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National Fire Research Strategy Conference Proceedings, July 22 - 25, 1985

Bernard M. Levin, Editor

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Fire Research
Gaithersburg, MD 20899

December 1985

Final Report

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, ***Secretary***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

The views and recommendations of the Workshop Reports represents a summary or synthesis of ideas and opinions presented by individual members of the panel. Individual panel or workshop members may disagree with some of the statements contained in their own group report.

The statements and recommendations in this report do not necessarily reflect the views of the National Bureau of Standards or of the National Fire Protection Association.

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PREFACE

During the past decade, we have made major advances in understanding fire, its growth, and its dangers. We are now developing scientifically-based methods of fire safety analysis. These advances give us the expectation of better, technically supported, and more cost effective fire safety.

These improvements in fire safety are threatened by shortages of funds and facilities and the resultant diversion of scientific expertise to other areas. As supporters, users, and performers of fire research, we need to consult, coordinate, and cooperate to use all of our resources to their greatest advantage. The conferees in this meeting of the National Fire Research Strategy Conference agreed that a National Fire Research Strategy is key and they outlined the essential elements of such a strategy.

The National Fire Research Strategy is viewed as an evolving product of the efforts of the many participants of the Conference. All persons interested in fire safety are encouraged to become involved in this process. There will be future meetings of the Conference, workshops on specific topics, ad-hoc task groups, and draft plans and reports that need your input. You are each urged to carefully read this report, give your comments, and participate in the Plan development and implementation. Your comments and suggestions may be sent to either of the following.

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NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Overview Panel
at the July 22-25, 1985 Meeting

A. BACKGROUND

This meeting of the National Fire Research Strategy Conference is a continuation of the initial conference convened in Quincy, Massachusetts in August 1984. This initial conference, sponsored by the National Bureau of Standards and the National Fire Protection Association, was called to review the need for a restatement of national goals and directions for U.S. fire research.

The participants at the Quincy meeting recommended that "a coordinated fire research plan should be developed to achieve the reduction in fire losses in the United States in accord with the objectives of the Fire Prevention and Control Act of 1974."

The workshop participants of this second meeting of the National Fire Research Strategy Conference (which was a direct result of the 1984 Quincy meeting) responded to the recommendation and made considerable progress toward developing a coordinated fire research plan. In doing this, they attempted to develop a flexible plan, or strategy, that is more than a relatively fixed and detailed list of future efforts. They tried to develop a fire research strategy that includes approaches for coordinating the diverse set of activities conducted by the various sectors of the fire community.

B. VIEW OF THE OVERVIEW PANEL

The charge of the Overview Panel included the integration of the findings of the other panels and the development of generalized conclusions encompassing the full view of the Conference. The underlying theme of the Conference discussion was the need for a national consensus supporting a comprehensive fire research strategy. While the bulk of the text in the individual workshop reports discusses technical matters, two other areas of co-equal merit (managerial and political) were interwoven through the discussions and the reports of the other workshops. To have a truly comprehensive strategy that will represent a national consensus, it is essential to address all three areas--technical, managerial, and political.

The key technical needs to be addressed were seen as: developing models and other methods for quantifying hazard and risk; producing the data needed to effectively utilize such methods; and transferring rapidily the technology from scientific findings to applied use.

The key managerial need to be addressed was seen as providing an open means of free communication and coordination where all of the parties involved can see the total need, their part in the effort, and the impact that they can make. The participants at this meeting proposed that the continuance of the National Fire Research Strategy Conference as an ongoing body offers the best instrument for this.

The key political needs to be addressed were: pulling together the widely diversified groups of the fire community; healing divisions within the community; building consensus; and mounting the needed (long term, broad-based) support.

C. RECENT ADVANCES IN FIRE TECHNOLOGY

The Conference recommendations reflect the realization that we are making dramatic progress toward meeting the key technical needs mentioned above. We are rapidly developing the technological resources needed to bring about significant improvements in our ability both to reduce the risk that fires will strike and, once fire has begun, to effectively control its consequences with lower physical and human costs.

A primary catalyst has been a series of advances in our basic understanding of fire itself, including flame dynamics, gas production, and other combustion processes.

A second catalyst has been powerful new generations of computers with vastly improved information handling, analytical and interfacing capabilities. These new computers now enable us to simulate extremely complex, real-world phenomena, such as fires, to a degree of realism that was practically unattainable just a short time ago. Associated with these new generations of computers has been the development of important new technologies, such as expert systems, that can use such computers effectively and can couple them with both researchers and practitioners.

It is now realistic to anticipate that fire research can provide the base for national programs that can greatly alleviate many of today's pressing problems. Fire research can also lead the way to a not-so-distant future in which scientifically valid techniques for ensuring fire safety are in widespread use.

Fire research findings can help:

- manufacturers analyze cost-effectively the smoke toxicity or other fire impact of new materials and assemblies of materials;

- designers determine the impact of specific combinations of fire protection features on the hazards involved and the resultant level of safety provided.

- designers, and the officials who regulate their designs, analyze whether potentially useful variations on current safety codes do in fact offer levels of safety "equivalent" to the current code provisions;

- fire services diagnose, on the scene or in pre-fire planning, the most effective and safest line of attack on a growing fire; and

- our judicial system unravel the often tangled knot of responsibility and liability in the aftermath of a fire with greatly enhanced surety.

Such advances in fire safety will increase significantly our ability to provide higher levels of fire safety together with reduced costs, the encouragement of useful innovations in products and building design, and a wide variety of other benefits. The full promise of fire research, however, lies in its potential to reveal the details of fire development and how to control that development. Such fire safety analysis has immense value to all.

Reaching the full promise will require both the continued scientific development of our quantitative understanding of fire and related phenomena and the translation and transfer of this knowledge into useful analysis tools. While much lies ahead, the advances of the last decade have shown the way and are now bearing fruit.

D. QUANTIFICATION OF FIRE RISK AND HAZARD

To understand and prevent or control fire we need to know what material is burning, where in the structure it is located, its size, and what products it is giving off. We then need to know when any detection device, automatic sprinklers or other fire initiated safeguards will be activated and their effect on the fire. We need to know how fast a fire spreads, where, and what byproducts (and their interactions) are produced by the various burning materials. If there are people present, we need to know whether they are aware of the fire, how they will respond to that awareness, whether they know the building's floor plan and the best escape route, and whether the fire or noxious products are moving rapidly enough to cut them off before they can reach the exit. We should be able to validate optimal strategies for the local fire service. After the fact, we need to know what started the fire, what contributed to its severity and how well safeguards performed.

New scientific knowledge is progressively enabling us to simulate better the probable outcome of a fire. Thus we can analyze, with improving certainty, the effects of using various building materials, egress routes, alarm systems, etc., to determine their impact on overall fire safety. Previously, to determine the effects of the countless interacting variables that must be taken into account, we had to build a building and burn it down experimentally, at great cost. (An alternative, of course, is to rely on professional judgment and small-scale tests, both of which have been pressed to the limits of their reliability.) Burning a building, even a highly instrumented building, gives us data only on that particular building design; we have been unable to confidently predict the effects of minor but possibly significant alterations in that design.

Scientifically based simulations, by contrast, are relatively inexpensive and can be altered incrementally to identify subtle but significant interactions beyond the reach of experiments in which an actual building are burned. This ability to predict without burning is, at once, the power and promise of fire research.

E. DATA NEEDS NOW AND IN THE FUTURE

Long-Term Needs

To gain the simulation capability described above requires that the simulation model incorporate extensive data on, for example, the behavior of various materials in fires, the likely delay that occurs as occupants decide whether to evacuate or not, the physical and chemical properties of combustion, and the effects of specific fire safety elements (e.g., detectors, automatic sprinklers, smoke control, etc.) on developing fire situations. We need not only additional data but improved methods for collecting and analyzing such data.

Much of this type of data is not now available. To acquire the needed data, however, means ambitious programs of materials testing, analyses of past fires (both those reported to the fire service and the far larger number considered too minor to report), surveys of public awareness of fire safety measures, etc.

Acquiring such large data banks, and developing the simulation models to use them, will involve us all in an iterative process in which we should do all the following: acquire data; construct models to simulate actual fire conditions; test, and as needed, change the models; and, likely, discover that new data is needed to accommodate the refined models. This is characteristic of science in general.

Complementing the data gathering (and of comparable need) is the development, implementation, and application of a methodology for abstracting, organizing, coding and analyzing data from actual fires.

Short Term Needs

As in other fields, however, data needs in fire research also reflect the current imperatives of fire safety and the national economy. Local fire services need the best information available now on how to tackle today's fires, as do product manufacturers, code officials, regulatory bodies, designers, fire investigators, and the many others with responsibility for fire safety. There is no need to slight these short-term operations oriented needs in favor of the longer-term research oriented ones or vice-versa. Indeed, the two efforts should be complementary.

F. TECHNOLOGY TRANSFER

A critical need in fire safety is technology transfer, or the translation of scientific output into guidelines, tools, and other products that can and will be put to use in current fire safety efforts. Some observers believe the amount of untranslated data to be extensive, others less so. Still others point to the uncertainties, both in terms of public safety and legal liabilities, inherent in using innovations which have not been tested through extensive previous use.

Nevertheless, a strong theme running through the conference workshops was the need to enhance technology transfer. The researcher, whose talents lie in research and not in the development of professional tools, can only be a consultant in the transfer of technology to the ultimate user. Instead, the users who are most familiar with the specific needs must assume the prime responsibility by defining those needs and the form in which the transferred technology would best meet them. The researcher can then assist the transfer, especially if the transfer process requires extensive interpretation and analysis of the data to meet the defined needs.

G. COORDINATION AND COMMUNICATION IN THE FIRE COMMUNITY

The fire community includes: the entire fire service (paid and volunteer); engineers and architects; researchers in the Federal government, academia, and private industry; state and local officials; manufacturers; and many others. The resources available for fire research are limited compared to the magnitude of the effort required. Moreover, no one organization, agency, group or industry has the resources to organize a fire research program that integrates all relevant aspects, encourages free exchange of ideas and technology, and provides the output that only effective interactions can produce. Thus when we use the term "national" strategy for fire research, we are not using it as a synonym for "federal"; the efforts needed to advance fire research are so broad that every sector must be a full partner in developing and implementing a truly "national" strategy.

This necessary diversity and freedom of action on the part of all participants creates a need for full coordination and communication to avoid, for example, unintentional duplication of effort, or the development of potentially complementary efforts that, in fact, "talk past each other" because crucial commonalities are not included in early planning stages. An otherwise useful research project, for example, may produce results that are of little use to practitioners because the research neglected to include consideration of some vital real-world variable.

In recent years much of the former distance between various sectors and philosophies within the fire community has narrowed as disparate groups have discovered shared goals and the possibility of mutual benefits from closer working relationships.

We need to narrow these gaps even further to facilitate additional synergistic activities that share data, facilities, personal expertise, and experience as needed. Directories of ongoing research projects, public education activities, and other relevant data could be quite useful. The results of this conference demonstrate the enormous potential value of such coordination and communication.

H. STRATEGY FOR THE FUTURE

Based on the reports of all of the panels and its own deliberations, the Overview Panel proposes the following principles and recommendations for the future:

1. The National Fire Research Strategy Conference should continue to provide a focal point for fire research, as a means for facilitating coordination and communication among the various sectors of the fire community, and as a mechanism for developing and maintaining the interpersonal relationships that are vital for cooperative effort. The steering committee of the

conference should be augmented and maintained to provide this continuity. The Center for Fire Research should continue to act as the conference secretariat.

2. The work of the conference should be supported by task forces as appropriate. Initial task forces, which should be composed of volunteers from the fire community, should include:

   a. A task force to address the identification, recruitment, support and retention of scholars for fire research careers.

   b. A task force to address the physical and organizational infrastructure for fire research, including the ability of Federal, state, and local governments, industry, fire services, and universities to promote the sharing of resources.

   c. A task force to address the full range of technology transfer issues.

   d. A task force to compile directories of relevant organizations and ongoing research. Much of this task has been accomplished as part of the preparations for this conference; additional work remains to be done.

3. The augmented steering committee should develop a national fire research strategy based on the results of this conference and consultations with the various sectors of the fire community. This strategy should include research, development and technology transfer priorities and should suggest appropriate roles for the several fire community sectors.

   The steering committee's draft of the national fire research strategy should be distributed to the participants of the Conference for review. It should then be revised and submitted for public review.

   The national strategy should then be distributed widely to provide policy makers, research planners and funders, and the fire community with guidance on both short-term and long-term goals and directions for fire research in the United States.

<u>Overview</u>

Co-Chairmen - Harold Nelson
Henry Roux

Recorder - Paul McClure

Panel Members - Robert Barker
Clyde Bragdon
John Bryan
Howard Emmons
Clayton Hathaway
Peter Lund
John Lyons
Jack Snell

NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Materials and Products I Workshop
at the July 22-25, 1985 Meeting

A. INTRODUCTION

Reliable information about the property characteristics of products and their constituent materials is essential to efforts to improve the nation's fire-safety record. Currently, manufacturers, builders, architects, engineers, code-enforcement officials, and others who bear the responsibility for assuring acceptable levels of fire safety lack objective means for evaluating the fire hazards posed by materials and products in a variety of uses. To remedy this situation, manufacturers require information and methods that enable efficient development of profitable products, while providing an acceptable level of fire safety. Similarly, architects, engineers, and other design professionals require a variety of products and materials with assured levels of performance and the means to confidently select materials and products to achieve a desired level of fire safety.

Hazards assessment is now based on subjective judgments made by individuals who largely rely on past experience. These individuals lack the tools for determining whether a change in the formulation of a particular material or a design modification actually improves fire safety. If a change results in a product that is more resistant to ignition but more likely to generate toxic smoke, for example, is the modified product safer or does it pose a greater risk? A similar dilemma faces the manufacturer because such tradeoffs cannot be quantified today.

Inadequate data on properties of materials also hampers the efforts of researchers who are working to develop models of fire dynamics. Such models, which have the potential for accurately simulating fire growth and spread, thus greatly reducing fire-testing costs, require information about the fundamental properties of materials. The information now available, however, is incomplete. As a consequence, fire safety efforts cannot take full advantage of recent modeling advances.

The performance of a particular material or product depends on its chemical and physical properties, as well as on the circumstances in which an item is used. Simply stated, a product or material is neither safe nor unsafe. Rather, an item's safety level must be evaluated in the context of its end use. Recognition of this fact dictates that tests of a product or material must not be limited to one set of fire conditions, which cannot represent the range of real-life situations the product or material may encounter. The challenge is to develop models that are applicable to a range of uses and fire conditions and to improve the accuracy of fire hazard assessment. In the area of toxicity assessment, for example, models that would enable one to assess the dangers posed by a class of materials under a variety of fire conditions from data gathered from a limited number of test conditions would be a significant improvement over our current capabilities.

Such sophisticated modeling techniques are technologically possible. In fact, current models can assess the specific contribution of materials to fire growth in a compartment. In the future, models will be able to simulate the complex interaction between building design, the composition and arrangement of building materials and contents, and fire detection and suppression systems. Advancement from the historical hazards-assessment approach of "build and burn" to the sophisticated models of the future depends on our ability to determine the property characteristics of materials and products.

The research programs proposed here can bridge many of the gaps in our knowledge of how the fire performance of materials and products affects overall fire safety. This information is key to virtually all efforts to improve the safety levels in buildings and transportation vehicles. The ultimate beneficiary of the recommended research is the general public. The ability to assess the hazards of specific materials and products and the knowledge to support the development of new improved fire-safe materials and products hinges on the establishment of the proper technological base. To neglect the needed research is to forego the tangible opportunity to improve fire safety, an opportunity afforded by the present state of our knowledge of fire processes. The question is whether sufficient resources from industry, government and academia will be allocated to capitalize on this opportunity.

The panel devoted most of its time to identifying key research needs as they relate to the overall fire problem. It was readily recognized that the proposed research will require the resources of government, industry, and academia. Time did not permit division of research tasks and determining the commitment of resources necessary to solve the problems identified. The panel recognizes the importance of these elements in the research-planning process.

The panel identified ten research thrusts intended to address the needs and inadequacies described above. The thrusts are not equal in importance and are listed in the priority order determined by the panel. The first three thrusts, Fundamental Properties of Materials, Material Fire Hazard Assessment, and Correlation of Standard Fire Tests with Performance in Actual Fire, are roughly equal in importance and are broad research areas, ranging from rather fundamental research to the development of engineering tools.

Thrusts four, five and seven, Solid Phase Degradation Chemistry, Soot and Particulates, and Heat Transfer from Flames, are relatively fundamental research thrusts to develop the technology base needed in other areas. Thrusts six, nine and ten, Fire Performance of Building Assemblies, Corrosiveness of Combustion Products, and Fire Residues are more applied research projects which are directed towards specific material research needs. Thrust eight, Extinguishment Systems, contains both a fundamental research component, i.e., understanding extinguishment mechanisms and an applied engineering component, i.e., developing cost-effective fire extinguishment systems.

It must be recognized that these ten thrusts were identified by a small group (10) of fire researchers and practitioners from government, industry and academia during a short workshop. Other, equally important, material research thrusts may be identified in the future.

B. RESEARCH THRUSTS

I. Fundamental Properties of Materials

Thrust: Develop and assemble fundamental material property information and measurement techniques for use in fire dynamic modeling efforts.

Current Situation: Material property information is incomplete and often inaccessible, thus seriously hampering modeling efforts. Lacking, in particular, is material property data over a range of real fire conditions. The utility of some of the current information is questionable because many property-measurement methods now used are inadequate.

Proposed Goals:

1. To supply modelers with needed material property data.

2. To develop the apparatus and methods required to provide the needed data.

Needed Action/Research Elements:

1. Identify those material properties that are required inputs to fire models.

2. List those needed material properties which are not available or require improved accuracy.

3. Develop new/improved apparatus and methods for securing the needed data.

Performers: Universities, government and industry.

Priority Factors:

Importance - High. This activity underlies the entire modeling effort.
Probability of success - High
Cost: $3-5M
Time: 2-5 years

Technical Challenges: Primarily an engineering task. Current technology will support development of the needed instrumentation and apparatus.

Technology Transfer: Will require the development of a material property data base, the input to which must be checked by consensus standards organizations.

Barriers and Issues: Activity will require close cooperation with the modelers to determine and prioritize their needs.

Alternatives: Use existing data supported with the judgment of experienced researchers in the field.

Key Action Steps: See needed action/research elements.

Impact: Increased accuracy of the models, reduce the duplication of material property data measurements, assist product and material development, provide input to regulators and standards writers.

II. Material Fire Hazard Assessment

Thrust: Develop the means to quantify the fire hazard of various materials and products.

Current Situation: Manufacturers of new materials and products need a mechanism to assess the effects of material/products changes on overall fire safety. Trade-offs in material/product development--e.g., greater resistance to ignition vs increased smoke production, or reduced rate of heat release vs increased toxicity--must be considered in the overall context of fire hazard assessment. The current system--i.e., code compliance, government regulations--requires a manufacturer to develop materials and products to pass a specific test.

Proposed Goals: Develop the capability to quantify the end-use hazards of products and materials in real-fire scenarios. This will allow objective identification of improved products, reduce product development costs and foster public acceptance of products.

Needed Action/Research Elements:

1. Further develop and refine mathematical models such as the Harvard Fire Code and FAST (Fire and Smoke Transport).

2. Develop the capability to model the burning of products and materials.

3. Identify those property characteristics of materials that are necessary inputs in models.

Performers: Industry, academia, and government. This is the most critical element in the cycle of material/product development and acceptance. It requires the participation of all those who can contribute to and will be affected by this advancement in hazard assessment.

Importance: This development would allow objective decision making by manufacturers, engineers, fire fighters, builders and consumers.

Probability of Success: In a rudimentary way, the process has already begun and has proven valuable in certain cases. Applications in complex situations exponentially increases the difficulty of developing a useable model, however.

Cost: $5-10 M

Time: Continual development, but significant progress within 5 years.

Technical Challenges: The underlying chemistry and physics of burning materials needs to be developed. Modeling of a burning product poses a formidable scientific and engineering challenge.

Technology Transfer: Make models user-friendly so that the practitioner is comfortable using them; achieve recognition within model code writing mechanism; educate authorities having jurisdiction; validate model.

Barriers: Funding, acceptance and validation.

Alternatives: Continue full scale testing and subjective decision making.

Key Action: Limitations of models must be clearly defined.

Impact: Reliable models will encourage material development. Current tests do not accurately assess hazards and may actually keep safe products off the market. Models will allow greater flexibility for architects, designers and engineers, and will provide information critical to fire-safety policy.

III. Correlation of Standard Fire Tests with Performance in Actual Fires

Thrust: Establish relationship between results of standard fire tests and performance in actual fires.

Current Situation: Codes require certain material performance requirements based on standard fire tests. The relationship of test results to performance in actual fires is not clearly delineated.

Proposed Goal: Determine which standard fire tests provide data that can be used to reliably predict performance in actual fires. Modify those that are inadequate or develop new standard fire tests as required.

Needed Action: Identify standard fire tests used in codes. Determine applicability of results of standard fire tests to predictive models.

Performers: Industry, government, academia

Importance: High. Needed by code officials to improve effectiveness of regulations. Needed by fire modeling professionals to quantify so-called "fire properties" of materials.

Probability of Success: High

Cost: $2-5M

Time: 2-3 years

Technical Challenge: An engineering challenge to extend application of existing technology.

Technology Transfer: See goals.

Barriers/Issues: None

Alternatives: Identify limitations of standard fire tests.

Key Steps: Foster exchange of ideas between testing and modeling disciplines.

Impact: See goals.

IV. Solid-phase degradation chemistry

Thrust: Study solid-phase degradation to understand the mechanism of degradation and its modification.

Current Situation: The mechanisms of material degradation in fire environments are not understood. Fire retardant chemistry is largely empirical.

Proposed Goals: Understanding material degradation mechanisms may lead to materials with improved fire properties through either modification of the base material or the addition of fire-retardant chemicals. The goal is to provide the understanding necessary for the modification of the various material's fire performance ranging from soot to ignition and burning or toxic gas production.

Needed Action/Research Elements: First-class chemistry researchers must address this research area at a very fundamental level. Several independent researchers are needed in a coordinated effort to address the different aspects of the problem and contribute to its resolution.

Performers: Government, industry, and academia.

Importance: Material and chemical manufacturers need the research results; however, the research is very complex and must proceed at a very fundamental level exceeding the research capabilities of most manufacturers. Success could lead to greatly improved materials and products.

Probability of Success: Probability is good if significant financial resources are available to maintain the effort.

Cost: Five year effort at over $0.5M per year.

Technical Challenge: The technical challenge is high. New scientific understanding is necessary.

Technology Transfer: The technology will be transferred initially through technical journals and symposia. Most material and chemical manufacturers keep abreast of the technical literature applicable to their products.

Barriers: The single barrier is adequate financial resources. With sufficient continued funding, quality researchers and facilities will be attracted to the field.

Alternatives: The alternative is to continue making incremental, largely empirical, improvements on a trial and error basis.

Key Action Steps:

1. Commit the necessary resources.
2. Plan the program.
3. Recruit high-quality researchers and facilities.
4. Coordinate the research to achieve maximum progress.
5. Disseminate the results through technical reports, journals and symposia.
6. Adjust the initial research plan as appropriate.

Impact: New and improved fire safe materials will be developed economically.

V. Soot and Particulates

Thrust: Investigate production of soot and particulates from burning materials and relate their amount and their character to the material properties, composition, and burning behavior of the parent material.

Current Situation: The mechanism of production of soot is not well understood. Soot contribution to flame radiation is not well characterized. Soot is a product of all fires. Its impact on fire fighters, particularly during cleanup, and on fire victims is not characterized. Other particulates are also generally ignored.

Proposed Goals: Determine to what extent soot and particulates present a hazard; identify soot contribution to flame radiation.

Needed Action:

1. Develop information concerning the initial production of soot.

2. Measure its contribution to flame radiation.

3. Develop a model for the deposition of soot.

4. Measure absorption properties of soots.

5. Perform similar actions for particulates.

Performers: Government, academia, industry.

Priority: Soot and particulates are probable carriers of toxins and are known intermediates in radiation.

Probability of Success: Identification and particle size determination, high; identification of absorbants, medium to high; radiation, high.

Cost: $5-7M

Time: Medium, initial results in two years; continuing for 4-8 years.

Technical Challenge: Technical challenge is high for initial formation mechanisms.

Technology Transfer: Scientific articles, technical-popular articles, press releases.

Barriers and Issues: Major barrier is demonstrating that the soot generated in the laboratory is representative of real fires.

Alternatives: For modeling, make estimates from less well known data.

Key Action Steps: Delineation of radiation from soot measurement.

Impact of Action: Evaluation of hazards, possible elimination of serious risk, probable saving of lives.

VI. Fire Performance of Building Assemblies

Thrust: Develop models to predict fire performance of various building assemblies.

Current Situation: To meet building code requirements, fire-resistance-rated assemblies are field-erected with little variation from the prototype tested assembly. Greater flexibility in design is needed to allow transfer (substitution) of assembly components without necessitating costly large scale fire resistance testing, while maintaining adequate level of performance.

Proposed Goals:

1. Develop methods to predict behavior of assembly components to permit transfer (substitutions) without detracting from fire performance.

2. Characterize fire severity in current occupancies.

3. Develop models to predict behavior of assemblies of materials exposed to post-flashover fires that more nearly characterize expected fire severity in building fires.

Needed Action/Research Elements:

1. Characterize performance of components in existing test environments (elevated temperatures).

2. Develop models taking into account factors of fire growth and heat load in expected building fires.

3. Develop parameters for component transfer in assemblies.

4. Provide interim testing to evaluate algorithms.

5. Validate model.

Performers: Government, academia, industry.

Importance: Medium - needed by designers/architects as a design aid (flexibility of design); needed by materials suppliers to facilitate markets.

Probability of Success: High

Cost: $3-5 M

Time to Accomplish: Medium to Long (5-10 years).

Technical Challenges: Requires "accurate" assessment of fundamental "reaction to fire" properties of materials; and poses difficult fire-dynamics problems.

Technology Transfer: Output in form useable by architects, and structural and fire protection engineers.

Alternatives: Continue costly testing of prototypes; overdesign of structures.

Key Steps:

1. Determine expected heat loads in building fires.
2. Characterize performance of materials.
3. Develop and validate models.

Impact: Provides economic alternatives to building code requirements.

VII. Heat Transfer from Flames

Thrust: Develop the ability to predict heat transfer (radiative and convective components) from flames.

Current Situation: Fire growth in structures is largely controlled by the convective and radiative heat transfer from materials already burning and by the response of non-involved materials to existing flame heat transfer properties. Fire spread and growth models require knowledge of flame heat transfer and material response to this thermal input.

Proposed Goals: Develop methods for predicting heat transfer from flames; correlate soot production to the properties of the burning material; determine the effects of flame heat transfer properties on materials.

Needed Action/Research Elements: Further development of non-intrusive optical diagnostics for determination of flame properties. Development of mathematical models to simulate flame processes.

Performers: Government, academia and industry.

Importance: This research is necessary to support the development of:
1. models of fire growth in structures
2. tests to measure the fire properties of materials
3. methods and strategies for extinguishing fires

Probability of Success: High

Cost: $1-2M

Time: 2-4 years

Technical Challenges: Continued extension/improvement of efforts already under way.

Technology Transfer: Information must be readily available and rapidly disseminated to those responsible for test method development and fire modeling through technical journals and symposia.

Barriers and Issues: None other than lack of financial resources.

Alternatives: This is fundamental work, requiring state-of-the-art experimental capabilities and strong analytical modeling. Work must be carried out at the highest level.

Key Action Steps: All needed action/research elements.

Impact: Better test methods; improved fire spread/growth modeling efforts.

VIII. Extinguishment Systems

Thrust: Understand extinguishment mechanisms, impact of extinguishing systems in fire growth models on the selection of materials, and the changes to materials properties after an extinguishment agent is applied.

Current Situation: A basic understanding of extinguishment processes is still unknown; more detailed data is needed regarding the interaction of the material and the agent during the combustion process.

Proposed Goals:

1. Ability to model extinguishment action.

2. Ability to determine the most cost effective combination of materials and systems using modeling.

3. Validate trade-off concept.

4. Discover new trade-offs for the installation of suppression systems.

Needed Action:

1. Study combustion process and extinguishment mechanism.

2. Develop modeling capability which includes the addition of detection and suppression system parameters.

3. Model by computer the trade-off concept. Validate by large- and small-scale tests.

4. Study changes in materials properties during combustion when extinguishing agents are applied.

Performers: Government, industry, academia.

Priority: This research is a high priority for the validation of trade-off concept. Design professionals would be able to use the models to predict levels of safety for risk managers who would then make informed decisions.

Success: The probability of success is high, however, there is also a high degree of difficulty. Development of apparatus and testing techniques for studying the extinguishment process will be formidable.

Cost: $2-4 M.

Time: 3 years for production of some significant results and an additional 4 years until the projected completion date.

Technical Challenges:

1. Development of apparatus for studying the extinguishment process.

2. Development of models capable of evaluating the effectiveness of different suppression systems.

3. Development of techniques to measure changes in materials properties when extinguishing agents are applied during the combustion process.

Technology Transfer: User friendly systems will aid both the design professional and the authority having jurisdiction in providing optimum useage of materials and suppression systems.

Barriers and Issues: Money for research and the view held by some that current empirical data is sufficient to provide most cost effective combinations of materials and systems.

Alternatives: Re-evaluation of existing data to assure its optimum application.

Impact: Substantially reduce casualty and property damage figures.

IX. Corrosiveness of Combustion Products

Thrust: Develop test methodology for characterizing corrosive properties of products of combustion.

Current Situation: Current performance criteria for determining material response in combustion toxicology and flammability tests do not characterize the potential for corrosive damage to different substrates.

The corrosive products of combustion can attack materials and change properties critical to the performance of certain products or systems, such as computer components and wiring in electronic control devices.

Proposed Goal(s): Development of methodology will permit characterization of the potential of materials and products to produce corrosive atmospheres. This information can guide: 1) the choice of materials to reduce the production of corrosive products in fires; and 2) the design of components and devices capable of functioning in atmospheres anticipated from fires.

Needed Action: Research to identify problems encountered at actual fires that can be traced to corrosive action of products of combustion. Utilization of current and developing test methodology which prescribes a range of exposure conditions which can be employed in corrosivity testing.

Performers: Government, industry and academia.

Importance: Medium - Needed for design consideration by manufacturers of equipment and components subject to degradation by corrosive products of combustion.

Would assist interior designers in selecting contents and interior finish which in the event of fire would not produce products of combustion that adversely affect performance of sensitive equipment.

Probability of Success: High

Cost: $0.5-1 M

Time to Accomplish: 2 years

Technical Challenge: Requires application of existing materials characterization technology to combustion products.

Technology Transfer: Ordinary channels of information are open to manufacturers of corrosion-sensitive products and to designers of facilities housing corrosion-sensitive equipment. Make performance requirements that will help reduce potential for producing corrosive products of combustion known to manufacturers of interior finish, furnishings and other room contents.

Barriers and Issues: Not a life safety issue and, therefore, may not merit allocation from limited resources.

Alternatives: Isolate susceptible equipment from products of combustion.

Key Action Steps: Preparation of report on problems encountered in actual fires which document need to establish methodology for characterizing corrosive properties of products of combustion.

Impact: Reduce major cost of "clean-up" following a fire.

X. Fire Residues

Thrust: To characterize the material residues from fires. These are defined as the ash, char and violatiles remaining at the fire scene.

Current Situation: Material residues from fires have not been studied and the health effects of exposure to these materials are unknown.

Proposed Goal: Assess the hazards fire residues pose.

Needed Action/Research Elements:

1. Air sampling at fire scene (post fire)

2. Categorize materials, pyrolyze and examine residues for toxicants (unusual or unexpected concentrations).

3. Examine residues of like materials at fire scene and compare with (2).

Performers: Government (fire service) and academia.

Importance: Medium

Cost: $100,000/year

Time to Accomplish: 2-5 years

Technical Challenges: Scientific - Determine toxicant(s) relationships to chronic health problems.

Technical Transfer: For medical treatment.

Barriers: Limitations of fire ground studies

Alternatives: Do nothing.

Key Steps: Collect and assess/samples

Impact: Improve medical treatment of exposed persons.

Materials and Products I

Co-Chairmen - Richard Magee
James Winger

Recorder - Mark Bellow

Panel Members - Richard Brooke
Edward Clougherty
Arthur Cote
Paul Garn
John Nickles
Steven Packham
C. Ross Thompson
Thomas Waterman
Susan Womble

NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Materials and Products II Workshop
of the July 22-25, 1985 Meeting

A. INTRODUCTION

The workshop members organized their deliberations around one question: What research do manufacturers and specifiers need?

The participants first determined that for the purpose of establishing research needs, manufacturers and specifiers--such as architects, interior designers, and other "agents" of the consumer--are sufficiently alike to be considered together. Similarly, the participants determined that it was not useful to break the categories down further although the phrase "materials and products" covers an enormous range of substances, combinations of substances, and goods. Materials and products was taken to mean the wide range of items from basic building materials to consumer products and finished structural assemblies.

The workshop began its task by reviewing the prework papers' recommendations for research, and organized those proposals into categories (Appendix 1). These were later related to major research areas. The members agreed that all of the suggested studies could yield significant and useful information or tools. However, they decided that the broad charge presented to the workshop was best served by identifying a more general set of research needs.

From the list of research needs suggested by workshop members, the participants identified five major research areas in the area of materials and products. These are described in Section B. The first two research areas encompass, in many ways, the products of the remaining three areas identified. However, workshop members agreed that research areas 3, 4, and 5 are of major importance and should stand alone.

The workshop participants also identified significant themes and concerns that cut across all five research areas. Insufficient funding, for example, is a problem that we all complain about. But participants emphasized that the underlying reasons for this absence of funding--lack of concern and conviction that fire research is important, for example--varies in different areas of the field. Thus, modeling research might lack funds because funding agencies have not been persuaded that it is a useful component of fire prevention and control.

The workshop participants also emphasized that in all of the research areas identified, considerable work has already been done. But in many cases, the pieces of research have not been brought together in a comprehensive way that is useful in making design and application decisions. For example, many test methods are available that describe properties of materials but the members felt that a set of tests is needed that can be used with various combinations of materials to predict performance in real-world fires.

Finally, the need for improved data collection and analysis techniques is common to all of the five major areas.

B. MAJOR RESEARCH AREAS

The prework papers and workshop participants perceived research needs were grouped into the following five major research areas.

I. Develop engineering methodologies for fire risk assessment of individual products or materials.

Currently, no adequate methodology exists that can be used to properly evaluate the role of a product or material with respect to fire safety. Because of this, a need exists to develop a system for assessing products' fire performance. Components of this system should include: fire incident data that can lead to the identification of hazard and risk; test methods or models that measure or predict characteristics such as ignition, flamespread, rate of heat release, total heat release, smoke obscuration, and toxicity; a methodology for assigning realistic weighting factors to relevant fire properties based on the end use environment; and methodology for combining each of the above into a tool to assess fire risk.

The goal of this research area is to take data collected from fires and identify key performance parameters, then combine them in a way that permits manufacturers or "specifiers" to systematically evaluate the risk posed by a product in its end use.

Accomplishing this goal will require six research elements. These must be conducted in the following sequence, since each item depends on the completion of the previous item. These are:

1. Improving fire record data collection and analysis capabilities.

2. Developing and modifying tests.

3. Standardizing tests.

4. Continue developing dynamic fire models.

5. Developing a scheme to determine weighting factors to produce a fire risk assessment.

6. Establishing a system of technology transfer to implement and use the methodology.

This work could be conducted in virtually all sectors of the research community. The first, second, and fourth actions could be conducted by investigators from industry, academia, and government. Test standardization, a scheme of weighting factors, and a system of technology transfer could be developed by consensus standards groups. Potential sponsors of actions, except the scheme of weighting factors, could include government, industry, and professional, trade, and testing organizations. The development of a scheme to determine weighing factors would best be developed by the individual paticipants in consensus standards groups.

The participants ranked this research high in importance, as well as in potential for success, albeit over the long term. The cost would range from $4 million to $6 million, and the work would take between 3 and 10 years to complete.

This research could be accomplished with no new technological breakthroughs. However, improvements are needed in data collection and analysis, fire modeling capability. Also a better relationship between test methods and real-world fire situations must be established. In terms of technology transfer, this research area would require publication of findings in journals and standards, and presentation of seminars for the implementation of methodology.

Several barriers impede the successful completion of this research area. Before fire record data can be improved, more funding is needed for proper training and for the acquisition of hardware and software. Also, some industries oppose test development, viewing such tests as threats to their interests. Test standardization, weighting factors, and fire risk assessment are all hampered by lack of consensus about what such standardization should involve. Weighting factors and fire risk assessment both suffer from lack of consensus. A dynamic fire model lacks adequate funding and is also hampered by a skepticism as to the reliability of this methodology. A barrier to technology transfer is its lack of proven capability.

II. Develop engineering methodologies for fire risk assessment of various systems, assemblies and configurations of products.

This research thrust would be based, at least in part, on the data yielded by the first research area. Currently, no method exists to evaluate the combined performance of two or more materials or products in a fire situation, although many fires are in fact fueled by such combinations. A more realistic method for evaluating multiple factors that affect safety of life and property loss from fire is needed for a cost-benefit approach to fire safety. Other work dealing with methodology for fire risk assessment of individual materials and products has an important influence on this research. Previous research forming a part of this study is available and needs to be collected and reviewed.

The goal of this research is to develop the capability of testing the performance of individual materials and products and from that data predict multiple material, product, and system performance. To accomplish this goal, two research actions are needed. First, researchers must investigate fires to study the performance of combinations of materials and products. Second, they must develop models and tests to predict the performance of multiple materials and products and to perform full-scale tests for validation purposes.

With funding from both the public and private sectors, this research could be carried out by investigators in government, industry, and academia. It ranks high in priority, since manufacturers, designers, regulatory officials, and property owners all need to determine fire risk. It also ranks high in its probability of success. Technology transfer would provide a technical basis for making regulatory documents truly performance oriented, and would assist manufacturers in developing products and systems to provide levels of fire safety. The cost is estimated at between $0.5 million and $2 million per year over a 10-year period. The barriers are economics and codes.

III. <u>Evaluate human (consumer, specifics, etc.) behavior relative to materials and product use</u>.

If consumers did not misuse products, there would be a substantial reduction in the number of fires. Fires caused by clothes draped over a heater, a dropped cigarette, or food left on a stove are not primarily problems with products. Similarly, do-it-yourselfers are unregulated and continue to install finished walls, heaters, fireplaces, woodstoves, and other materials and products. These circumstances generate a need to determine how to motivate and educate consumers on appropriate behavior. Getting people to behave in a safer fashion--as they do in other countries--could sharply reduce the problem. Alternatively, materials and products can be made more resistant to consumer misuse.

The goal of this research area is to reduce the rates of injury and death, as well as the incidence of fires, caused by carelessness and misuse of products and materials. A second goal is to increase the number of buildings, especially dwellings, that have properly operating fire detection and suppression systems. A third goal is to educate consumers to select products by safety characteristics.

To accomplish this goal, four research actions are necessary.

1. Summarize existing information on how behavior is affected and how attitudes are shaped.

2. Investigate how to increase consumer awareness and how to overcome consumer apathy.

3. Research the accuracy of data on fire causes, ways to improve this data base, and uses to which the data can be put.

4. Research escape and safety methodologies with respect to smoke generation, combustion, or other aspects of products and materials.

This research could be conducted by investigators from private industry, academia, market research organizations, and behavioral research organizations. The research ranks high in priority; the subject has largely been ignored and little research has been done. The probability of success is also high; established methods of market research are applicable to the problem. The cost is estimated at $10 million over the next five years, a figure that includes the cost of disseminating information and conducting education campaigns. This public information program would also be the chief technology transfer agent needed.

The chief technological challenge in this research would be pinpointing the triggers that motivate people to practice safety.

Currently, four barriers impede progress in this research area. First, the fire research community retains a bias against soft research, a bias that is reflected both in the allocation of research funds and in acceptance of research results. The CFR and the National Fire Research Strategy Conference have a hard science orientation, with bias against human behavioral research, although such research is explicitly included in the CFR charter. Second, the research is hampered by our limited knowledge about attitudes on fire safety; this low knowledge base provides little foundation to build on. Third, such research is hard to do accurately, as evidenced by Coca-Cola's recent costly marketing research that nevertheless resulted in product failure. Fourth, the average consumer gives low weight to safety when he purchases products.

IV. Evaluate capability and reliability of products that reduce the risk of fire.

People put a lot of trust in smoke detectors, sprinklers, and other fire safety devices. Currently, however, we do not know when the first generation of detectors will fail; there are signs that this is already happening. Detectors also have high false-alarm rates. The industry is in a price-driven market, with no standard to force reliability and durability. Neither do we know the reliability of the new fast-acting residential sprinkler systems. Some people are skeptical about whether these products will perform as their promoters claim. There are no standard reliability test methods and criteria for many fire safety products, including dampers, fire resistant finishes, and others. Longevity is a particular issue.

The first goals of this research area are to establish information on reliability and to develop a set of tests and standards for reliability. Another related goal is to make consumer products with built-in tolerance for behavior error.

Four research elements are necessary to meet these goals.

1. Laboratory and field research on the causes of device failure and false alarm.

2. Obtain failure incidence data from devices in the field over the long term, after developing a standard format for data collection.

3. Develop methods and criteria for testing the reliability of devices. (Do not rely on the minimum standards currently in effect.)

4. Research ways to improve quality, reliability, and performance characteristics (e.g., different day-night sensitivities), and to reduce false alarms.

5. Research ways to improve products to make them more tolerant of behavioral errors.

This research could be conducted by CFR, USFA, CPSC, and by private manufacturers, university-based researchers, the fire service, fire research organizations, and testing laboratories. It ranks high in importance--particularly work on smoke detector reliability in homes--and carries a high probability of success. The cost would range from $1 million to $3 million over a three-year period. The technological challenge would be to develop short-term test methods that accurately predict long-term performance. Increased stress tests may not be valid in this respect. A second challenge would be economic: how to build in reliability at a low cost, and how to avoid pushing reliability out of the market by price competition.

The single barrier to this research area is the assumption by some people that current test methods do apply to new fire safety devices. Those who believe they do raise barriers to the need for further testing. The key issue is whether current testing is adequate to predict long-term reliability.

V. <u>Develop fire tests and models that accurately measure and predict the fire performance of products</u>.

An underlying theme of fire research is the development of reliable and cost-effective fire tests and models. In particular, fire tests will probably always be a part of establishing fire performance. Tests, however, can be costly and expanded use of analysis is desirable. There has been significant progress in this area, particularly in the last decade, but substantial effort is still required.

At present, the methods of reliably modeling and testing fire performance are not generally available or affordable. Single tests are often used to evaluate material and product fire characteristics, where sets of tests would produce more accurate depictions of real-fire performance.

The goal of this research area is to construct methods of analysis and a series of laboratory-scale fire tests that permit prediction of fire development under those fire scenarios that create the highest incidence of loss of life and damage to property.

To accomplish that goal, four research elements are necessary.

1. Assess current predictive and test methods of evaluating fire performance by controlled full-scale fire experiments.

2. Reduce this assessment into predictive-model format.

3. Develop computer programs and graphics to predict performance and present results.

4. Conduct fundamental research to develop the technology base on which fire tests and models are established.

This research could be conducted by government agencies, university-based researchers, and private industry. Interaction and communication among these groups is particularly important for success. This research ranks high in importance, since all elements of society benefit from the reduced costs of fire loss that this would produce. Although the research is difficult, the probability of success is high. The cost would range from $1 million to $2 million annually, and could be accomplished over a five- to ten-year period. The chief technical challenge would be making stand-alone computer capabilities widely available, and achieving a better understanding of pyrolysis and turbulent combustion processes. Technology transfer could be achieved through CFR reports.

The barriers to success are similar to those of research areas one and two. In addition, progress would be hampered by a lack of communication between the various constituencies in fire research community.

C. INITIATING THE WORK

The research described should be, and probably can only be, accomplished if all interests participate, including Federal, state and local government, manufacturers, specifiers, private consulting and research organizations, and academia. Federal funds, at least in the form of seed money, will be required for intiation of work.

The research into materials and products is recommended in a cohesive package, both technically and adminstratively. Management accomplishment in this area, including attracting funding and technology transfer, will be at least as difficult as technical progress.

One reasonable strategy for initiating and sustaining work in this critical area is to first plan and outline in detail the required research and projected benefits (pay-off). This could be done using Federal seed money to several diverse organizations who would independently develop technical and administrative/management strategies. Since the goal would be to identify the best and most comprehensive strategy, duplication of effort should not be of concern. At least six projects funded at $50,000 each should produce the necessary first step. The second essential step would be to initiate dialogue through a third party to consolidate all of the work. The next step would be to "assemble" a research "team" to initiate work under oversight of a single organization, whose task would be to facilitate work, maintain a dialogue and provide for continuous review of results among various performers. Work should be done in relatively small, discrete pieces with rigid deadlines. Review teams of experts from all appropriate disciplines should be convened, on at least an annual basis, to provide guidance and arrange field "testing".

D. PAY-OFF

The results of the research described would be measured as a part of the overall program. Pay-off is expected in terms of: improved fire safety of materials and products; reduced costs of materials and products; reduced costs of testing; greater certainty in real fire performance; and attendant reduction in fire loss.

E. FUNDING SUMMARY

The workshop participants did not agree on specific levels of funding or time frame required. Ranges were adopted as follow:

Research Area One - $4-6 Million over 3-10 years
Research Area Two - $5-20 Million over 10 years
Research Area Three - $10 Million over 5 years
Research Area Four - $1-3 Million over 3 years
Research Area Five - $1-2 Million over 5-10 years

(A reasonable goal based on the above might be $9 million per year for 5 years.)

F. ADDITIONAL OPINIONS

On several issues some workshop members felt important items were not addressed or required additional information. Time permitted only brief expositions on these topics.

Research Area Number Three

Not much spent in last ten years on behavioral research. While the costs may appear disproportionately high for the next few years, they are a small fraction of the total for the long run.

Psychological research is expensive and takes time; it involves large samples of people. Also, there are many products--consumer equipment, materials, fire safety devices--that each have their own aspects to measure.

This issue deals directly with the people part of the problem--the morbidity and mortality rates. It will have a high benefit-cost ratio.

Most people attending the conference are scientists or engineers. A "vote" on priorities from them is unlikely to reflect the importance and potential payoff of this area.

Research Area Number Four

Presently the approval standard of independent testing laboratories such as UL and FM for many building and fire safety products already contain criteria for essential reliability and capability factors as a condition for these products receiving such approval. Fire sprinklers, both standard response, quick response and residential sprinklers, are prime examples. While this might not apply to the complete universe of all products, there is no apparent need to expand research dollars and effort in such a pursuit. Further, the cost to fund such duplicate effort would be astronomical.

Material and Products II

Co-Chairmen - Richard Gewain
J. Thomas Hughes

Recorder - Susan Walton

Panel Members - John Blair
Nicholas Chergotis
Gerard Faeth
Frank Fee
Robert Glowinski
Ralph Johnson
William Koffel
James Milke
Paul Quigg
Philip Schaenman
Robert Williamson

APPENDIX 1 - Materials and Products II

The following list is based on prework papers submitted by participants. The parenthetical numbers indicate research area in which workshop members placed the proposals.

A. Materials Properties Research/Test Methods

1. Basic Fire Research (1, 5, 2)
2. Smoldering Fires (1, 5, 2)
3. Escape Data, Smoke (1 + 5)
4. Fire Toxicity Hazard Standards Experiments (1, 5, 2)
5. Fire Safety Under Zero Gravity (2, 1, 5)
6. Smoke Generation from New Building Products (1 + 5)
7. Quantify Toxicity and Corrosiveness of Products of Combustion (5)
8. Structural Fire Performance of Building Components (2, 5, 1)
9. Small-Scale Flammability Test (5)
10. Chemistry and Chemical Kinetics of Fires (5)
11. Measurement of Product Characteristics (1 + 5)

B. Modeling/Predicting

1. Predicting Heat Transfer (5)
2. Structural Model for Wood (5, 2)
3. Link Solid and Gas-Phase Predictive Models (5)
4. Predict Flame Radiation (5)
5. Predicting Product Performance from Small-Scale Tests (5)

C. Use of Results of Research/Design

1. Define Level of Fire Safety (1, 2)
2. Technology Transfer (1 - 5)
3. Institutional Mechanisms (1 - 5)
4. Computerized Requirements and Design System (2)
5. Fire Safety Information System (1 + 5)
6. "Handbook" of Fire Properties (5, 1, 2)
7. Toxicity Data and Choice of Materials (5)

D. Specific Product Development/Information

1. Solid and Liquid Heating Devices (3)
2. Escape Mask Impact (4, 3)
3. Fire Growth Assessment by Detector System (4)
4. False Alarm Study (4)
5. Detecting Small Fire (4)
6. Smoke Detector Response
7. Fire Retardants and Fire Performance (4)
8. Fire Resistant Materials for Aircraft (4)
9. Fast Response Sprinklers vs Standard Sprinklers (4)
10. Expand Usage of ESFR Type Sprinklers (4)
11. Fast Response Sprinklers and Life Safety (4)
12. Cost-Benefit of Residential Sprinklers (4)

E. Cost of Litigation vs Research

1. Expenditures for Litigation vs Research (1)

NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Design and Engineering I Workshop
at the July 22-25, 1985 Meeting

A. INTRODUCTION

The Design and Engineering Workshop discussed the research necessary to permit design engineers to supplement technical expert judgment with technical data.

The Workshop decided to focus on the research necessary to quantify safety, rather than on the research necessary to quantify the fire performance of materials and building components. It recognized, however, that good test methods, which do not exist in some areas, are a prerequisite to having an engineering-based system of design.

Three major thrusts were identified: improvements in fire modeling; making full scale assessments of hazard from small scale tests; and fire risk assessment. These thrusts are all related, and there are similar barriers to their respective exploitation. Thus, the common barriers and the means to overcome them are discussed together.

B. RESEARCH THRUSTS/NEEDS

I. Fire Modeling

Thrust: Improvement of predictive capabilities of fire models

Current Situation: Fire modeling, a field which has been developing over the last 10 years, needs amplification and application to be truly effective. There is also a need to develop a body of research data which can be used to provide accurate input to the models.

Proposed Goals: To obtain accurate and reliable engineering tools, or models, for design of fire-safe facilities.

Needed Actions: The Workshop believes that research is required to improve models' predictive capability in the following areas:

1. Fire Growth - vertical flame spread; heat transfer: effects of ventilation.

2. Fire Suppression - action of suppressing agents.

3. Response of detectors to flaming and smoldering combustion - effects of ventilation on smoke movement.

4. Structural response to fire (Human response needs to be investigated by others but this is not an issue for this Workshop.)

5. Full scale tests of representative configurations.

6. Definition of range of validity of models.

7. Fire-related material properties - heat of combustion; heat of gasification; thermal conductivity.

Performers: Government, academic, fire research laboratories (public and private). Computer facilities are available; large scale testing will require specific facilities.

Priority Factors:

A. The importance of this research is high with a high probability of success. The cost is anticipated to be high. Most of the research would be on a continuing basis.

B. The research results will be used by the following groups to obtain accurate and reliable engineering tools on models for the design of fire-safe facilities: architects; construction specifiers; fire protection engineers; and insurance companies.

C. The following groups will benefit:

1. The construction industry and manufacturers of building material (conventional and changing technology) will benefit through increased market penetration, reduced liability and more rapid acceptance of emerging technology.

2. The detection/alarm industry, the sprinkler industry, the chemical suppressant industry, the transportation industry (airlines, ships), and building owners and operators will benefit through maximizing design efficiencies for effective life safety applications and design.

Technical Challenges: This research requires continuation and refinement of past and current programs. Additional fundamental information on the action of fire suppressant agents is needed.

Technology Transfer: Attention must be paid to making the fire models "user friendly."

II. Full Scale Hazards from Small Scale Tests

Thrust: A reliable methodology for determining full-scale hazards from a limited number of small-scale tests is needed.

Current Situation: This workshop concluded that there are currently few programs to communicate, integrate and generalize such data.

Proposed Goals: To develop the capability to make accurate assessments of overall fire hazards using small-scale test results.

Needed Actions: Develop procedure for predicting full scale hazard from small scale test results. Analysis should conform to the following guidelines:

1. Validation of small-scale tests is essential.

2. Initial validation procedure must be sufficiently broad to test expected range of physical parameters.

3. There should be compatability among small-scale data, full-scale measurements, and input data for analytical models.

4. Final test procedures should emphasize small-scale test parameters.

5. Validation tests should duplicate realistic fire situations.

6. Resulting test methods for fire safety practitioners need to be economical, reproducible, and simple.

Performers: ASTM, SFPE, NFPA, NBS, Private Organizations

Priority Factors:

The importance of this Thrust was rated high. The likelihood of success, the cost, and the time required are all interrelated.

It is needed by designers, regulators and manufacturers for better design, regulation and manufacturing and for the reduction of complexity of testing procedures.

Technical Breakthroughs Required and Technical Challenges

Breakthroughs: Fit small scale toxicity test results to predict full scale fire environments.
Define parameters of upward flame spread.

Challenges: Define fire performance of materials in varied geometries.
Develop more emphasis in procedures of physical scaling.

Technology Transfer: Not a significant problem in this area.

Barriers: The major barriers are: An inadequate supply of new professionals; a reluctance of manufacturers to participate, due to the proprietary nature of product information and industry needs for individual market segments.

Actions to overcome Barriers would include:

1. Identification of resource centers and advertise these to community.

2. Development of overall cost/benefit analysis procedures for producer and user.

3. Application of new results to show better and more general performance analysis of materials.

III. Fire Risk Assessment

Thrust: Develop a professionally accepted methodology which will objectively assess the fire hazard severity, and which will quantify fire safety goals. The design and engineering of facilities will be enhanced by use of this methodology which will permit comparison of alternative approaches to meeting fire safety goals.

Current Situation: Experts recognize that design engineers currently lack the ability to quantify input data as well as output objectives. Codes and standards are often based on arbitrary guidelines for protection levels, failing to provide quantifiable objectives that could be used to compare alternative approaches or designs for achieving fire safety. Some attempts to deal with these situations are in phases of development.

Proposed Goals: Establish methods that would allow practitioners to design and/or evaluate fire protection approaches, based on an assessment of actual "real life" hazards. Endorse development of quantitative methods that define levels of risk, and fire protection. Promote design and/or comparison of design alternatives to better assist fire safety efforts.

Needed Action: Research in this field should stress:

1. Coordination and integration of existing test methods and standards.

2. Modeling that defines relationships among variables, selecting critical elements in different situations.

3. Response to proposed actions of Thrusts I and II (Fire Modeling and Full Scale Hazards from Small Scale Tests).

Performers:

1. Prof. Fitzgerald of WPI has made an initial effort to develop such a system. NFPA Committee on Systems Concepts is also involved in this area; additional efforts have been initiated by others.

2. The Society of Fire Protection Engineers should take a leading position in this area, through a reestablishment of its Research Committee.

3. The system will require consensus support from other groups that are involved in fire protection. Ongoing review and development will be needed to stay current with emerging technology and to deal with diverse needs and situations. If re-established, the SFPE Research Committee could deal with this need on a continuing basis, actively seeking comments and participation from all groups involved.

Priority Factors: The importance of the research is high with a medium probability of success. The cost is anticipated to be medium to high. The work should be completed in a medium time frame.

Technical Challenges:

1. Development of objective data bases for use in discrete areas.

2. Identification of gaps in existing technology--and completion of research projects to provide data as well as concepts that are not currently available.

3. Devising a means to coordinate the application of data derived from many different areas.

Barriers: There are many barriers, both professional as well as societal, to improved fire safety. These barriers can be divided into four major categories: 1. Technology Transfer, 2. Education, 3. Funding and 4. Direction/coordination of efforts. A barrier to sharing data and experience in fire safety is the proprietary nature of innovations. Understandably, companies of all sizes are reluctant to take steps which would promote sharing of breakthroughs in R&D. This is a common problem, but exacerbated because of concern over questions of product liability or product image.

To implement an effective fire research program for design professionals, closer interface must be maintained with other fields. Fire safety, though very important, is not the sole function of a facility, be it a hospital, hotel, warehouse or manufacturing facility. Integrating fire safety concepts with functional design is not generally accomplished adequately.

Technology Transfer: This is technology transfer--making use of current and future research and data to develop improved engineering techniques.

Technology transfer means using and sharing research and data.

To improve technology transfer, this workshop offers the following recommendations:

1. An information management system should be developed to facilitate the dissemination and retrieval of fire research results. The Society of Fire Protection Engineers should take the lead in developing such a system. Additionally, the Fire Research Abstracts and Reviews, once supported by USFA/FEMA, should be re-instituted, and entered into a computer based information management system. It would appear that a grant is necessary to accomplish this latter task.

2. Researchers in applied, as well as fundamental, areas should be encouraged to publish in refereed journals. This may require the establishment of a peer-reviewed journal oriented to applied research.

3. The USFA mission of Technology Transfer should be revitalized.

4. Federally-sponsored research should include a Technology Transfer component program as an objective.

Education barriers identified by the Workshop encompass both the practitioners and enforcers respectively of fire safety.

C. GENERAL COMMENTS

Fire safety issues are becoming increasingly complex. They often surpass the seemingly disparate interests and qualifications of architects, engineers, building code officials and other regulatory professionals. The workshop members feel that this gap hampers efforts of the well-intentioned majority in those fields, who remain reluctant to make decisions and formulate policies which depart from traditional "cookbook" solutions to fire protection. Regulations and fire code changes now, and in the future, will require greater technical sophistication.

The workshop recommends that these efforts to educate both the public and the fire safety professionals be continued and expanded as follows:

1. Continuing engineering education programs for fire protection professionals should be developed and presented. The SFPE has taken the lead in this effort. That effort needs to be supplemented by engineering colleges.

2. Concerted efforts must be directed toward the development of new fire protection engineering programs at both graduate and undergraduate levels.

3. Public awareness and public education on fire safety should be strengthened. The NFPA and USFA have the lead in this effort.

Funding of research was also identified as a barrier to achieving the goals identified by the workshop.

All disciplines and occupations playing a role in fire safety--engineers, designers, regulators and equipment manufacturers--suffer from a shortage of funds and from limited staff resources in support of research and training. In part, this situation developed because of a lack of strong constituencies, in both the public and private sectors, that would marshal greater financial support for programs championed by most experts in fire safety.

The most pervasive barrier identified was the lack of direction and coordination of the entire fire safety research effort. Research is usually conducted on a crisis management basis, and relies too often on a disaster-directed mode. A handful of well-publicized fires--kept alive in media accounts--force the field to initiate research projects limited in scope, and of scant value in the overall context of fire safety.

Those professionals in the field do not always see the value in developing and/or implementing improved solutions. Many employed in fire safety at all levels prefer to adopt a "let the other guy do it" approach. The workshop concludes that this situation is not the result of a lack of good intentions--since efforts of many companies as well as government agencies and associations are commendable and demonstrate a long-standing involvement. Rather, it is an information gap which fragments the field and its professional corps. This gap emphasizes differences, not common interests, and fosters a sense of powerlessness on the part of those who might become more active.

Economic disincentives curtail efforts of practitioners to move beyond horizons of immediate, short-term financial gain. Recognition of an existing status quo, and the perception on the part of too many in the field that the status quo is desirable, constitutes a major shortcoming.

The workshop members believe that this conference itself is a major step toward providing needed direction and coordination to achieve a technology-driven program. To facilitate this coordination, the workshop further recommends the following:

1. A higher level of rational attention be given to the fire problem in the U.S. This national focus can come only from government and private sector cooperation.

2. Basic guidelines on fire research--which identify key measurements of broad application--should be developed and implemented. These would allow more effective use and coordination of ad hoc testing and research within the overall framework identified in the stated needs section of this document.

<u>Design and Engineering I</u>

Co-Chairmen - Frederic Clarke
Kenneth Dungan

Recorder - Julian Weiss

Panel Members - Norman Alvares
Jack Barritt
Paul Croce
Rolf Jensen
Charles Lazzara
Roy Mathers
David McCormick
Wayne Moore
J. Gordon Routley
Frank Shisler
Merwin Sibulkin

NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Design and Engineering II Workshop
at the July 22-25, 1985 Meeting

A. SUMMARY

The primary research goal identified by this workshop is the development of knowledge-based, performance-oriented codes and standards. With this aim, we established priorities in two areas - Long Range Research Thrusts and Immediate Research Thrusts. The former consists of, in order: 1) Modeling; 2) Expert Systems; and 3) Fire Safety Measuration. The second group includes: 1) Smoke; 2) Fire Protection Systems; 3) Building Technology; and 4) Information Transfer. For each of the latter, a problem statement, a set of research needs and a strategy are presented. A common description of the barriers faced by our research thrusts concludes this report.

B. INTRODUCTION

The workshop group consisted of thirteen members with different affiliations and areas of interest.

Affiliation

- FRCA, PCA, SCA*
- NCSBCS, NIH, BOCA
- FM, UL
- University of California - Berkeley
- Grinnell Fire Protection Systems Co.
- Ruskin Manufacturing Co.
- The Gamewell Corp.
- Shaw Associates
- Koppers Co.

Areas of Interest

- Building Codes
- Test and Evaluation
- Fire Retardant Chemicals
- Fire Retardant Treatments
- Smoke Control
- Alarm Systems
- Sprinkler Systems
- Operational Fire Safety
- Industrial Fire Research
- Academic Fire Research

The group was charged with discussing the research necessary to permit designers and engineers to supplement subjective judgment with technical information. Facts, data and methods would be systematically assembled,

*Full names of organizations are listed in Appendix C.

to permit credible measurement of the level of safety inherent in the design and engineering of facilities, equipment, and vehicles.

The discussion focused on the designer and involved the development of long range and immediate goals dedicated to: 1) the development of knowledge-based codes and standards and 2) information and technology transfer.

In each of the three long range and four immediate major thrusts identified below, the problems, research needs, and strategies are sequentially discussed. Barriers were found to be common and are, therefore, described in one section at the end of this report.

C. LONG RANGE RESEARCH THRUSTS

I. Modeling

Once the workshop arrived at the consensus that its primary goal was to encourage knowledge-based code and standard development, the item of highest continuing and long range priority became model development and validation. The term "knowledge-based" needs careful definition. If a requirement is based on fundamental physical principles, through detailed mathematical quantification and experimental verification, it is called "knowledge-based." An example is structural design based on beam and plate theory which permits calculations of deflections and stresses; and therefore, of safety by comparison with known yield strengths as a function of the anticipated applied load. To be able to perform such a calculation for fire safety is our aim. Because this ability is beyond the forefront of current technology, a considerable research effort is required. Until that effort is complete, we will rely on existing "consensus-based" codes and standards, which establish the currently best available methods for achieving fire safety.

The transition between these two types of standards will be gradual and continuous. Current techniques may continue unchanged. We will, however, understand their consequences; and therefore, be able to quantitatively assess trade-offs between alternative approaches to the same safety goals. A consequence of this understanding will be the possibility of having performance codes instead of specification codes. Again, definitions are appropriate. A "Performance" code means that a result is required by law and that the method by which that result is achieved is left to the discretion of the designer. However, he then assumes the burden of proof to show quantitatively that the required safety is achieved by his design. Because we now lack the ability to make quantitative predictions, the current system is largely one of specification. A "Specification" code means that a specified method is required by law. Once validated computer models and expert systems become available, the more cost effective performance code for achieving fire safety will be possible.

Because the needed fire modeling is so broad in scope and long range in time scale, the workshop identified it as having highest priority. We could not define in the time available more detailed research needs, barriers, or action items. Suffice it to say that the Center for Fire Research (CFR) at the National Bureau of Standards (NBS) is uniquely well-equipped to identify initial action items and direct their execution internally and externally and that such activity is of primary importance to a successful national fire safety strategy.

II. Expert Systems

During the discussion of the needs of designers/engineers, a recurring theme was the fact that to optimize fire safety design, expert consultants are usually very desireable. While it is recognized that practicing consultants have considerable expertise, they are few in number and quite often limited to specific areas (e.g., a particular code or standard, or technical area). During early design stages, mistakes, and the escalating costs to correct them, can delay a new building or facility. As existing buildings can be expected to change in occupancy and structural features with time, the ability to quickly evaluate the fire safety of the modified structure is a crucial engineering need.

Expert systems offer two outstanding potential features for the design/engineering/code enforcing community. First, they provide an excellent means for transferring research results to the end user (as is discussed elsewhere in this report). Second, they provide a superior means of implementing the desired transfer toward knowledge-based codes. Their promise in this regard springs from the fact that the ability to combine actual research results and fire measurements with the experience and practical judgment of recognized experts allows informed users to reach rational decisions on various engineering and design matters. If variations from codes and standards or an innovative approach to a design problem must be considered, these systems should help everyone better understand the possible consequences of such an action, especially if the level of fire safety is affected.

The technical obstacles that must be overcome to permit widespread use of expert systems are formidable. These systems will probably require microprocessor capability that does not exist today. In addition, a system will have to be able to synthesize fire behavior through the use of models - most all of which will need to be developed. Identification and programming of the "expert" will be needed. Given the complexity of specific fire problems, this programming will be costly and time consuming. Finally, the cost effectiveness of such systems will need to be addressed, especially if computer costs for running complex models remain high.

As is discussed elsewhere, the CFR must take the lead role in the development of such systems. Because their development is so closely tied to model development and indicated need, it is not possible to prioritize what systems should be developed first. The potential benefits of this technology are such that we believe that their development -- as well as the development of the underlying models -- should be a priority. Further, they should be made available to the practicing community as soon as possible after their development so as to begin the movement toward knowledge based codes and standards which permit the designer and regulator to make rational decisions on design, installation, and tradeoff issues.

III. Fire Safety Measuration

The third long range goal which evolved from our workshop consensus was the problem of developing measuration techniques to assess the level of fire safety. Two separate problems exist: 1) find methods to evaluate the fire safety inherent in a given design; and 2) decide what level of safety is acceptable. The first is easier since it is a technical question with primary input from classical disciplines, such as fluid mechanics, heat transfer, mechanics and risk analysis. The second combines social and political sciences as well as economic decisions associated with tradeoffs, risk transfer, redundancy, etc.

To a large extent, the research necessary to determine what levels of fire safety measuration are required will depend on other activities described in this report. As our understanding of fire dynamics improves through model development and the rationale for understanding the design of structures and fire protection systems improves, our ability to assess practical limits to fire safety will improve. It is our belief that if knowledge-based standards and codes are to become a reality, there must be a consensus over what is to be gained in the way of fire safety.

This is a problem for the entire fire research community. Establishment of a framework by which such decisions can be made should start now. CFR and the United States Fire Administration (USFA) coupled with the possible continuing input of this Strategy Conference should lead in defining what issues and research is needed to develop the necessary consensus. Individual groups -- i.e., industry, government, research and testing labs, insurance and risk analysis and the standards organizations -- should then be able to develop individual objectives so that a final agreement can be reached on appropriate levels of fire safety.

D. IMMEDIATE MAJOR RESEARCH THRUSTS

IV. Smoke

Problem: A major immediate research thrust identified by our workshop was that of smoke, its quantification and control.

Needs: Questions we identified as needing answers through existing or imminent fire research fall into three categories.

1. Characterization: What is the definition of smoke? How do we measure it? What constitutes the safety hazard of smoke -- is it toxicity, obscuration, soot, or other aspects such as corrosivity?

2. Production: How do we predict smoke production rates in a given fire scenario? How does smoke type and amount change with fire scale? How does smoke evolve as it moves away from its sources?

3. Transport and Control: How does smoke travel? When does pressurization suffice and when are mechanical barriers necessary to control its movement? How do we evaluate the interaction of smoke control systems with suppression systems such as sprinklers? Are refuge areas viable and when will people be willing to use them? How do we establish design criteria for full scale tests of smoke control systems to establish their credibility and reliability?

These questions effectively state a problem which is well-posed and within the competence of the fire research community. The solution to this problem may be the most readily obtainable, directly visible, useful product of our fire research effort. As noted by the Congressmen Wednesday morning, such evidence would make funding of fire research an easier task.

Strategy: The approach to address this need which emerged as our group's consensus was that the Center for Fire Research at NBS take the lead on this problem, based on its existing skill level and available facilities, particularly in modeling and measuration. We see three stages of activity:

1. Define needed results. This is a multi-organizational task with input and possible funding from ASHRAE, OLS (Operation-Life Safety), USFA, NFPRF, NCSBCS, FAA, et al.

2. Develop and implement a detailed research program. CFR should do this utilizing internal expertise on aerosols, toxicity and fluid mechanics with external expertise from universities, research and testing laboratories in the United States as well as with NRC in Canada and the BRI in Japan assisting as required to optimize progress.

3. Implementation. This is a key step which imposes on researchers the responsibility of following through on the results of their work to the point of a quantifiable impact on life safety. Again, a marriage of diverse groups such as CFR, USFA, OLS, ASHRAE, et al, is envisioned here.

A primary advantage of this research area is the coupling of a high probability of success (this problem being within existing research competence), with an opportunity for a large impact since many fire deaths appear to be smoke related. The workshop therefore suggests that this major thrust receive immediate and concentrated attention.

V. FIRE PROTECTION SYSTEMS

Problem: A major research thrust is the need to systemmatically investigate the effectiveness of active fire protection systems in all types of fires. The need is based on the established fact that there is no single, uniform fire which exhibits similar properties of heat transfer, flame spread, smoke production, etc. In addition, new technologies are being considered for wide-spread use in buildings and new expectations of human behavior--based on recent research--will be affecting the design of safety systems. We anticipate that designers/engineers/code enforcement personnel are now routinely engaged in questioning applications of these technologies -- most critically in the areas of tradeoffs and redundancies in levels of protection.

Needs: Three areas of needed research were identified: 1) suppression systems, most notably sprinklers; 2) detection devices, most notably smoke detectors; and 3) alarm systems. Of most concern was the ability to generate information for all three types of systems which would enable the designer/engineer to install and use the systems in a way dictated by occupancy or construction features. In addition, the evaluation of devices by testing laboratories was seen as requiring study to determine if existing standards are appropriate for the level of technology as it exists today.

Table I outlines specific questions and needs in this area. In general, the major components of this research thrust include four distinct areas:

a. Development of criteria for selecting/developing fire protection system. One type of fire protection systems is not suitable for all possible fires in an area. Of special note is the question of flaming vs. smoldering combustion as it pertains to life safety, suppression, egress, etc.

b. Development of information on the performance of smoke detectors in large-scale fire and of criteria for the appropriate level of sensitivity for a given occupancy to prevent unwanted false alarms, etc.

c. Development of application criteria regarding response characteristics, effectiveness, installation criteria, etc., given particular construction and occupancy factors.

d. Establishment of appropriate alarm technology and awareness to help ensure people respond appropriately and quickly in a fire emergency. Included in this area is the need to better understand human behavior in a fire emergency.

Strategy: Past programs suggest that any progress in this area will require a concerted effort on the part of the private sector (manufacturing interests, testing and research laboratories, and certain standards groups) and the U.S. Fire Administration. A suggested strategy is for the USFA -- possibly working together with the CFR -- to develop a program outline which will address the major technical issues and serve as a blueprint for developing the research framework.

It is believed several fire research centers have the capability to perform most of the required work. Investigation of human response factors may require involvement of non-fire researchers (although the CFR could do this work). It is also believed that funding or sponsorship would be available from several sources: the USFA for those areas responsive to the charge given them in America Burning; the manufacturing industry through individual manufacturers or trade associations such as National Fire Sprinkler Association, NEMA, etc., and by individual organizations such as independent testing labs, insurance interests, building groups, etc. Use of a private sector group such as Operation Life Safety or the National Fire Protection Research Foundation (NFPRF) to act as a central coordinating point for the fund raising and program administration is also desirable. Such an entity could coordinate technical expertise from around the country to monitor the research activity for responsiveness to needs, technical merit, etc.

Sufficient technical capability now exists to perform this program. It is expected that work could be completed in 3-5 years. Although there are three distinct programs involved, some suppression/detection tests could be conducted in concert with others to reduce costs. The results should be easy to assimilate into engineering and design practice, especially if the underlying assumptions, limitations, etc., are incorporated into knowledge based codes and standards which permit the designer to make rational decisions on design, installation and tradeoff issues.

VI. BUILDING TECHNOLOGY

Problem and Needs: The discussion of major research thrusts related to building technology crystallized several important components in a field in which much research has already been completed. The urgent research needs arrived at with the working group involved synthesizing existing information, questioning criteria, and model creation.

We look to a system for evaluating available data and prior research results to determine whether existing criteria are valid. We suggest the following:

1. Critical assessment of what is in place now; i.e., data, past experience, rating tests, etc., to determine the performance and cost effectiveness of present criteria.

2. Development of a model to predict fire assault on structures and the structural response to fire. This model should consider: occupancy conditions, fire loading, in-site protection systems, etc.

Strategy: The overall strategy to achieve structural research needs, like the other major thrust areas, involves a wide ranging coalition. The organizing partner (and program developer) should be the National Bureau of Standards because of their disinterested position, varied expertise centers (Center for Fire Research and Center for Building Technology) and the existing capability to provide verification of the building technology that already exists.

While the coalition approach assumes several working partners in this research effort, primary support should necessarily come from the various materials interests under the banner of their associations (AISI, PCA, NFPA, SPI, Gypsum, etc.) with funding of existing product research.

The potential exists for research in this area to have a significant and perhaps near term impact because much of it involves a synthesis of existing data, with our workshop's expressed priorities of model development and information transfer.

VII. INFORMATION TRANSFER

Problem: Any discussion on information transfer must answer several key questions: What is available? Who needs it? In what form do they need it? What technology should be brought to bear to improve the form of that information transfer tomorrow? Over the years, considerable fire research has been conducted without including provisions for transferring the information to the next user. That audience may vary. For example, the output of a basic research project is probably best directed to an applied research effort and the latter must be responsive to the designer and engineer. Certainly, the form of the information must be such that the designer and engineer can best use it. To date, however, that form is almost always limited to reports, papers, monographs, etc., which are often difficult to directly use in a specific design case. As the quantity of research information grows, it will become more and more difficult for designers and engineers to remain current.

Need: Obviously, any research project should have the requirements of the next user in mind. Beyond that, however, is a need to allow informed users to have ready access to existing data in a form that can also be readily used. A key part of this need is the recognition that fire is an extremely complex subject. To assure that technical decisions are made as accurately as possible, it is highly desirable to continue the long-range development of expert systems on a priority basis. In the meantime, the development of engineering data bases and improved transfer mechanisms could greatly facilitate application of existing technology.

Strategy: The need for improving our capabilities in transferring research results to the design, engineering and code enforcement community is a very high priority need. Because of its unique position and capabilities, CFR is the best qualified to lead the national effort to improve this effort. Specific action plans include:

a. Development and support for existing mechanisms of developing and maintaining data bases on world-wide fire research and related activities, (e.g., incident reporting). CFR and USFA funding of such activities is essential, as is the need to provide means to make such information freely available and accessible.

b. Through its contacts with universities and the educational community, the CFR should develop means to introduce fire science concepts into the education channels of architects, engineers and other technical courses. Cooperation with the National Science Foundation should assist in this effort.

c. With the CFR in the lead, continue research into the development of expert systems. Independent research laboratories and universities should also be involved. Because of the wide-spread interest in expert systems at NBS, the CFR is again uniquely qualified to lead in the research effort to apply this technology to fire and fire protection design, assist the private sector in developing systems of interest and in correlating the latest in model development into the systems to assure they remain current and in step with the latest measuration technology.

The required resources for implementing the first two parts of this strategy exist. Except for increasing the number of data bases, incremental costs are not excessive. Immediate implementation is recommended as payback should also be immediate. Development of expert systems is considered a long-range thrust and is discussed elsewhere in this report.

E. BARRIERS

There are several barriers which may reduce the probability of implementing the research strategies proposed. While lack of funding is the most obvious, consideration in fear of inducing legal liability is also a major concern. For some areas of research, there is an apparent lack of facilities to conduct research on a systematic on-going basis (e.g., a high rise structure to validate a comprehensive smoke transport and control model).

Besides these more obvious barriers, there are also institutional barriers which must be considered. In general, any well-established, in place system could provide a disincentive to investment. Our code and acceptance process itself is one such potential barrier. In some areas (e.g., building assemblies), an elaborate infrastructure of specific requirements and performance criteria have evolved over the years which have resulted in manufacturers and testing laboratories investing considerable sums in product development and test facilities. Any research program touching on these areas in which private sector support is expected would likely require a prediction of measurable payback for the investment in terms of demonstrating much improved performance, lower costs to the manufacturer or end user, or an expanded market. An added perception is that the codes and standards process itself could prevent a timely introduction of a new innovation to the user, thus creating an additional disincentive.

Closely related to the above is the question of the person applying changes to the existing codes or standards. For example, there is a significant national investment in the experience of code enforcing personnel. A major change in a code or standard would have costs associated with informing these people about the new change as well as in the re-building of the experience base. In our view, construction of knowledge-based codes could help minimize this impact and assist in improved implementation of the changes when the code is first used.

The final barrier is associated with the historical fact that individuals and organizations sometimes take hard positions. This is understandable (but not desirable) where there are competing technologies (e.g., suppression vs smoke control) and, in some cases, where particular special interest groups may be involved. Quite often, however, such barriers exist only as a matter of opinion. This underscores the fact that fire protection is still largely an art and sometimes an opinion has little more than an individual's personal experience and knowledge behind it. Consequently, lacking a suitable knowledge base for many of our current requirements also serves as a disincentive for investment if an influential person or organization can sink a new innovation solely on opinion. It also underscores a designer's/engineer's problem for proposing a new innovation for use in a new building or facility.

Design and Engineering II

Co-Chairmen - Paul Fitzgerald
Patrick Pagni

Recorder - John Petraglia

Panel Members - William Christian
David Hammerman
Russ Kidder
Henry Mader
Jonas Morehart
L. L. Neibauer
Richard Plettner
Martin Reiss
Ken Schoonover
Harry Shaw
William Young

Table 1

1. Determine appropriate sensitivity to use for adequate protection, considering different fire scenarios.

2. Determine appropriate sensitivity to use as the basis for certification.

3. Determine a method to verify sensitivity.

4. Determine the benefits of photoelectric vs. ionization by occupancy.

5. Determine what criteria should be used for location/spacing (e.g., NFPA 72, Appendix E).

6. Determine whether existing standards are at appropriate level of technology.

7. Determine the effects of standard or fast response sprinkler technology on smoldering and on flaming fires.

8. Determine how spacing, K factors, and waterflow can best be determined based on performance standards.

9. Determine how suppression/detection system costs can be reduced for new installation or retrofit.

10. Determine how room and ceiling configuration affects performance of suppression, operation, spacing, etc.

11. Determine the effects of induced air currents on sprinkler/detector operation.

12. Determine a framework for accepting new suppression systems.

NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Regulatory and Risk Workshop
at the July 22-25, 1985 Meeting

A. INTRODUCTION

In order for research to have an effect on fire problems it must, to some degree and in some form, be acted upon. Most often that action will take place through the adoption and enforcement of codes and standards. Therefore, the task of this panel has been to identify and develop strategies for research that are needed so that those concerned with providing fire safety can make their decisions, to a greater extent, on the basis of technical data and quantified impact rather than the way they are made today.

There was general agreement among participants that a carefully-conceived research stategy was needed to make this attainable. As they saw it, the program should identify: 1) the kinds of data needed; 2) the analytical techniques to be brought to bear on the information made available; and 3) the process by which the data could be packaged and made useful.

Although much data on fire incidents are currently being gathered, the data often neither support nor rebut many of the present regulatory requirements. The kinds of information gathered therefore depend on the problems to be addressed. In collecting, organizing, and analyzing fire incident information, there are four factors to be considered. First, the information should serve as the basis for risk analysis. Second, it should be centralized to eliminate overlapping and wasteful duplication of information. Third, it should be specific enough to identify fire problems. (Current reference to the "Fire Problem" lacks clear definition and explanation. Codes and standards are purportedly adopted to address fire problems. But unless these problems can be clearly identified, they cannot be addressed adequately by the codes.) Finally, it should be more historically oriented. That is, it should be used in comparison with the regulations in effect at the time of construction, not those in effect at the time of the fire.

In sum, the panelists agreed that--for a start--more complete, more accessible and more reliable information is needed as a basis for regulatory research and revision. In this context, "data" was determined to include:

1) the collection and comparison of <u>all</u> pre- and post-fire incident data; 2) fire and other test data; 3) behavioral data; 4) source data; and 5) environmental, reference and economic data.

All of this information would lay the ground work for rigorous quantitative analysis. There was a consensus that the analysis of choice should be risk analysis and that this, in turn, could be classified in several ways. To begin, there are various types of risk--potential, probable, perceived, actual, and acceptable--as well as a repertory of techniques. Some of the tools of risk analysis include:

Fire predictive modeling, e.g., for use in developing knowledge of causes and what can be done to alleviate them; knowledge-based systems, e.g., for use in analyzing risks in residential fires; plausible scenarios, e.g., for use in estimating the degree of hazard of combustible materials, considering the effect of ignition, rate of heat release, toxic gases and the like.

The initial goal would be to look for consistent measures in sufficient detail to assess fire mitigation methods. Having selected the appropriate technique(s), an investigator could assess levels of risk, identify and then analyze hazards, quantify the risks and, finally, conduct a cost-risk-benefit analysis to which all the preceding phases have contributed.

Risk analysis could make two important contributions to the workshop's goals. First, it might help the regulatory community understand and use certain fire effects quantitatively, (i.e., ignition and burning of fuel-rich hot layers; wall and ceiling burning temperatures; buoyant flows up stairwells; and toxic gas change and transport between fire production and escape route.)

Second, it is a prerequisite to helping regulators decide what to regulate and how to regulate it.

Even with accurate and complete data combined with sophisticated analysis, a third step is still needed. The research must be packaged and made useful. Once research results have been validated, they must be transferred to users. Developers of codes must understand the uses and limitations of research results, and be assured that practical applications have been reviewed by persons with strong science and engineering backgrounds. In light of the currently used, seat-of-the-pants risk analysis used to aid in the drafting of codes, it would be useful to prepare an impact assessment guide to review traditional fire protction requirements of building codes and standards. Paradoxically, we make in depth reports on failures but not on successes. (Thousands of fires where little or no damage is reported go uninvestigated.) An impact guide might help regulators discover what works.

Following through on this charge, the panelists agreed that prior to embarking on such a comprehensive data gathering endeavor, it is necessary to determine what research is currently available. Furthermore, the construction of accurate and complete data bases is indispensable to the risk and hazard analysis techniques that would be applied to specific situations. These data bases would be of two kinds: (1) a research data base that would be comparable to LEXIS in law or MEDLARS in medicine; and (2) a fire data base, that would aggregate: behavioral, test, demographic, and economic data relating to fires; and formulas for computing quantitative results.

B. RESEARCH NEEDS

I. Research Information Base

The elements of a research information base exist, but they are fragmented and diffuse. In particular, fire safety research issues are addressed by many Federal agencies--amounting to an estimated $40 million of scattered activity--and by private industry, which spends about $120 million annually in fire safety development. What is needed is an information base that would be centralized, free of redundancies and accessible to authorized users. Whether the national coordinating body should be Federal or private remained open. What is not at issue is that this body should track ALL federal, state and private fire research and safety projects.

THEREFORE RESEARCH IS NEEDED TO:

Develop a method of identifying and coordinating national (and international) fire research, and creating an information bank to include:

problem(s) researched
facility
sponsor
status (completion date)
output (or work product)
funding (who and how much)

Identify an appropriate location, form, and manner in which such information is collected, stored, and disseminated.

This research should be conducted by NBS/CFR or NFPA--in-house and by grantees.

II. Fire Data Base

A separate fire data base should be developed. This would comprise data on fire incidents and on fire tests in sufficient detail to permit users to assess fire mitigation methods and alternatives. The entire fire-related community needs this information to prioritize its efforts and to identify regulatory response and levels of protection and hazard. As with the proposed research information base, much (but not all) the information is available, but in highly fragmented form. Test and performance data are needed, for example, to define the effects of building configuration and detector sensitivity on fire growth; or to determine what structural assemblies and designs should be permitted by regulatory officials; or how to draft performance specifications for the flammability of furnishings. The creation of a fire data base should be a cooperative effort of Federal agencies--with NBS/CFR or the Fire Administration taking the lead--the NFPA, associations of elected and appointed officials, and the insurance industry.

THEREFORE RESEARCH IS NEEDED TO:

Develop a methodology for collecting pertinent fire data. That data should include:

- Test data.

- Empirical knowledge.

- Behavior of those exposed to, confronted with, or victimized by fire.

- Physiological effects of fire exposure on victims.

- Reference data.

- Economic information.

- Environmental data.

III. Analytical Tools

The creation of complete data bases is a necessary, but not sufficient step, in applying knowledge to fire prevention and mitigation. The fire community needs more analytical tools that incorporate this knowledge and that can be used in regulating and in determining risk. There is a need to quantify potential, probable, actual and acceptable levels of risk and for publishing them--possibly as NFPA/ASTM standards. We also need an understanding of the code application process itself. A computerized expert system could become a fast and efficient guide to assist enforcement personnel in applying codes. As an additional example, it should be possible to design decision support systems to evaluate tradeoffs and equivalencies in building and fire codes. A final example would be an assessment technique for identifying "acceptable" levels of risk--that is, the reduction of fire losses to acceptable levels--using existing techniques (i.e., decision tree).

THEREFORE RESEARCH IS NEEDED TO:

Develop a methodology for comparing fire information relative to the functioning of material, hardware, and structural elements in a building before and after a fire--these elements to include sprinklers, alarms, F.R. construction, opening protection, furnishings, occupancy characteristics, etc.

Analyze the data to:

Identify appropriate analysis techniques; establish levels of risk; identify hazards; identify and quantify the fire problems; evaluate the hazard; quantify the risk; and set a cost-risk-benefit ratio.

Develop methods that can be used by those:

Responsible for developing, adopting, and promulgating codes and standards; and responsible for enforcing codes and for accepting alternate protection or equivalencies.

Determine the validity of these methods.

The technical effort should include the development of training packages and materials that facilitate the use of the analytical tools.

This research should be undertaken by NBS/CFR, NFPARF (research), ASTM, appropriate universities, and other private research groups through grant funding.

IV. Additional Research Needs

In addition to the three interrelated programs outlined above, the panelists believe that RESEARCH SHOULD BE UNDERTAKEN in specific fire areas, as follows:

- Learn how to commercially produce cigarettes that will not ignite furniture and mattresses. The Cigarette Safety Act provides a beginning. NBS/CFR, the cigarette industry, the fire community, CPSC, USFA, and HHS all should be involved.

- Determine practical and feasible ways to produce furniture that will not ignite when a cigarette is dropped on it. The Upholstered Furniture Action Council has made significant progress in this area, using better performance fibers and heat conducting welt cords. However, more research remains worthwhile. The industry, NBS/CFR, and CPSC, would contribute.

- Heating equipment fire research, with NBS, CPSC and some universities sponsoring research.

- Structural assemblies risk assessment. Sponsors: NBS, Underwriters Laboratories, AIA, universities, forest products companies.

- Building configurations influence on sprinkler/detector sensitivity and on fire growth. Sponsors: NBS/CFR, NFPA, UL.

- Retrofit package for residential sprinkler systems. Sponsors: sprinkler manufacturers, FM, UL.

- Measures of fire load and fire stress rating. Sponsors: CFR, FM, UL, equipment manufacturers, NFPA.

- Flammability of furnishings. Sponsors: NBS/CFR, UL, CPSC, industry.

- Optimization of sprinkler response time. Sponsor: NFPA, code officials, revising NFPA 13 and 13D as appropriate.

- Effects of ceiling height, sloped ceilings, beams and lintels on effectiveness of residential fire protection systems. Sponsors: NFPA, UL, FM.

- Determine combination of automatic sprinklers and compartmentation design standards that provide optimal protection. Sponsors: NBS/CFR, NFPA, FM, Southwest Research Institute.

- Provide heat out and air velocity time data for a wide range of fuel loading. Sponsor: NFPA, strengthing NFPA 13, with support of FM, UL.

C. CONCLUDING REMARKS

The combination of massive contemporary data (information) bases with sophisticated analytical tools could be applied to many situations. Among those identified are: the drafting of a fire handbook of formulas and data; the creation of a performance-based, risk-oriented fire code; and the drafting of economic initiatives for fire sprinklers and detectors. What these projects share is their amenability to quantitative analysis. Thus, a performance-based fire code would consist of consensus performance levels developed by means of risk modeling. Similarly, developing economic initiatives for sprinklers and detectors demands a quantitative evaluation of existing building code modifications, and a cost-benefit analysis of tradeoffs.

In conclusion, panelists agreed that the coordination of data and analysis can resolve many regulatory problems--the updating of codes, the analysis of acceptable levels of risk, the determination of what structural assemblies should be permitted, and the resolution of residential fire protection problems, to mention a few--that concern regulatory officials involved in fire-related matters.

Regulatory and Risk

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Alan Stevens

Recorder - Arnold Levine

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Douglas Greenaway
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Chester Shirmer
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NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Real-Time Extinguishment and Hazard Analysis Workshop
at the July 22-25, 1985 Meeting

A. RESEARCH THRUSTS

I. Technology Transfer/Research Bridging

Definition: The group voiced concern that fire research is not being effectively translated and integrated for use by fire fighters. How can such technology transfer be encouraged and expedited? Is there a need--or a way--of mandating developmental research in this area at the federal level? What about cooperative projects between the private and federal sectors? Even if there are obvious practical benefits embedded in basic research findings, how can that information be translated and disseminated to local fire fighters? What mechanisms and programs should be developed, and under what aegis, for doing this? Partial or preliminary results from soundly based research in many cases, could be put into use to save lives and property. That would require a closer interaction between fire fighters and researchers than has been customary.

Current Situation: Certain programs are in place and could be used more effectively for technology transfer. The success of several National Forest Service computer systems, which themselves could probably not be applied for use in combatting structural fires, represents a good example of applying developing technologies to accomplish important tasks. The fire service community could learn some general lessons from those applications. Also, there are institutions that could be better used for efficient technology transfer, including the Federal Laboratory Consortium and the Centers for Higher or Continuing Education at various universities. They could play an increasing role in selecting and packaging technology for use by fire fighters.

Improved hardware and also "software" (that is, ideas as well as computer software) exist that should be evaluated, improved, and put into use. Breathing apparatus, devices to see through smoke-filled spaces, better suppression equipment including improved water nozzles and retardants, and special hazard systems are just a few examples. Technology transfer often will involve technologic development as well as information dissemination and marketing--both of ideas and equipment.

Research: Several areas deserve examination. The urban-wildland interface, a fire fighting problem in its own right, should be explored further for providing insights into technology transfer. The solution of each environment's unique fire problems could lead to new ideas in the complementary settings as well as the interface. The other key on-going process, whose implementation will need study, is a way to build input from fire fighters into the entire research process--from planning through development and use.

Steps and Estimated Costs for Implementation: First, the existing fire-related research literature must be critically reviewed and put into a data base (compatible in format with that of the U.S. Forest Service fire information data bases), to be administered by the U.S. Fire Administration (USFA) at an estimated annual cost of $300,000.

Second, the review board, which will be administered by USFA, should include representatives from the following organizations: IAFF, IAFC, NFPA, ISFSI, SFPE, NEMA, IFSTA, and the National Volunteer Fire Council as well as college level educators. The board will be charged with identifying, and facilitating the flow of, technical research information whose application could benefit the fire service community. The information should flow both ways between the research and fire service communities. This should be a permanent undertaking of USFA, at an estimated annual cost of $250,000.

Third, USFA will need to provide technical support and equipment for this undertaking. Also, it will publish a users' guide of fire-related research projects, and the information also will be stored on the data base system and updated continuously. The estimated annual cost is $150,000.

Fourth, henceforth, research funding proposals will include a lay-language summary, as will the final reports.

II. Fire Behavior Modeling and Applications

Definition: This thrust was defined as meeting the following goals: providing fire fighters and officers with the capability of acquiring and processing data, for use in real time, on the basis of tested computer models of fire behavior. These models of the future would include information about the design of buildings, their contents, and the environments in which they are situated. Besides helping fire fighters directly in training and in doing pre-fire planning, the models could be useful for hazard analysis on the fire ground, estimating the likely damages resulting from structural fires such as imminent building collapses and the effect of fire protection systems. Moreover, current models could prove useful for "marketing" purposes, such as convincing appropriate individuals that certain changes in fire codes are worth implementing or that certain protection equipment is worth installing, and for doing economic analysis of fire losses and fire prevention measures. In addition, such models might help in planning for unusual architectural features, such as atriums or redesigned loft structures.

Research Areas: Based on a discussion of progress in modeling wildland fires, the group suggested that the available knowledge base for the modeling of structural fires and their suppression be evaluated. The crucial question is whether this knowledge base is adequate for pragmatic-minded developers to fashion a crude but workable model system for describing structural fires. Parallel, simultaneous efforts are needed to learn how to best use the crude models now available and to continue the development and validation of better versions. A key constraint is that the model(s), once developed, be usable on microcomputer systems, such as those that would be available to an average fire department. Although crude models now exist, they have not been made available nor have they been tested by fire fighters.

Other capabilities that should be worked into such a modeling system include: improved hazard evaluation; the effect of occupancy changes on the fire-safety requirements of particular buildings; and the improved use of sophisticated fire protection systems, which either could benefit in their design from modeling or, alternatively, information derived from such systems could be plugged into the modeling system to improve it.

Steps and Estimated Cost for Implementation: The first phase of fire model building would occur in six steps that could be undertaken in a two-year period and cost between $750,000 and $1 million. The project could be managed by USFA, using input from the fire service community and systems engineers. Those steps consist of first, defining the applications; second, defining scenarios that serve as useful, potentially readily marketable prototypes; third, structuring the system level model and the requirements to meet it, including its general processes and elements; fourth, establishing submodels required for each process and element in the modeling approach; fifth, identifying and reviewing the available research and assessing its applicability; and sixth, identifying new research needed to build the model and fill any gaps.

The scope of the second phase will determine its cost, but a minimum estimate is three years, with an annual cost of up to $1 million. First, it involves the building of the initial system and then conducting sensitivity analyses to identify new research that would provide the best payoff. User friendliness should be established at this stage, and the effort would be sponsored by USFA. Second, the research that has been identified should be conducted and/or sponsored by the NBS Center for Fire Research (CFR), and will involve efforts by basic researchers and systems engineers. There must be considerable interaction and feedback during the final several steps noted in the foregoing.

III. Fire Simulation

Definition: The availability of reliable fire modeling systems is a prerequisite for sophisticated fire simulations, which ideally would fully represent all the stages and variables that go into creating a structural fire and then suppressing it. To be useful as a training tool, the simulation must be displayed so that the viewer can interact with it in "real time" slower, or possibly even faster than a real fire would progress--controlling the variables and acting to suppress the simulated fire in a variety of ways. The system should be adaptable also to serve pre-fire planning purposes and to train fire inspectors and other personnel. If possible, an adaptive capacity should be built into such a system, making use of the principles being realized from artificial intelligence studies. Thus, the know-how and experience of the person running the simulation might thereby be used to improve it in a more-or-less automatic way.

Research Areas: How close is the technology to meeting these requirements? Thrust two suggests that models themselves are not yet adequate to this task. How many variables must go into such models? Can they be designed so that users and modelers can test and evaluate them against real situations to ensure their credibility? Research areas could include factoring in effects of wind, suppression, ventilation, and so forth.

Moreover, another basic challenge yet to be met is the development of computer graphics and video disk displays that can realistically simulate the confounding conditions, such as smoke and steam, associated with a rapidly changing fire. So far only simple systems can be run on fairly sophisticated computers--eventually the converse must be true: sophisticated systems must be run on simple (cheap) microcomputers.

Training Application Issue: Because a major use of simulation would be for training fire fighters, it might be worth exploring whether other successful applications, such as the simulation systems developed by the Defense Department, airlines, and other agencies, have provided know-how adaptable to the training of fire fighters.

Steps and Estimated Cost for Implementation. First, USFA should take the lead in establishing the requirements for building such a system, and attention should be given to planning a tiered simulation system--one that includes very simple elements and highly sophisticated ones. The task itself should be undertaken under contract, perhaps funded by NBS for six months at the cost of $125,000, and done by systems engineers working closely with users (representatives from the fire service community). Second, under an NBS contract for about $500,000, modelers must make a critical inventory of existing models to see how they stack up against the requirements for the simulation system. Third, as part of this, critical gaps must be identified by the modelers, under NBS, over six months for $150,000.

Fourth, a simulation process will be synthesized from existing models in an effort directed by USFA and that involves technology-oriented people from the academic sector over an 18-month period, costing about $400,000. Fifth, a prototype will be built by representatives of the simulator producing industry, with modelers and users serving as advisors. This, too, could be a USFA-directed project, costing about $2 million over 18 months. Sixth, again the critical techlnology gaps must be filled by the modelers, such as those at NBS, over 12 months at a cost of $250,000. Seventh, an enhanced prototype with new features can be developed and readied for marketing. Earlier steps are to be repeated as necessary in a seventh and final step that should go forth in several 6-month cycles, each costing about $200,000.

B. GENERAL COMMENTS

Impediments: Besides limited financial resources, the group identified two major impediments that well could interfere with reaching these and other goals.

First, the fire service is its own impediment. Historically, fragmented into virtually countless regional, urban, and rural organizations, the needs of the fire service community often cannot be articulated--or met--because there is no efficient way to do so.

Second, the U.S. Fire Administration has recently been an institutional impediment. A central organization is needed to assess, amass, and evaluate technology and research--and to help make it available to the fire service community. USFA has been handicapped in meeting such needs by its own system and by its dependence on annual appropriations. There is a need for the reprogramming of present USFA funds and for new initiatives.

Recommendations: Although the group considered making several general recommendations, it settled on urging the Joint Council of Fire Service Organizations to become the leader of the fragmented fire service community and thus help it overcome its problems with technology transfer. Having a stronger central organization would aid the community in building the communications infrastructure it clearly needs.

Maintaining Momentum: The group recommends that a smaller continuing group be convened to review the final report emerging from this Conference and its recommendations. The need for and the enthusiasm surrounding the initiatives recommended above are great. Let us not lose that momentum.

Real Time Extinguishment and Hazard Analysis

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James Kerr

Recorder - Jeffrey L. Fox

Panel Members - Richard Custer
Joseph Donovan
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Ken Henry
David Hoover
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NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Investigation and Litigation Workshop
at the July 22-25, 1985 Meeting

A. INTRODUCTION

The Investigation and Litigation workshop of the National Fire Research Strategy Conference was charged with the responsibility to discuss how research might lead to improved procedures for experts trying to investigate and/or understand specific fires of interest. This would include procedures used by fire and arson investigators, liability lawyers, codes and standards writers, government regulators, product manufacturers, etc., for reconstructing a fire and determining the key factors that influenced its ignition, growth and hazards.

The committee immediately set out to develop a "mission statement" or purpose, describing in broad terms what it hoped to accomplish:

> To reduce the incidence of repetitive fire, determine future research and planning needs, and provide sounder data for the litigation process through improved investigative procedures, more extensive fire investigations, better methodology for fire reconstruction, and a better understanding of fire ignition and growth and human behavior.

The committee also reached one initial understanding concerning its direction. Committee members feel that it would be nearly impossible to attempt to tackle the problems with litigation, as it refers to fire. The committee recognizes that the litigation process is driven by legal prerogatives that set it aside from other processes. But, the committee believes that the methodologies and necessary information gathering remain the same for fire investigation and litigation. Therefore, suggestions pertinent to fire investigations are equally applicable to fire litigation.

The second main understanding was the critical need for more fire research in non-arson fires. Members of the committee believe that although the overwhelming majority of fires are accidental, rather than arson, accidental fires are rarely investigated with the same degree of thoroughness as arson, unless there is a large loss of life and/or dollars. The committee members further agree that until a larger percentage of accidental fires are sufficiently investigated, progress in the area of fire prevention may be limited due to a lack of public awareness of the problem of accidental fires and a lack of an information base for programs to prevent these fires.

The committee divided the subject of "investigation/litigation" into four distinct recommendations which follow:

1. To improve the quality of fire investigation through a better understanding of fire physics and chemistry and the psychology of human behavior, before, during and after a fire, and to provide the proper training to achieve this goal.

2. To implement and develop the advanced methodologies and investigative aids needed by those involved in the investigation and litigation processes and identify and/or create collection agencies for obtaining this information.

3. To expedite the means by which information and data are analyzed and disseminated to the fire service community and to the public, underscoring the need for fire prevention and investigation.

4. To increase resources used to investigate accidental fires, establishing prioritized investigations based on the number of fires, fatalities, dollar loss and other identified factors.

The following portions of this report will suggest strategies for achieving each of these objectives and specific actions that may be taken to reach these goals.

B. STRATEGIES

I. Fire--Evaluation and Education

To improve the quality of fire investigation through a better understanding of fire physics and chemistry and the psychology of human behavior, before, during and after a fire and to provide the proper training to achieve this goal.

The first strategy necessary to implement this goal is to determine the information available and the information needs for improved fire investigation from all appropriate sources. One way to achieve this goal is to go directly to the associations and organizations which are critically involved in fire research and prevention. Four key sources are the National Fire Academy, the International Association of Arson Investigators, the National Fire Protection Association and the Society of Fire Protection Engineers. In addition, more than 200 additional organizations can provide some critical information in this area. These groups include research organizations, legal societies, government agencies and insurance groups.

A second strategy is to create the atmosphere for quality fire investigation, securing top level local government support for quality fire investigations. To achieve this goal, one must address the problem of economic support. The committee determined that it is essential for the fire community to develop a cost/benefit analysis which will convince the local hierarchy--government administrators--of the need for fire investigation in accidental fires, as well as those presumed to be arson.

In addition, a group such as the International Association of Fire Chiefs or the National Fire Protection Association could sponsor a symposium on investigation, targeting city administrators, district attorneys, and the insurance industry, to show the financial, civic and social benefits of fire investigation.

And, if there is administrative support for fire investigation, in all probability, resources and information will reach everyone within the fire service community.

A third strategy underlying this goal is to integrate the knowledge of human behavior in fire circumstances into the investigative process. The committee agreed that it was necessary to develop a systematic approach for determining human behavior in connection with fire, through standard interview procedures.

To achieve this goal, the committee recommended the identification of organizations and educational institutions, such as the National Fire Academy; the Bureau of Alcohol, Tobacco and Firearms; the Federal Bureau of Investigation; the University of Washington; or the University of Maryland with expertise in the area of interviewing processes to develop and standardize a basic interview process to be used in fire investigations.

The fourth strategy is to integrate information concerning the physics and chemistry of fire into the investigative process. This would insure the necessary technology and information transfer from the scientific laboratory to the end users, i.e., the fire investigators and fire fighters.

There are a variety of ways in which this can be achieved. First, the committee called for funding of centers that can provide "user friendly" technical information, such as Worcester Polytechnic Institute Center for Firesafety Studies, the University of Akron, and the National Fire Protection Association to name a few.

Second, the Center for Fire Research should establish mechanisms for "popularizing" fire chemistry and physics research. A minimum requirement would be to provide a layman's translation of the Center for Fire Research technical reports.

Third, organizations such as Underwriters Laboratory, Factory Mutual, the Center for Fire Research and Southwest Research Institute should share large scale fire demonstrations/videos/films with fire investigators.

Fourth, the Center for Fire Research should be urged to develop a computer based "expert system" to be used by fire investigators. This system would prompt fire investigators on key investigative questions.

The fifth strategy is to improve the accuracy of predictive techniques for fire phenomenon and human behavior. The first step in this process is to establish a panel of fire investigators to prioritize their predictive needs. This should increase the accuracy of predictive techniques for fire phenomenon and human behavior.

The sixth and final strategy is to develop proper educational programs for fire investigators. To do this, two steps are necessary:

1. An educational task force should be created to coordinate the proper curriculum for training and education of fire investigators with the National Fire Academy and other educational institutions.

2. Current fire investigator certification programs should be studied. A national certification program should be recommended, as a result of the study.

II. Methodologies and Investigative Aids

To implement and develop the advanced methodologies and investigative aids needed by those involved in the investigation and litigation processes and identify and/or create collection agencies for this information.

The first strategy to reach this goal is to establish an inventory of available tools--information and investigative aids--to be used in fire investigation.

The first way to achieve this is to create a panel of experts, both within and outside the fire community, sponsored by the National Bureau of Standards, to determine the inventory of tools that could be used in fire investigation. This panel would make recommendations on which tools are effective in the investigation process.

An additional approach would be to develop a handbook compiling information on materials' properties and behaviors that are useful in fire investigation.

The second strategy is to identify current investigative aids and procedures in need of standardization and/or dissemination to the field.

To achieve this goal, another panel of experts should be established by the National Bureau of Standards, which would determine methods of standardization for computation and measurement tools used in the fire investigation process. At the same time, it is necessary for a group, such as the National Fire Protection Association or the National Bureau of Standards, to compile information on investigative aids and standardization of their use.

III. Analysis and Dissemination

To expedite the means by which information and data are analyzed and disseminated to the fire service community and to the public, underscoring the need for fire prevention and investigation.

To achieve this goal, the primary strategy is to develop a way to analyze data currently being collected in a timely, uniform manner, and to disseminate it to all interested parties as an aid in the identification of new fire threats and trends.

There are three basic means to this end. First, it is necessary to assemble an organization involved in the collection, analysis and dissemination of data to bring about a more expeditious process. Second, it is advisable to establish a task force whose mission will be to direct the uniform analysis of the National Fire Incident Reporting System (NFIRS) data. Third, it is essential to create a task force which will determine the most effective methods to be used to reap the full benefits of this data base.

Some members of the committee indicated a pressing national need for a systematic approach to investigative information gathering on a second, more intrusive level of information. These members called for investigations to go beyond the level of detail provided in the National Fire Incident Reporting System. NFIRS can identify general areas of interest, such as solid fuel heating fires, but do not provide the specifics that may be necessary to effect appropriate prevention measures.

Other members of the committee pointed to the practical realities, which they believe make this goal difficult. Fire investigation resources are limited, and additional paperwork would prove burdensome for the already overworked fire investigator. Without a significant increase in resources, these members believe that this second level of investigation would be another hardship on the local level.

IV. Accidental Fires

To increase resources used to investigate accidental fires, and to establish prioritized investigations based on the number of fires, fatalities, dollar loss and other identified factors.

All members of the committee shared the strong belief that one of the biggest problems in fire investigation is the nearly exclusive emphasis on the investigation of arson-related fires, rather than accidental and suspicious fires. All stressed the need for fire investigation in every instance in which it is practically feasible. The ideal goal called for fire investigation of every fire, although the committee did recognize that time and economics might make this impossible.

Once again, the committee called for public recognition of the benefits of fire investigation. The committee recommended that a task force be created to develop the kind of cost/benefit analyses which will convince local administrators of the need for the investigation of all fires. Local government resistance to accidental fire investigations was targeted as a major barrier to this achievement.

C. CONCLUSION

It is the conclusion of this committee that if the specific actions recommended are followed to the degree practical and possible, an improved investigative and litigative process will develop. This improved process should lead to a better understanding of fire causes, both the physical and human aspects. This knowledge should then result in the identification of intervention steps that will reduce the incidence of fire.

Investigation and Litigation

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NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

Report of the
Research for Fire Safety and Survival
of the July 22-25, 1985 Meeting

A. INTRODUCTION

Definition and Scope

The charge given to the workshop on Research for Fire Safety and Survival was to "discuss specific research that would provide an improved scientific and technical base for fire safety programs directed at people at risk in fires and those directly responsible for their safety; that is, building occupants, experts who train the public in fire safety and building owners and managers."

The above description of the workshop's charge was accepted by the workshop members with one modification. It was agreed to add "fire fighters" to the list of those affected by the fire safety programs.

Survival was viewed as a product or outcome of the response of the environment and people's responses to their specific situations under discrete conditions of fire development. The question was raised as to whether the emphasis should be on making the environment safe or whether strong consideration should be given to enabling persons to take responsible actions for their own safety. It was concluded that it is equally important to address both aspects for survivability.

The scope of the discussion included the topic of fire prevention since obviously if fire is prevented, survivability is insured (other workshops were not likely to cover the topic of fire prevention). Since the topic was "survival", the workshop was concerned with research related to "life safety" as opposed to concern over property damage.

Where We Are

In general it was felt that the state of the art in understanding fire safety survivability is severely limited. This situation results in a lack of the necessary building blocks or basic principles to permit rigorous analysis or quantification of many of the factors relevant to life safety. This weakness is demonstrated, for example, in the fire community's inability to agree on factors such as tenability limits, or to address global issues of integration of hazard, occupant behavior, and facility response. It requires direct attention if significant progress is to be made in developing broad, effective strategies for fire survivability.

General Issues of Policy

There are numerous policy issues which appear to serve as barriers to progress in this area. Some of them are not unique to this topic. For instance, the general public is not well educated in this area, and as a result does not perceive fire safety as a major issue. Traditional modes of communicating this knowledge are felt to be inadequate. Further, people are dominantly conditioned by their daily activities and routines, and therefore cannot always be relied upon to take appropriate actions in emergencies. And finally, major advancements in research and resulting technology are seldom perceived to be cost/beneficial--at least initially. In a society where competition for available resources is excessive, the perceived cost/benefit relationship is important.

Unique to the area of survivability are factors such as human behavior, individual tolerance, and so forth. It is the group's perception that human behavior research has been treated without serious priority, and as a result it is not viewed in the fire research community as a popular research area.

Rationale

A crucial step in arriving at proposed research thrusts involved identification of the broad, dominant elements or factors associated with survival. In somewhat traditional fashion, elements were identified as:

prevention
warning
protection
escape and rescue

These general elements were discussed in detail, relative to the dominant issues for survival. Figure 1 provides a brief outline of key variables or factors associated with each element. Extensive discussions of each of these topics resulted in identification of eight broad research thrusts.

B. RESEARCH THRUSTS

The following list of general research thrusts reflects the consensus of the workshop members regarding the major areas where research is needed to improve survival in fire.

1. Epidemiology of fire incidents
2. Fire and burn education/training
3. Use and reliability of detection and suppression devices
4. Improved active protection devices
5. Integrated hazard/evacuation/refuge models
6. Performance and assessment methodologies for code requirements
7. Equipment and methods to improve fire fighter survival
8. Strategy implementation for fire fighter safety

Each of the general research areas has been expanded upon according to the conference format. Specific research topics within the general thrust are identified and relevant policy factors are outlined. The following sections of this report present this formatted information.

I. Epidemiology of Fire Incidents

Thrust: Develop improved quantitative information and understanding of fire deaths and injuries.

Current Situation: Autopsy studies on fire deaths are being collected and a standard autopsy protocol is being evaluated. However, no directed studies have been initiated on civilian fire injuries. The U.S. Fire Administration has contracted for the development of an emergency medical treatment protocol for fire victims with the American College of Emergency Physicians (ACEP).

The goal of the autopsy study/protocol is to determine "why" people die in fires. The "why" includes: (1) what toxic product(s) cause deaths, (2) the materials that produced the toxic product(s), (3) compliance of the structure with existing codes and (4) factors which might have changed the outcome.

The goal of the injury study is to determine: (1) the cause of the injury, (2) the type of injury, (3) compliance of the structure with existing codes, (4) factors which might have changed the outcome (reduced/eliminated the injury) and (5) the factors that led to survival.

Proposed Goal: This information should be fed back into the Life Safety Code or other performance standards, existing or proposed.

Needed Action/Research Elements:

Autopsy Study: Initiate a thorough review of the present autopsy protocol/study to determine if it provides the appropriate information. Of particular concern, do the results correlate toxicological information with: cause and type of fire, applicable codes and standards, and fire detection and suppression systems?

Injury Study: Initiate a fire injury study as a means to understand for a number of incidents the cause of the injury, the effectiveness of fire protective (warning) systems, the role of products contributing to the injury and why victims survived.

Performers/Present Situation: FEMA/U.S. Fire Administration presently funding ACEP to do develop treatment protocol.

International Association of Fire Fighters is conducting an autopsy study using a standard post mortem protocol.

What should be done: Injury study must be done in cooperation with medical community and fire services. Broader interest in funding and support for this research area is needed.

Priority Factors and Challenges:

Autopsy Study

Priority Factors:

Importance: High.
Probability of success: High
Cost: $100K
Time: 4-5 years

Technical Challenges: Correlate results of Autopsy & Injury Studies to requirements of applicable codes and standards. Technology exists today - no major breakthrough needed.

Technology Transfer: Information and knowledge should be used to evaluate existing codes, standards, materials, and detection and suppression hardware

Injury Study

Priority Factors:

Importance: High.
Probability of success: Very difficult
Cost: $200K
Time: about 5 years

Technical Challenge: Major difficulty is to get medical community involved and the cooperation of the fire victims. The need for scientific or engineering breakthroughs is not currently apparent.

II. Fire and Burn Education/Training

Thrust: Develop basis for specialized/targeted education and training.

Current Situation: In the United States today there is a failure to appreciate the risk from fire and burns. Such injuries are preceived as rare events, hence there is a need to motivate and educate people to be more concerned about fire and burn education.

Even though there are programs directed to target audiences, many times the content is not tailored and specific enough to meet the needs of specific populations. There is also a lack of technical basis upon which to evaluate fire and burn educational programs.

Proposed Goals:

Improve understanding of how people react to fire situations.

Establish evaluation programs for all fire and burn education programs.

Perform needs assessment of different target populations based on built environment and occupant characteristics.

Develop technical and implementation strategies to reduce burn injuries.

Reduce fires due to arson with special emphasis on juvenile firesetters.

Needed Action/Research Elements:

Significant resources must be allocated to develop better methods of evaluation, tailored specifically to fire and burn education programs.

There is a need to design survival strategies for specific populations and occupancy configurations, i.e., children, elderly, handicapped, one and two family dwellings, multi-family residential occupancies, places of public assembly.

In the area of juvenile firesetters, model programs must be formulated based on technical and sociological input, and made available to communities throughout the country.

There continues to be a need to provide the fire service, building managers and others who disseminate information with more appropriate, useful techniques.

The public needs to be made aware of fire and burn hazards, e.g., clothing ignitions, and gasoline, propane and other high hazard factors that are routinely found in everyday life.

Performers/Present Situation:

1. Program Evaluation Researchers (Universities)

2. Developers of educational programs (NFPA, ISFSI)

3. USFA

4. Insurance Companies

5. Program Disseminators (schools, building managers, etc.)

Priority Factors:

Importance: High. Failure to properly develop and convey educational and training technology that will measure impact of people behavior will result in unilateral reliance on design and protection strategies--a very unrealistic posture.

Probability of success: If financial and institutional resistance to developing and providing programs can be overcome, probability of success should be high.

Cost: Baseline costs $100 - 200K per year

Time: 3-5 years

Technical Challenges: Improvement of evaluation/data collection methods. Development of method for evaluating the effectiveness of in place programs and for training experts to use the new methods. Development of technical basis for selecting content uniquely tailored to specific populations.

Technology Transfer: The output from this effort would be directed specifically at organizations which train educators, and local organizations which implement such programs.

Barriers: Mechanisms must be identified for funding and dissemination of such programs. Techniques must be identified and implemented that overcome typical cultural problems in successful implementation of such programs in neighborhoods.

Action: This is a highly specialized area involving many actors. It is recommended that USFA and NFPA jointly plan a follow-up strategy session to examine this topic in further detail.

III. Use and Reliability of Detection & Suppression Devices

Thrust: Develop strategies for effectively implementing state-of-the-art detection and suppression devices, and methods for identifying failure modes.

Current Situation: State-of-the-art detection and suppression device technology can provide a reasonable level of life safety protection. However, these systems are not in wide use. The reasons appear to be largely economic and attitudinal. For example, the cost of retrofitting existing structures is high, and experience with systems in place has shown that they are not properly maintained. Very little is known about other modes of failure, and as design demands on these devices are relaxed, sensitivity of performance to failure thresholds will become critical.

Proposed Goals: Broad scale use of detection and suppression systems to improve life safety and reduce property loss. Primary targets are residential occupancies.

Needed Action/Research Elements:

Provide basis for determining/predicting failure modes. Develop approaches and perform cost/benefit analyses for universal as well as targeted implementation. Clearly identify and rank barriers to use. Ascertain the extent and relative degree of influence of each of the barriers, such as life cycle costs, lack of or misinformation about performance, lack of social responsibility, absence of incentives (insurance, codes, public programs), and absence of clear cut cost/benefit analyses.

Develop and protect strategies to overcome existing barriers.

Monitor benefits as they accrue from increased use.

Performers: Work done by economic, psychological, and educational communities. Funds provided by device manufacturers and material suppliers and/or U.S. Fire Administration.

Priority Factors:

Importance: High
Probability of success: High
Cost: $3 million (research cost only)
Time: 5 years

Technical Challenges: Reliability/failure mode identification

Technology Transfer: This process is ongoing.

Barriers: The key barriers to implementation are cost and social attitudes.

IV. Improved Active Protection Devices

Thrust: Develop basis for improved active protection devices for life safety.

Current Situation: While state-of-the-art protective devices are effective, improvements would assist in usage and improved life safety protection.

Proposed Goal: Improved effectiveness of protection devices leading to decreases in life and property losses.

Needed Action/Research Elements:

Basic to any research in this area is the need to develop sufficiently accurate methods to predict hazard development and the role of detection and suppression. This is required in order to rationally determine what improvements are needed. The state-of-the-art protection devices can be improved in a number of ways. Exploratory research is needed to consider novel protection systems and suppressants. One improvement would be to reduce the false alarm rate of detectors without reducing their ability to provide timely warning. Another would be to provide greater reliability, security and resistance to tampering. Future models could even be self-maintaining. Assess the need for a standard sound (quality and quantity) and effective audibility levels, as well as explore novel means of communication.

Develop needed information for improvements of sprinkler head design, location, response time, etc.

Identify and develop sprinkler system specifically designed for and made cost/effective for retrofitting.

Develop methods for failure mode analysis and conduct pilot studies.

Develop the technical basis and the performance criteria for an integrated smoke control strategy for various occupancies for use within entire fire scenario context. Consider trade-off and performance aspects with other protection devices.

Performers: NRC Canada, National Bureau of Standards, Factory Mutual Research Corporation, other research labs and universities

Priority Factors:

Importance: Medium
Probability of Success: High
Cost: $500K/yr
Time: 5-10 years

Funding Sources: Hardware Industry, Insurance, Building Code Organizations

Technology Transfer: Information and methods developed under this thrust would be directly incorporated in codes and standards, and received by hardware designers as guidance in equipment development.

Barriers: A major barrier to achieving the goals of this thrust is the availability of experts necessary to develop the technical understanding of the physical processes involved.

Action: A lead agency (NBS) should develop a broad framework for characterizing/identifying the interrelationships of dominant relevance in measuring fire hazard development, and the effects of responding detection and suppression devices. This framework should be used to systematically prioritize and pursue segments of the research as broader issues of funding and resources permit.

V. Integrated Hazard/Evacuation/Refuge Models

Thrust: Develop integrated models for formulating evacuation/refuge strategies.

Current Situation: Many people are using inappropriate survival strategies for particular buildings. Knowledge regarding whether or not to evacuate is not well founded, and the extent to which fire safety is over or under designed is not determinable--and seldom of interest until someone is injured or killed in a fire.

Proposed Goals: Develop technical basis and methods to permit rational selection of appropriate evacuation/refuge strategies based on the capabilities of occupants, occupancy hazards, the building layout and fire protection systems. This requires a high level of system integration.

Needed Action/Research Elements:

To select optimal strategies, integrated, comprehensive analytically based models of fire incidents are needed. The models must include probable human responses and physical, mental, and sensory limitations, building hazards, layout, fire protection features, furnishings, measures of tenability, smoke movement and all other elements that affect the probability of survival through detection, evacuation and refuge.

Review past fires with emphasis both on those who died and those who lived.

Validate innovative fire survival concepts, strategies, and products.

Performers: NBS, FMRC and university researchers will do the work in the fields of physics, chemistry, system safety analysis and computer modeling. NBS and universities will do the work in psychology. NFPA and USFA will do the work in statistics and data collection.

Priority Factors:

Importance: High. Code writers need models to refine and quantify equivalency judgments. Fire protection engineers, architects, and the fire service need models to improve life safety through better designed buildings. Building users need the model to select the best survival strategies for particular people in a particular building.

Probability of success: Ultimate success depends on acceptance from the regulatory authority having jurisdiction. Probability of success in developing the technical basis is high providing there is adequate funding. First comprehensive models should be available in 5 to 10 years.

Technical Challenge: Generally, models need to be based on better empirical data. Models of human behavior need improved data for input and improved techniques and algorithms for computer modeling. Behavioral input must be provided by fire investigations and targeted studies that identify response behaviors and associated probabilities.

Integration of models for human behavior, hazard development and facility response is a complex challenge involving basic studies of phenomena, human factors, and tenability as well as detailed efforts in numerical procedures and user friendly computer software.

Technology Transfer: Fire Safety Evaluation Systems can be increasingly based on empirically-derived quantitative models, and, thereby, rely less on expert judgment. Evaluation systems can be used by local jurisdictions and building designers (architects and engineers).

Building owners and managers and fire service personnel can base their fire emergency plans on alternative strategies evaluated using the model. In addition, an important avenue for application involves design engineers, and major codes and standards groups.

VI. Performance and Assessment Methodologies for Code Requirements

Thrust: To develop a methodology for evaluating and describing code requirements in performance terms.

Current Situation: The technical basis and impact of many building code requirements are unknown. In fact, much of the present code is based on a combination of folklore and intuition. As a result, it is difficult (if not impossible) to directly evaluate on a scientific basis the adequacy of a code, "trade-offs", alternate designs, and proposed changes. In most cases, such assessments are made on the basis of intuitive judgment. Such judgements are quite subjective and difficult to defend in a scientific sense.

Proposed Goal: The objective is to develop a scientific basis for evaluating, and describing code requirements in performance terms.

Needed Action/Research Elements: This research involves three distinct elements:

1. Defining current code requirements,

2. Developing integrated computer models for assessing the impact of specific requirements, and

3. Developing a methodology for evaluating and describing code requirements in performance terms.

Performers: A fire modeling group has been established within the Center for Fire Research. This group has the modeling capabilities but probably lacks building code expertise. Other multi-disciplinary organizations with extensive fire modeling capabilities may also be able to undertake this work. In any event, direct input from the model building code organizations (BOCA, SBCCI, ICBO and NFPA) will be necessary. Furthermore, peer review by other affected interests will also be required.

Priority Factors:

Importance: This methodology is needed by policy makers, designers, and enforcement personnel so that informed fire safety decisions can be made on a technical rather than intuitive basis.

Probability of success: Difficult. This research has a relatively high probability of success provided that integrated computer models are developed and adequate funding is secured. A potential problem may be the institutionalization of current code requirements.

Cost: $350K

Time: 5 to 10 years

Technical Challenge: Development and validation of multiple purpose computer models to permit broad comparisons of design options in a quantitative manner.

Technology Transfer: This methodology will provide the basis for a great deal of "technology transfer" in the areas of:

code and standards development
engineering design methods
enforcement
product development

VII. Equipment and Methods to Improve Fire Fighter Survival

Thrust: Develop technology base and measurement techniques to improve fire ground measurement and assessment of real time hazard development; examples include combustion product generation and transport, and structural collapse. Explore applications of automated fire fighting equipment to avoid fire fighter exposure.

Current Situation: There are no reliable methods or equipment currently available to accurately assess the state of a developing fire relative to fire fighter safety. Ranking fire officers typically employ judgment in directing tactics.

Proposed Goal: Reduce risk of fire fighter injuries and deaths due to combustion product inhalation, building structural collapse, and related hazard insults.

Needed Action/Research Elements:

Basic research must continue in order to develop sufficient understanding of facility fire dynamics to permit development of reliable simulation techniques.

User friendly computer models applicable to fire ground activities must be developed and validated.

Innovative measurement techniques must be developed to permit real time monitoring of a developing fire.

Technology development for automated fire fighting tactics (e.g., robotics) for major fire insults.

Performers:

Research - Segmented Research Activities at: NBS, FMRC, FAA, and DOD (Navy/NRL)

Funding - Multiple Sources: USFA, DOD, FAA, IAFF/IAFC and FEMA

Priority Factors: Fire fighters are routinely injured or killed on the fire scene due to such factors as building collapse, large scale fire insult (explosions) and so forth. Successful completion of focused research in this area could revolutionize fire tactics, reducing or virtually eliminating fire fighter casualties due to these causes.

Such capabilities are within reach, but require a serious advocate. A significant portion of the effort involves transfer of computer and robotics technology from other areas, and development of measurement methods consistent with other primary fire research activities.

Cost: $350K

Time: 3-5 years (first generation)

Technical Challenge: Development of real time measurement techniques conducive to fire ground applications. Development of applicable/functional robotics capabilities for specialized fire fighting.

Barriers/Issues/Roles & Actions: The significant barrier to accomplishing the objectives of this thrust lies in identification of a lead sponsor which recognizes the direct and intrinsic value of these efforts.

A candidate lead agency is FEMA, where alternative applications are conceivable in disaster tactics. Research to provide the hazard development component and measurement techniques should be done at NBS and its associated grantee network. While some expertise in robotics exists at NBS, a major source of this technology can be found in DOD, at some level of development.

Implementation of this thrust (e.g., technology transfer) will require commitment from the fire service, and defrayment of expenses associated with new training. It will also require cooperation among research groups, private sector equipment developers, and the fire service. A lead agency such as FEMA, USFA, or NFPA is best suited for this difficult responsibility.

Action Item: Identify lead organization and level of interest.

VIII. Strategy Implementation for Fire Fighter Safety

Thrust: Identify training, education and control/feedback methods to insure implementation of state-of-the-art or novel safety equipment and practices by fire fighters.

Current Situation: There exists equipment that meets stringent standards for protection. Many times this equipment is under-utilized or improperly utilized in hazardous situations. The life style of many fire fighters is not healthful (lack of fitness, inappropriate diet). Most municipalities do little to combat these practices. There is a need for greater emphasis on leadership training for fire service managers so they can reduce the occurrence of these problems.

Proposed Goals:

Improve effectiveness of fire suppression activity as it relates to the safety of personnel.

Instill "safety and health" consciousness at every level of the fire service.

Greatly increase the cost effectiveness of the fire service by reducing health and safety related costs.

Needed Action/Research Elements:

Incorporate human behavior elements such as attitude and human factors into general training and education techniques which are unique to fire ground tactics and behavior.

Develop basis for "effective" training methods; identify cultural barriers.

Develop framework for cost/benefit analyses for local municipalities to enhance resource allocation and priority for these programs.

Priority Factors:

Importance: High. Fire fighter safety records are at an unacceptable level throughout most of the U.S.

Probability of success: Good, but highly dependent on motivational factors within the fire service.

Cost: $100K

Time: 2 years (pilot study)

Technical Challenge: Development and implementation of specialized human behavioral models.

Technology Transfer: Fire Service

Barriers: The major barrier is the cultural resistance to change and image impact.

Action: Develop a pilot study and select lead sponsorship such as USFA/NFPA/IAFF. Determine the adequacy of state-of-the-art human behavior models for application.

C. CONCLUSION

A focus on survival is a necessary mechanism for determining crucial research thrusts which will improve the U.S. record on fire safety. This workshop group has identified some major research thrusts, begun the process of enumerating more specific areas of research, and identified some policy factors relevant to the specific research.

It was the collective feeling of the working group that technical issues associated with survival (life safety) should constitute a major element in any nationally targeted strategic research plan for fire safety. While the group is satisfied that the dominant thrusts were identified and addressed, further consideration should be given to correlation with the extensive list of research items contained in the conference prework package.

Research for Fire Safety and Survival

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Figure 1. NEEDS PROCESS

PREVENT	WARN	PROTECT IN PLACE	ESCAPE/RESCUE
education materials	human response/education	limit fire size	means of egress/refuge
		product selection	
codes	detect	contents	human behavior
- compliance	response signatures	design factors	
- effectiveness	nuisance alarms		human capacity
	product selection	early suppression	
targeted new technology	(education)		human escape mobility
	field evaluation	environmental controls	
product design	reliability analysis	toxic gas	equipment/devices
	installation, testing	smoke particulate	
sound engineering basis			strategy selection
	alarm	occupant factors	
	standard signals	tolerability	environmental/physiological
	sound levels		
		fire character/scenario	education/training
		hazard evaluation	
			formalized planning
		fire fighter factors	effectiveness eval.
		building collapse	(plan, exercise, execute)
		breathing	

NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

July 23-25, 1985

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Brief Summary of Workshop Topics

Overview - This panel will develop the frameworks to be used in organizing, integrating and presenting the outputs of the various panels. It will integrate the findings of the individual panels and develop generalized conclusions that encompass the more specific conclusions of the other panels. It will also serve as the communication link among the other panels during their deliberations.

Materials and Products - This panel will discuss the research that is needed so that:

1. Manufacturers can efficiently develop and profitably market useful products while providing a generally accepted level of fire safety.

2. Architects, interior decorators and other professionals can select building materials and building furnishings that provide any desired level of fire safety.

Design and Engineering - This panel will discuss the research necessary to permit designers and engineers to supplement subjective judgment with technical information. Facts, data and methods would be systematically assembled, to permit credible measurement of the level of safety inherent in the design and engineering of facilities, equipment, and vehicles.

Regulatory and Risk - This panel will discuss the research that is needed so that those concerned with providing fire safety can make their decisions to a greater extent on the basis of technical data and quantified impact. Potential users include: code officials, standards organizations, insurance companies, corporate risk managers and their government equivalents.

Real Time Extinguishment and Hazard Analysis - This panel will discuss research that would assist fire officers in prefire planning of fire fighting activities and in directing activities at the fire ground by providing technically based "tools" and guidelines. These "tools" would assist the fire officers in predicting the relative effectiveness and safety of alternative fire fighting strategies.

This panel will also discuss research that would permit manufacturers to design and produce equipment that would increase the effectiveness of firefighters or increase their safety.

Investigation and Litigation - This panel will discuss how research might lead to improved procedures for experts trying to investigate and/or understand specific fires of interest. This would include procedures (used by fire and arson investigators, liability lawyers, codes and standards writers, government regulators, product manufacturers, etc.) for reconstructing a fire and determining the key factors that influenced its ignition, growth and danger.

Research for Fire Safety and Survival - This panel will discuss specific research that would provide an improved scientific and technical base for fire safety programs directed at people at risk in fires and those directly responsible for their safety, that is, building occupants, experts who train the public in fire safety and building owners and managers.

APPENDIX C

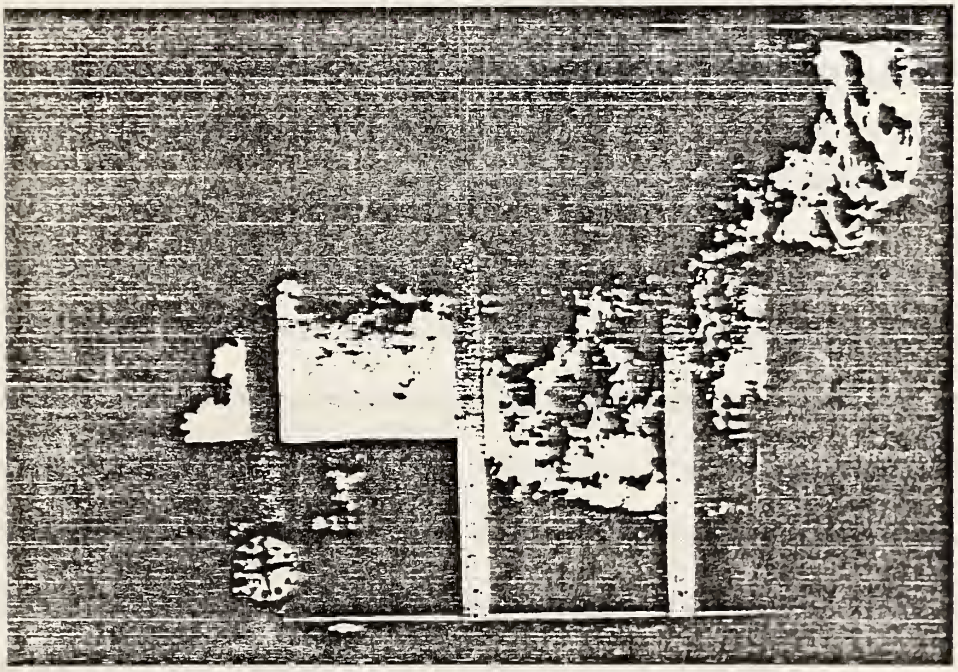
ABBREVIATIONS USED

ABBREVIATION	FULL NAME
ACEP	American College of Emergency Physicians
AIA	American Insurance Association
AISI	American Iron and Steel Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BOCA	Building Officials and Code Administrators International
BRI	Building Research Institute (Japan)
CFR	Center for Fire Research
CPSC	Consumer Product Safety Commission
DOD	U.S. Department of Defense
ESFR	A Fast Response Type Sprinkler
FAA	U.S. Federal Aviation Administration
FAST	A Model for the Transport of Fire, Smoke and Toxic Gases (W. Jones)
FEMA	Federal Emergency Management Agency
FM	Factory Mutual System (Insurance)
FMRC	Factory Mutual Research Corporation
FR	Fire Resistant (Construction)
FRCA	Fire Retardant Chemicals Association
HHS	Department of Health and Human Services
IAFC	International Association of Fire Chiefs
IAFF	International Association of Fire Fighters
ICBO	International Conference of Building Officials
IFSTA	International Fire Service Training Association
ISFSI	International Society of Fire Service Instructors
LEXIS	LEXIS - A Data System for Laws and Legal Matters
MEDLARS	Medical Literature Analysis and Retrieval System (National Library of Medicine)
NBS	National Bureau of Standards
NCSBCS	National Conference of States on Building Codes and Standards
NEMA	National Electrical Manufacturers Association
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NFPARF	National Fire Protection (Association) Research Foundation
NFPRF	National Fire Protection Research Foundation
NIH	National Institutes of Health
NRC-Canada	National Research Council of Canada
NRL	U.S. Naval Research Laboratory
OLS	Operation Life Safety
PCA	Portland Cement Association
SBCCI	Southern Building Code Congress International
SCA	Smoke Control Association
SFPE	Society of Fire Protection Engineers
SPI	Society of the Plastics Industry, Incorporated
UL	Underwriters Laboratories, Incorporated
US	United States
USFA	United States Fire Administration
WPI	Worcester Polytechnic Institute

NATIONAL FIRE RESEARCH STRATEGY CONFERENCE

BATTERYMARCH PARK
QUINCY, MASSACHUSETTS

AUGUST 28-29, 1984



A REVIEW OF THE NEED FOR RESTATEMENT OF NATIONAL GOALS AND DIRECTIONS FOR FIRE RESEARCH IN THE UNITED STATES

Table of Contents

Section A

Preface

Fire Research in the United States has, in 1984, reached a critical point at which decisions and policies have to be made to ensure its continuance and to establish directions in light of changing technologies and economics.

- This is an important time for fire research in the United States. New developments are making it possible for us to consider practices in fire protection and fire safety evaluation that until recently were considered either impossible or impractical. Simultaneously, technological advances in other fields are creating exciting new possibilities for further reduction of fire losses and fire protection costs. Recently there have been significant shifts in the policies of the Federal government concerning its role in technology development and basic and applied research generally and in fire research in particular. Current Administration policies support a Federal role in basic and generic applied research, but seek to shift to private sector and state and local governments responsibilities for support of other applied research, and most technology development. Finally, the total resources available for fire research are limited.

- In view of these factors, we believe that it is essential that the direction and strategy for fire research, particularly opportunities for joint or coordinated private and public sector efforts, be reviewed and that an attempt be made to develop both guidelines and a strategy for the future.

In order to begin establishing strategies, the National Bureau of Standards/Center for Fire Research and the National Fire Protection Association jointly sponsored a meeting of a small group of private and public sector leaders in fire research August 28-29, 1984, at the NFPA headquarters, Batterymarch Park, Quincy, Massachusetts.

Taking part were representatives from industry, trade and professional associations, academia, research and testing organizations, federal agencies, and Congress.

We hope the product of this conference will lead to a wider involvement of interests in a continuing commitment for application of a planned strategy for fire research in the United States.

Jack E. Snell, Director
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SECTION B

PERSPECTIVE ON THE GROWTH OF FIRE RESEARCH

Annual fire losses in the U.S. include 6,000 reported deaths and 31,000 injuries. The total cost of fire to the U.S. economy is estimated to be approaching $30 billion per year, some $6.8 of which is direct cost. The U.S. fire death rate along with Canada ranks worst of the nations of the world which report such data and, in fact, is over twice the international average.

This situation has existed for some time. Yet, it is widely believed that with improved knowledge of fire, fire safety education and training, and cost-effective technologies for reducing the risk of fire, both the losses and costs of fire in the U.S. can be reduced dramatically, i.e., by at least a factor of two or three. Thus, fire research is a crucial part of national efforts to achieve these savings.

Yet, fire research in the United States has a comparatively short history, and has traditionally not been accorded the status of a vital national commitment.

Despite this, there has been much valuable work done in both the federal and private sectors that has developed a fire research excellence in the country.

In the late 1950's, the National Research Council's Committee on Fire Research recommended a national program of fire research; by 1969 the committee reported small, but significant progress.[1]

Research into the phenomena and problems of fire has developed and matured rapidly since the late 1960's when the National Bureau of Standards was authorized by Congress to undertake a more comprehensive program of fire research.[2]

Impetus was given when the National Science Foundation, under the Research Applied to National Needs Program in 1971, began support of a number of fire research projects at major universities.[3]

The report of the National Commission on Fire Prevention and Control issued in 1972 under the title "America Burning" recommended that the Federal government strengthen its programs of fire research.[4]

When the Federal Fire Prevention and Control Act was passed by Congress in 1974, a greater degree of national coordination occurred, but this has been tempered by reluctance to assume Federal responsibility for the Nation's entire fire research efforts.

References

1. A Proposed Fire Research Program. National Academy of Sciences-National Research Council, Committee on Fire Research, Washington, D.C., 1959.

2. "Fire Research and Safety Act", Pub. L. 90-259, 1968. U.S. Code, Cong. & Ad. News.

3. See, for example, NSF/RANN Conference on Fire Research, Harvard University, Cambridge, MA, June 25-27, 1975, sponsored by the National Science Foundation.

4. "America Burning". The Report of the National Commission on Fire Prevention and Control, Government Printing Office (U.S.), Washington, D.C., 1973.

Fire Research has, however, been greatly advanced by federal agencies and programs, and much of the work done by universities and individual researchers would not have been possible but for federal grants and contracts.

The private sector has also maintained programs in fire research, much of which is performed by the research facilities of insurance companies, concerned industries, and trade and professional associations. The testing laboratories have played a key part in establishing a core of researchers in this country.

Despite all this activity there has never been a truly coordinated Nationwide strategy for fire research under which clear priorities could be articulated, information shared and resources allocated efficiently.

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SECTION C

PURPOSE

To bring together some of the principal organizations and individuals concerned with and about fire research to exchange views and opinions on the direction that fire research should take.

OBJECTIVES

1. Assess the current status of fire research.
2. Identify factors affecting progress in fire research.
3. Review the technologies that are now available for fire research.
4. Relate needs in fire research to capabilities to fulfill those needs.
5. Recommend a course of action that will lead to development and implementation of strategies to meet the fire research needs of the nation.

ORGANIZATIONS PARTICIPATING

American Iron & Steel Institute, American Society for Testing & Materials, Armstrong World Industries, Benjamin/Clarke Associates, Borg Warner Chemical, Center for Fire Research/National Bureau of Standards, Factory Mutual Research Corporation, National Fire Protection Association, Penn State University, Schirmer Engineering Corporation, Society of Fire Protection Engineers, Underwriters Laboratories, U.S. Consumer Product Safety Commission, U.S. Fire Administration/Federal Emergency Management Agency, U.S. House of Representatives, University of Maryland, Weyerhaeuser Company.

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SECTION D

THEMATIC HIGHLIGHTS OF DISCUSSIONS DURING CONFERENCE

The following is a brief sampling from the discussions in the two-day meeting. The discussions were detailed, highly technical in part, and sometimes contentious. Discussion topics included research needs, the fire problem, attitudes, roles, and financing. It reflects the optimistic outlook that emerged as the discussion proceeded that a new era in fire research truly is beginning and that the time for collective action is now.

"....There is a need for collective effort; no one organization, agency, group or industry has either the authority or resources to mastermind a fire research program that integrates all aspects, creates free exchange of ideas and technology and provides the output that only such an integration can produce...."

"....This group, while it is representative, certainly does not include many interests and individuals that need to be involved in the coordination of a national strategy...."

"....When we talk of a national strategy we use the term 'national' in its broader sense and are not using it as a synonym for 'federal'. For a coordinated fire research plan to be successful we must include every interest in its development and in its implementation...."

"....The federal involvement is subject to changes in commitment and dedication caused by fiscal priorities of the administration of the day. These changes are based on factors other than the belief in the need for fire research or a lack of such a belief...."

"....The work done by the National Bureau of Standards/Center for Fire Research has been the core of progress recently in basic fire research, and the applied research sponsored by the Federal Emergency Management Agency has led to the implementation of new approaches in the field. Many other federal agencies have initiated valuable fire research centered around their respective responsibilities. The Center for Fire Research, however, is seen as a vital and essential catalyst to progress and to the future of fire research in the United States. It is vital because it offers an independence that is not constrained by a need to consider market potentials and it is essential because it has the best resources in terms of facilities and personnel to be at the heart of progressive scientific research...."

"....The Federal Emergency Management Agency is also seen as having a major role, particularly in the transfer of the results of research to field applications...."

"....The private sector, while contributing much, obviously must consider the relevance of research to its own needs and its overall stability. Despite these constraints, many industries support fire research of a general nature in the national interest...."

"....Academic establishments depend primarily on federal grants and contracts to become involved or continue in fire research. As these resources diminish, programs cease and may never resume.

This has the effect not only of reducing active participation by some of the most inquiring and innovative centers of research, but also of eliminating incentive and opportunity for emerging scientists to pursue the field of fire research. The long-term result will certainly be a lack of experienced and qualified researchers in the fire field...."

"....Fire research is at a critical point in its history. There have been quantum advances in the technologies, particularly in those which can be used for physical measurement and analysis, together with the almost unlimited capability now afforded by electronics to handle data, and to resolve complicated problems at a level of sophistication never before possible...."

"....All this means we are closer to breakthroughs in fire research than at any time in the past. It is, in fact, a time of transition; we are on the threshold of a new era...."

"....What should be our objective? Should it just be to cut the U.S. fire death rate in half - that would still leave the U.S. as the highest in the world. Or should we aim to have the lowest? Perhaps a new form of objective is necessary...."

"....Looking at the relative emphasis placed on fire research in other countries, notably the industrialized nations, we have seen a much greater governmental influence than in the U.S. Apart from this aspect, however, it is the overall intensity of research in other countries that becomes readily apparent and the obvious excitement in those countries concerning the recent advances in fire technology, much of which had its conception in the U.S.; this activity indicates that if we reduce our efforts, the leadership we have given in this transition will pass to others and once again the U.S. will become the follower in fire research that, unfortunately, we were several decades ago and the U.S. will lose significant potential foreign trade opportunities for U.S. products and engineering services...."

"....Given that research must go on, and not at reduced levels, much needs to be done to bring all U.S.-based fire research into focus and endeavor to identify ways to coordinate, without dictating, so that the entire fire research of the nation is moving in harmony and is mutually supportive...."

"....Fire research is not seen to be just pure or basic research but rather all-encompassing; it must include finding solutions to the small but frequent fire problem as well as the occasional but spectacular incident. It must include the need to deal with the educational and attitudinal barriers that shape the behavior of people, not only en masse but individually when faced with fire. It must also focus on the whole question of determining the level of protection that should be provided, and on methods of assessment of risk that can be properly and judiciously accepted or not accepted...."

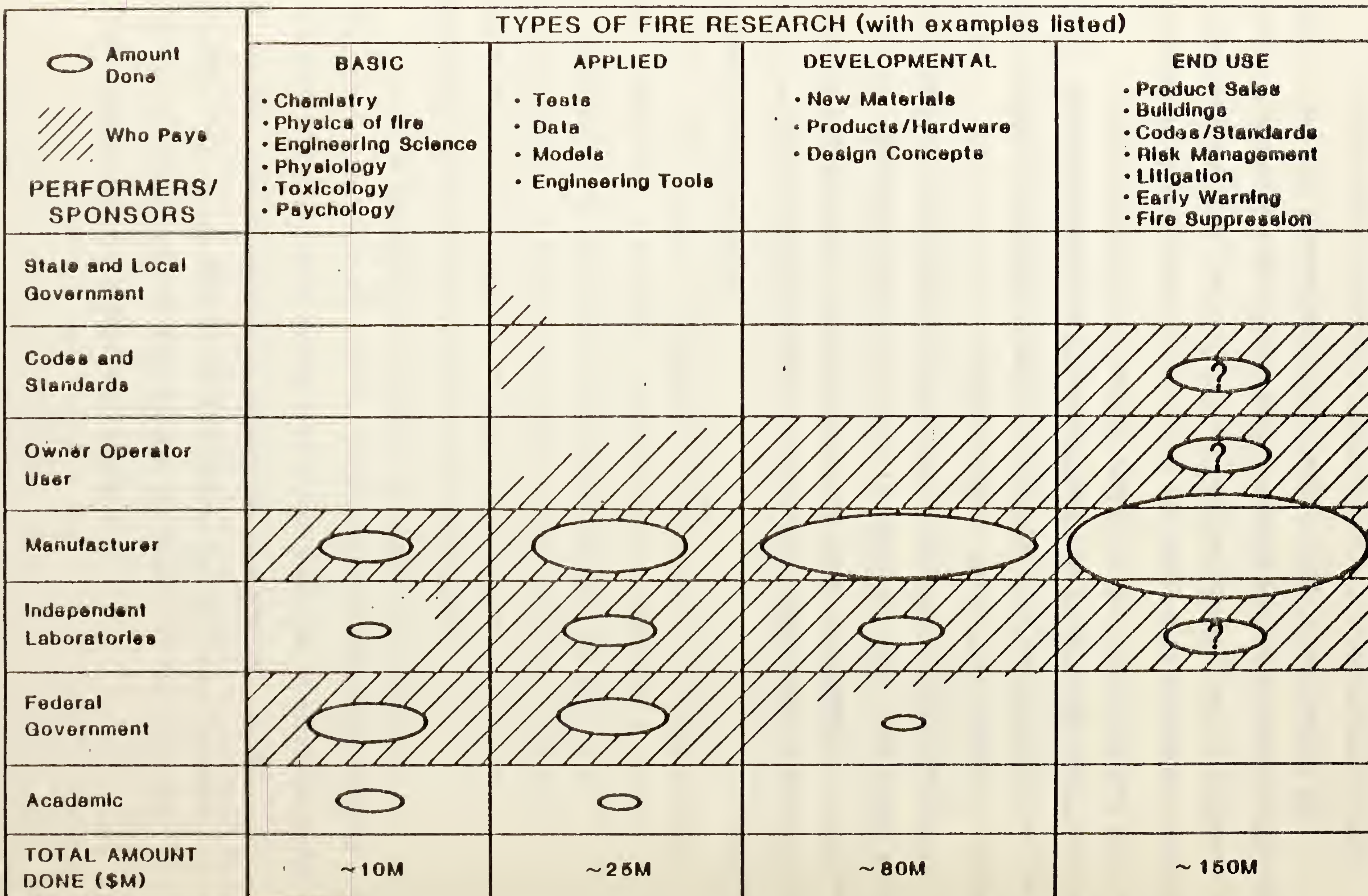
"....Fire Research is in need of a redefinition of its components and the scope of each. From such a redefinition there would be a logical structuring of the interactive roles each component can take in an overall strategy to maximize the impact of fire research. With this would come a clarification of the best resources and interests that should be involved in the research in its widest sense...."

"....It is recognized that meeting the needs of the future by research is more important than the preservation of those methodologies and practices that, while having done a creditable job in maintaining the status quo, have not materially reduced the fire problem. It is, however, fair to say that one of the reasons for the lack of greater impact is that transfer of the products of research to the field for implementation has not always been possible...."

"....The adaptations of recent technological developments that are changing fire research and the increased understanding that new methods can be applied to the fire problem must extend beyond the laboratory into acceptance and perception by those who deliver fire protection, those who prescribe levels of protection and those who are to receive protection from fire. This should be as much a part of the fire research strategy as the pure chemistry and physical aspects and make sure that delivery is complete, is equally part of the research needed...."

"....Without question, national fire research strategies are needed, and are needed now. They are essentially part of the new technology transition, if indeed that transition is ever to occur, and all those who have an interest should commit themselves to working to develop the strategies...."

TYPES AND MAJOR PERFORMERS AND SPONSORS* OF FIRE RESEARCH IN THE UNITED STATES



*This figure, adapted from tables developed at the conference, illustrates where various types of fire research are carried out now within the economy. The estimates of amount done are based solely on the knowledge of the participants and may underestimate research expenditures particularly in the Developmental and End Use categories.

SELECTED

MAJOR FIRE RESEARCH NEEDS

The following list of selected fire research needs was compiled from inputs provided by participants at the First National Fire Research Strategy Conference. These topics are not prioritized. Some are currently being researched; others are not. They are grouped to illustrate the types of research needed--using the classifications provided on Figure 1. There are strong interdependencies among many of these research topics. Subsequent activities and meetings of the National Fire Research Strategy Conference will include efforts to transform such listings into a national plan for fire research.

• Basic

1. Fundamental studies of flame ignition, spread, extinguishment, suppression.
2. Mechanisms of material performance in fire (degradation, soot and smoke formation).
3. Biological and physiological effects of toxic substances from fire.
4. Human behaviors relating to fire.
5. Scientifically-based reference computer fire codes (zone and field models).

• Applied

1. Quantitative models for fire and smoke hazard prediction.
2. Smoke toxicity measurement and prediction.
3. Predictive and simulation models of human response (decision and actions) to fire.
4. Expert systems for firesafety evaluation of specified facilities.
5. Epidemiology of fires.
6. Field test methods for detectors, smoke control and sprinkler systems.

• Developmental

1. Extend application of quick response sprinklers to additional occupancies.
2. Furniture, furnishings, solid-fueled heating devices firesafety.
3. Guide criteria for smoke movement, control, removal.
4. Translation, adaptation and delivery systems for fire research results.
5. Selection, evaluation/certification procedures for commercial firesafety computer programs.
6. Products and systems that are more fire-safe.

• End Use

1. Fire and smoke toxicity hazard assessment methods.
2. Means to establish firesafety level and equivalence of alternative designs.
3. Practical fire risk estimation techniques.
4. Firesafety for target groups (elderly, children, etc.).
5. Firesafety and fire protection education.

SECTION E

ACHIEVEMENTS OF THE CONFERENCE

In addressing the original intent of the meeting, the attendees analyzed and identified in some detail each of the five stated objectives for the conference.

While recommending that a wider involvement of interests will be required to develop a national strategy for fire research, the following is a brief summary of the overall conclusions reached in respect of each objective:

Objective No. 1: Assess the current status of fire research.

The current status of fire research is one of change and transition into promising new directions. Fire research is now at a critical point. Major advances are being made in capabilities to predict fire risk and appraise the impacts of design hazards or safeguards. The transfer of these advances to the fire protection community is just beginning.

Objective No. 2: Identify factors affecting progress in fire research.

Progress is being positively affected by the advent of new technologies and new approaches, but reduced financial resources for fire research are threatening such progress.

Objective No. 3: Review the technologies that are now available for fire research.

Technologies that can change fire research and produce effective solutions include, for example, physical systems for measurement of flame, gas production, and other combustion processes; powerful new generations of computers with vastly improved mass information-handling, analytical and interfacing capabilities; new capabilities for modeling and prediction of complex phenomena of fire growth and smoke movement along with behavioral patterns; responses of the humans and the performance of fire protection technologies, and important new technologies such as expert systems for effectively utilizing these tools and coupling them with researchers and practitioners.

Objective No. 4: Relate needs in fire research to capabilities to fulfill those needs.

Existing resources--trained professionals, facilities and funding--are limited. It is not yet clear these are sufficient. Nonetheless, significant advances can be made provided there is a coordination of effort involving an overall and dynamic plan in which all interests participate.

Objective No. 5: Recommend courses of action.

The course of action needed is clearly to involve all concerned in developing and implementing a national fire research strategy that addresses every aspect of fire research needs, resources and integrated action. This reflects the most important priority and the commitment of the participants of this conference.

Action Recommended

Those attending the National Fire Research Strategy Conference, having reviewed the current status of fire research; having examined many research needs, together with the availability of facilities and researchers; and having considered new and advanced technologies; resolved that the following statement be issued as a collective indication of intent to pursue the coordination of fire research in the United States:

A. A coordinated fire research plan should be developed to help achieve the reduction in fire losses in the United States in accord with the objectives of the Fire Prevention and Control Act of 1974.

The coordinated plan should encompass the following:

1. Development of an accurate identification of needs that is based on an inventory of completed or current research and prioritization of those areas requiring further investigation.

2. The Center for Fire Research fulfilling the crucial role of spearheading and coordinating basic and generic applied fire research - through independent research within the Center; by provision of grants, fellowships and technical support to independent researchers in universities and similar institutions; and by serving as an objective forum for reviewing and coordinating the national research effort.

3. Involvement of the academic community to take advantage of its scientific expertise and to assure a supply of scientists to carry on needed research into the next century.

4. Development of a plan to assure availability of the funding necessary to complete the required research. The plan should identify the potential benefits for both society at large and the specific interests of users of the research.

5. Means to effect transfer of research results to users such as engineers, designers, fire service and code officials and standards-developing organizations to permit implementation of the results for the public good in the shortest possible time.

6. Mechanisms to permit timely feedback from users to keep the plan dynamic and responsive to changing needs and capable of anticipating the effects of future technology where feasible.

B. That the National Fire Research Strategy Conference be continued and strengthened by the inclusion of others who have interest and concern in the matter of fire research and that with such infusion of additional expertise and support, it undertakes the development of the coordinated national fire research plan.

National Fire Research Strategy Conference

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Scenes from August 28–29, 1984 Meeting

APPENDIX E

SUPPLEMENTARY COMMENTS

Attendees of the meeting were invited to submit additional comments or information that they thought should be included in the report. Two workshop participants prepared supplementary comments.

Schirmer

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FIRE PROTECTION ENGINEERS
SAFETY ENGINEERS
CODE CONSULTANTS

August 7, 1985

Dr. Bernard Levin
Center for Fire Research
Building 224, Room A-263
Gaithersburg, MD 20899

Dear Dr. Levin:

Some very short comments regarding the report:

Page 74: The 9th line, the word "and" should be deleted after the word "sensitivity".

Of considerably more importance, the data base referred in this paragraph should more appropriately be under the leadership of the private sector and in this case I would suggest the NFPA to avoid the possibility of creation of a data base and data gathering methodology under a federally funded agency and the possibility of that agency disappearing along with its data collection mission. A private sector organization such as NFPA will have a considerably greater degree of continuity and therefore should take the lead in this area as far as actual implementation.

Page 76, under "Building configurations influence on sprinkle/detector sensitivity on fire growth, add FM as a sponsor.

Optimization of sprinkler response time sponsor should be the same as building configuration inasmuch as this is a part of exactly the same effort. The same is true with regard to effects of ceiling height, etc. This is a part of building configuration and should not be duplicated.

I have not reviewed any of the other groups' material inasmuch as frankly I was not there to listen to the discussion and do not feel that I would have any input other then from an editorial standpoint.

It was an enjoyable experience and I sincerely hope that it will prove productive not only from the standpoint of NBS/CFR funding but also from the standpoint of developing meaningful fire research on a coordinated and continuing basis.

Kindest regards,

SCHIRMER ENGINEERING CORPORATION

Chet

C. W. Schirmer, P.E.
President

jc

DEPARTMENT OF HEALTH & HUMAN SERVICES

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August 6, 1985

Dr. Bernard Levin
National Bureau of Standards
Center for Fire Research
Building 224, Room A-263
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Dear Bud:

I left the National Fire Research Strategy Conference with mixed feelings. In some ways it was great to be among so many prominent personalities in our field, but disappointing that the conference could not have suggested research of a more specific nature. I realize, as the title implies, it was a strategy directed meeting, but it seems to me that at least some of the pre-conference suggestions would have been addressed as needing priority treatment by researchers. If one finds the "strategy", it is that we should establish more task forces to talk about technology transfer.

If anything was identified as a National Fire Problem, it was the thousands of lives lost each year in this country in residences. However, the conference barely mentioned it. If the Congress has the slightest feeling that we are attacking that problem, they should be disappointed. Since the vast majority of fire deaths occur in poorer residential settings without even a simple smoke detector, how in the world will more research help? It would be more cost-beneficial to give smoke detectors to rural and city fire departments to install in these poorer residences and have them go around to replace the batteries each year.

Laying the National Fire Problem aside, there are several areas which could be tackled under the label of developing better Code provisions:

1. As our handicapped citizens attain more of their mobility goals, they will realize that they are totally dependent upon the elevator to leave a multistory building and the first thing society does is to take the elevator out of service.

2. We are experiencing more electrical fires, which if put in combination with Polychlorinated Biphenyls can cause a building to be closed for years. What would be the impact of automatic sprinklers on these electrical fires?

3. Our fire alarm systems, except for our schools, border upon disgrace. Nobody responds to a fire alarm as intended by the Code writers. Any alarm has to be followed-up by additional information. Our fire fighters waste precious time telling people to get out of a building instead of extinguishing the fire. Unwanted (as opposed to calling them false) alarms are costing us dearly. A major problem is that our fire alarm signals are not standard. The idea that all we need to do is ring a bell and everyone evacuates is absurd.

4. Our "state-of-the-art" Codes for the protection of hospitalized patients increase the cost of health care and cause many operational problems, but the first sign of smoke in the area triggers an evacuation. The concept of "protection-in-place" is a farce.

I guess these questions are part of what we could call our National Code Problem as contrasted to the National Fire Problem. I am in agreement that we need technology transfer, knowledge based codes, and the other broad research ideas from the conference; but we should have been a bit more specific.

Thanks for taking the time to listen to me. Let's continue to work toward a more fire-safe society.

Sincerely,

Jonas L. Morehart

Jonas L. Morehart, P.E.
Fire Protection Engineer

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

The July 22-25, 1985, meeting of the National Fire Research Strategy Conference was held for the purpose of initiating the development of a coordinated fire research plan to achieve the reduction in fire losses in the United States in accord with the objectives of the Fire Prevention and Control Act of 1974. One hundred and seventeen experts from industry, government, academia, and professional societies were assigned to one of nine panels or workshops to discuss different application areas of fire research and the needed research in the respective areas. The areas included: design and engineering; materials and products; investigation and litigation; regulation and risk; real time fire extinguishment; and fire prevention, safety and survival. One panel integrated the findings of the other panels and developed generalized conclusions. The nine panel reports and a list of attendees is included in these proceedings.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

conferences; fire data; fire investigation; fire prevention; fire protection engineering; fire research; fire science; management; proceedings; risk analysis

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