale.

FIRE SENSING AND EXTINGUISHMENT GROUP: Develops understanding, metrology and predictive methods to enable high-performance fire sensing and extinguishment systems; devises new approaches to minimizing the impact of unwanted fires and the suppression process which includes: research for the identification and in-situ measurement of the symptoms of pending and nascent fires or explosions and the consequences of suppression; devising or adapting monitors for these variables and creating the intelligence for timely interpretation of the data; determining mechanisms for deflagration and detonation suppression by advanced agents and principles for their optimal use; modeling the extinguishment process; and developing performance measures for the effectiveness of suppression system design.

MATERIALS FIRE RESEARCH GROUP: Performs research to understand fundamentally the mechanisms that control the ignition, flame spread and burning rate of materials and the chemical and physical characteristics that affect these aspects of flammability; develops methods of measuring and predicting the response of a material to a fire which includes: characterizing the burning rates of charring and non-charring polymers and composites; delineating and modeling the enthalpy and mass transfer mechanisms of materials combustion; and developing computational molecular dynamics and other mechanistic approaches to understand the relationships between polymer structure and flammability.

For Additional Information, contact:

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