

NISTIR 6539

Fire Research Needs Workshop Proceedings

Emmitsburg, Maryland, October 20, 1999

**William D. Walton
Nelson Bryner
Nora H. Jason, Editors**

NIST



**United States Department of Commerce
Technology Administration**
National Institute of Standards and Technology

**Federal Emergency Management Agency
United States Fire Administration**

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NOTICE

This Proceedings is the official transmittal of the workshop recommendations to the co-sponsor, U.S. Fire Administration, Federal Emergency Management Agency. It reflects the combined input of the workshop participants and not necessarily the views of the U.S. Fire Administration or the National Institute of Standards and Technology.

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FIRE RESEARCH NEEDS WORKSHOP
Emmitsburg, Maryland
October 20, 1999

1.0 INTRODUCTION

The mission of the United States Fire Administration (USFA) is to reduce life and economic losses due to fire and related emergencies, through leadership, advocacy, coordination with Federal agencies, and in partnership with fire protection and emergency services communities. Through Fire Administration leadership, a National Fire Research Agenda is developed with input from federal, state and local partners. Using this agenda, with a commitment to excellence, the USFA provides public education, training, technology, and data initiatives as follows:

Public Education: Develops and delivers fire prevention and safety education programs in partnership with other Federal agencies the fire and emergency response community, the media, and safety interest groups.

Training: Promotes the professional development of the fire and the emergency response community and its allied professionals. To supplement and support State and local fire service training programs, the National Fire Academy develops and delivers educational and training courses having a national focus.

Technology: Works with public and private groups to promote and improve fire prevention and life safety through research, testing, and evaluation. Generates and distributes research and special studies on fire detection, suppression and notification systems, and on fire and emergency responder health and safety.

Data: Assists state and local entities in collecting, analyzing and disseminating data on the occurrence, the control and the consequences of all types of fires. The National Fire Data Center, which administers the National Fire Incident Reporting System (NFIRS), describes the Nation's fire problem; proposes possible solutions and national priorities; monitors resulting programs; and provides information to the public and fire organizations.

The Building and Fire Research Laboratory at the National Institute of Standards and Technology conducts research related to the measurement and prediction of fire related phenomena and has a memorandum of understanding with the Fire Administration. The agreement calls for cooperation between the two agencies in the areas of planning, information exchange and technology transfer to improve fire safety.

As part of an ongoing effort to update and sharpen the National Fire Research Agenda, the Fire Administration in cooperation with the Building and Fire Research Laboratory, at the National Institute of Standards and Technology held two workshops to obtain input from the fire community.

The first focused on the needs of the fire service and was held October 13-15, 1999, in San Antonio, Texas. At that workshop, 32 members of the fire service representing national fire service organizations and a wide range of fire departments in both size and location were asked to identify the needs of the fire service. Areas of emphasis included fire fighting operations, firefighter health and safety, large fire incidents, fire mitigation, communications, and information technology. The findings from the that workshop are presented in a separate report.

The second workshop was held October 20th, 1999, in Emmitsburg, Maryland and focused on the needs of the fire protection community beyond the fire service. Representatives of professional organizations, trade associations, and building code organizations were invited to present their research needs. Unfortunately, a number of organizations were unable to attend; however, those in attendance provided a variety of recommendations. A list of the attendees is provided at the end of this report.

The recommendations of the workshop participants have been separated into 5 categories: design, fire protection systems, fire modeling, fire service and general recommendations. Since the participation in the workshop was limited, no priorities were placed on the recommendations.

2.0 PANEL RECOMMENDATIONS

2.1 Design Recommendations

2.1.1 Performance objectives

Issue: Performance requirements need to be linked to fire safety needs.

Need: Performance requirements must support and be clearly linked to specific fire safety needs.

Background: Connections between performance objectives and fire safety needs are frequently based on judgement rather than research. Designers frequently do not understand the objectives or research supporting prescriptive code requirements. This makes it difficult to convert prescriptive codes to performance based codes.

Comments: An example was cited in which a code requires fire exits to be spaced at no less than 150 foot intervals, but this appears to be based on visibility of exit signs. It may be more appropriate to base spacing of fire exits on how long it takes people to exit a building. If people can exit safely with one door every 300 feet, then additional exits signs may be required rather than additional fire exits.

2.1.2 Reliability and durability of design

Issue: Reliability and durability of installed fire protection systems

Need: Develop a method to evaluate reliability and durability of installed fire protection systems over the entire life cycle of the building. Develop procedures for ensuring adequate performance of fire protection systems over the life cycle of the building.

Background: Fire protection systems including fire pumps, sprinklers, smoke control dampers and standpipe systems currently undergo pre-occupancy testing, but once accepted may not be maintained adequately over the entire life cycle of the building. Both prescriptive and performance based building and fire codes make the assumption that fire protection systems will function properly throughout the life of the building.

Comments: A general trend in performance based design is to rely on active fire protection systems such as sprinklers and smoke control systems, rather than passive systems, such as building fire resistance. The reliability of active fire protection systems, in general, is not well documented. Active systems generally require more maintenance than passive systems. Once a building is turned over to the owners, the performance of all of the fire protection systems often is not verified over the life of the building.

2.1.3 Authorities having jurisdiction evaluation of complex designs

Issue: Continuing education of authorities having jurisdiction

Need: Authorities having jurisdiction need to be kept informed with respect to new and increasingly more complex design methods. Authorities need to be able to evaluate designs which incorporate the use fire models and other evaluation tools in order to assess correctly the performance of complex building systems.

Background: The increased use of performance based building design has resulted in an increased use of complex analytical design tools, such as computer based fire models. Authorities having jurisdiction or code officials frequently do not have training in understanding fire models and other tools which engineers are using to design fire protection systems. Code officials often are unable to assess or evaluate the performance data provided by designers. In many cases code officials are not knowledgeable concerning the limitations in the use of fire models.

Comments: Computer aided design of fire sprinkler systems have become common and have almost completely replaced hand calculations. The use of computer fire models and other fire calculations are becoming more wide spread for major projects. The assumptions, use and limitations of the tools are far more complex than those related to sprinkler design programs. Many building code departments do not have staff who are trained in the evaluation of building designs prepared with the use of fire calculations. Due to the complex nature of these calculations, adequate training cannot usually be accomplished in a short period of time.

2.1.4 Change of Occupancy

Issue: Building and fire code compliance as building use changes

Need: Develop procedure for updating the compliance with code provisions as occupancy use changes from initial design.

Background: The use of a structure may change throughout life cycle of building. For example, portions of an office building may be converted to retail sales. When corridor space is converted to storage, fire load and egress issues needed to be addressed.

Comments: An example was discussed in which the design for a high bay warehouse retail store included 96 inch wide aisles. Over time, the aisles were used for storage/retail space. The occupant stated that as long as 44 inch aisle width was maintained, the building was in compliance with building and fire code. However, the original design would not have been approved with 44 inch wide aisles. Further, crowded aisles prevent easy egress and add to the fuel load.

2.1.5 Human factors in performance based design

Issue: Human factors not included in performance based design

Need: Incorporate more human behavior into performance based fire protection design. Models used to simulate effectiveness of fire protection systems need to include human behavior.

Background: Most of computer based fire modeling performed in the support of performance based design does not include human factors. Computer fire models generally deal with effects of a fire, not with the interaction of people with the fire and the building during the fire. Human behavior is a crucial part of design and the designs need to take human actions in an emergency situation into account.

Comments: There are too few studies on human behavior during emergencies such as fire. Some work is being done in Canada, Northern Ireland, and Australia but it is not comprehensive enough. Some computer based models for evacuation are available but they tend to examine individual components and not the combined effects of fire on people. The Americans with Disabilities Act deals with how to make buildings accessible for people with disabilities, but not how best to evacuate them during an emergency. Research needs to include all forms of disabilities such as people in wheel chairs, blind individuals using guide dogs, and the deaf.

2.1.6 Impact of the use of alternative materials in residential occupancies

Issue: The effect of the use of new materials and technology on fire safety in structures.

Need: Characterize the impact of new materials and technology, such as laminated beams, metal studs and engineered wooden I-beams on the fire safety of structures.

Background: Alternative materials and methods of construction are becoming common in residential construction; however, the level of fire safety is not always known when compared to traditional construction methods. Wood trusses and steel studs may not provide the same level of fire resistance as solid wood members. Failure modes during a fire for alternative construction materials may not be well understood by the fire service.

Comments: New building materials and construction technology are being introduced at a rapid pace particularly in residential occupancies. Fire protection designers need information concerning the performance of new technology designs and how building components interact with each other. Fire fighters are unsure how to assess the potential for structural collapse during a fire in buildings with new construction techniques.

2.2 Fire Protection Systems Recommendations

2.2.1 Performance of fire protection systems

Issue: Data not available on the performance of fire protection systems

Need: Establish a database on the performance of fire protection systems such as sprinklers, smoke control systems, detectors, and alarms.

Background: If performance codes rely on data, then the data must be available and reliable. Insurance companies do not necessarily share information about the performance of fire protection systems. They consider it proprietary and use the data to set standards and rates. Industry sources may provide data, but that data is often on specific product lines and may be intended to show the benefits of the product.

Comments: There is a strong need for accurate data on fire protection systems in order to evaluate performance based codes. Data needs to be objective and readily available.

2.2.2 Analysis of complete fire protection systems

Issue: Evaluation of complete fire protection systems

Need: Develop methodology to evaluate complete fire protection systems instead of evaluating individual components.

Background: Fire protection systems include many components which are generally evaluated individually, but their effectiveness needs to be assessed in concert with all the components. For example, the requirements for fire doors in buildings with sprinkler systems and the requirements for both sprinkler and smoke control systems.

Comments: Performance codes may never completely replace prescriptive codes, but if they do, it will take a long time. Some have suggested there are redundancies in prescriptive codes that may be reduced in performance based codes.

2.2.3 Identification of the impact of fire protection systems

Issue: Evaluate trade-offs in terms of economic cost of fire protection systems versus loss of life and property.

Need: Conduct cost-to-benefit analysis of fire protection systems. Determine the acceptable level of risk.

Background: It is generally agreed that there would be a substantial reduction in fire fatalities if sprinklers were installed in all residences. The cost-to-benefit ratio for the installation of sprinklers has not been adequately determined.

Comments: There is an indication that the fire protection community devotes a substantial portion of its resources to a small number of buildings. For example, greater fire protection resources are devoted to retail occupancies such as shopping malls which experience a relatively low fire loss than to small residential occupancies where most of the fire fatalities occur.

2.3 Fire Modeling Recommendations

2.3.1 Data for fire models

Issue: Availability of input data for fire models.

Need: Establish standard of practice for input data and the application of fire models.

Background: Fire models are being used more often in fire protection design; however, the standard of practice for using fire models has not been established. Performance criteria need to cover a range of model inputs and not just a single fire scenario. There is no established criteria for the number of scenarios and the variations of input data which should be used with a fire model. Model users need to understand the sensitivity of the model to various input data.

Comments: All model have limitations and the user should only apply a model suitable for specific fire scenario. Determining a worst case fire scenario can be a difficult task. A fast growing fire may appear to be the worst case, but it may result in rapid detector and/or sprinkler activation where a smouldering fire would not. Model users need to understand spacial and temporal resolution of model output. Models vary widely in their resolution, particularly with respect to distances. Some models average the output over an entire room while others are able to predict conditions in thousands of small volumes within a room.

2.3.2 Extend the application of computer fire models with sprinklers to include life safety

Issue: Computer Fire Models

Need: Extend computer fire models with sprinklers to include life safety in single family and high-rise residential structures.

Background: The NIST industrial computational fluid dynamics computer fire model which includes rack storage and sprinkler activation is very good; however, most of the fire fatalities occur in one or two family residential structures. Further, the model has not been applied to high rise residential structures where potential for a catastrophic fire with large loss of life is great.

Comments: Three dimensional computational computer fire models traditionally have been used to evaluate fires involving industrial and other large buildings rather than residential structures. History has indicated that the fire department may be unable to quickly contain a serious high rise fire. Computer fire models may be helpful in convincing municipalities of the need for sprinklers in high rise residential structures, particularly when retrofitting existing structures.

2.4 Fire Service Recommendations

2.4.1 Firefighter physiology

Issue: Firefighter health and safety on fire ground.

Need: Develop better understanding of physiology of fire fighters on the fire ground.

Background: Fire fighting is physical activity different than most other occupational or recreational activities. Fire fighters are expected to participate strenuous physical tasks while being exposed to heat and mental stress, with little or no time to prepare. Further, many fire fighters are not physically fit. There has been little Federal funding to study this issue.

Comments: The condition of the heart and muscles have not been studied during exposure or during rehabilitation. There are no guidelines for the appropriate ratio of suppression activity to rehabilitation. A significant number of firefighter fatalities are due to heart attacks.

2.4.2 Fire ground incident command

Issue: Mid-level incident commanders lack training and experience in large fires.

Need: Develop virtual reality and simulators to train incident commanders for response to large fires. Training and simulators need to address wide variety of incidents.

Background: The fire service is experiencing fewer larger fires than in the past and incident commanders are receiving less experience at the scene of large fires. Computer based simulators are one means of offering incident commanders a wide range of experiences. Most of the current fire ground simulators are based on expert opinion and not on the physics of fire.

Comments: A large part of the decision making process is based on past experience. At the fire scene, incident commanders need to react quickly. With the reduction of large fires, fire officers may advance through the ranks without experiencing large fires. When faced with a large fire, inexperienced incident commanders tend to make poor decisions which leads to increased injury and fatalities of fire fighters. Further, fire fighters are now expected to respond with expertise on an increasing range of incidents including hazardous materials, urban search and rescue, and swift water and high angle rescue. Police departments have made increasing use of sophisticated and realistic simulators.

2.4.3 Firefighter health and safety

Issue: Reducing firefighter fatalities.

Need: Determine when appropriate for fire fighters to enter burning structure.

Background: In some countries fire fighters do not enter burning buildings. Building codes are designed primarily for protection of the occupants and not the fire fighters.

Comments: Presently there is little coordination between building design and firefighter safety. The building design focuses primarily on protecting the occupants and the property. Fire department operations are given little consideration in the design of the building.

2.4.4 Impact of fire department response time

Issue: How to best allocate limited fire service resources.

Need: Develop methodology for municipalities to allocate fire service resources.

Background: Fire service deployment is both an economic and political issue. The ISO (Insurance Services Organization) grading schedule is a widely used means for evaluating fire service deployment. However, the ISO ratings are based largely on historical data and may not adequately address the effect of fire department response time and fire department effectiveness. It is not known quantitatively how reducing response time affects the loss of life and property.

Comments: There is a need to understand impact of fire department response time, water supply, and human resources affect the loss of life and property. For example, building design and sprinkler systems can reduce the loss of life and property prior to the arrival of the fire department. The ISO rating schedule attempts to characterize a community and may not adequately address all factors. The ISO grading system favors improvements in the lower rated class cities where improving by one class may substantially reduce insurance rates. In many cases is not economically feasible to improve the class, but that does not mean that service cannot be improved.

2.5 General Recommendations

2.5.1 Review of Fire Research

Issue: Project/funding review board.

Need: Develop mechanism for selecting, awarding, and tracking fire research projects.

Background: Fire service research is not well coordinated in the United States. In many cases the fire service does not have input into selecting research areas. Selection of research topics should be based input from the users to determine the usefulness and impact of the research and technical input from independent reviewers to determine if the proposed work is technologically feasible.

Comments: It was suggested to avoid the National Science Foundation model which funds research according to a researcher's resume and how well a proposal is written. It was recommended to examine the Department of Defense model which uses specific rules to fund research according to needs with much less emphasis on reputation of researcher/academic institution. Projects should generate useful results in order to continue receiving funding.

2.5.2 Public education

Issue: Fire Prevention Culture

Need: Fire safety culture in America needs to change from focusing on fire suppression to fire prevention. Educate the public that fire prevention is crucial to reducing fire fatalities and property loss.

Background: Currently most fire departments focus on suppression of fires once they have started. The public and fire service needs to be educated that fire prevention is more effective than suppression in terms of saving lives and property. The public assumes that when a fire occurs, the fire service will save them. The culture needs to be changed so that the public learns to take responsibility for preventing fires.

Comments: Police often tell the mayor of a city that they do not have adequate resources to prevent crime, but the fire service will often only request the resources to suppress fire and not prevent them. One hundred fire deaths per week appears acceptable to society, but if there were 100 fatalities in airplane crashes each week, airplanes would be grounded. The public expectation is important. Airlines are expected to be safe, but the same people who expect aviation safety will not use seat belts or check their smoke detector. The public needs to be educated that fire safety is in part their responsibility.

3.0 ACKNOWLEDGMENTS

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