

A First Pass at Computing the Cost of Fire Safety in a Modern Society

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U.S. DEPARTMENT OF COMMERCE
National Institute of Standards
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Gaithersburg, MD 20899**

**U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
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NIST

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Notice

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**A FIRST PASS AT COMPUTING THE
COST OF FIRE SAFETY IN A MODERN SOCIETY**

*(With a summary of the impacts of the Center
for Fire Research's program on these costs.)*

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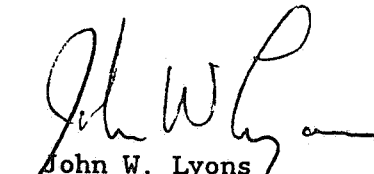
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FOREWORD

This study, and a companion study entitled, "Estimated Impact of the Center for Fire Research Program on the Costs of Fire," were prepared for the Center for Fire Research, now a part of the Building and Fire Research Laboratory, of the National Institute of Standards and Technology (NIST).

The "Cost of Fire Safety in a Modern Society," report provides an estimate of the total annual dollar costs of establishing and maintaining fire safety in 20th-Century United States. The cost of fire safety estimate is needed to serve as a basis for evaluating the benefits and appropriateness of current and proposed fire research programs of NIST. This was a relatively modest effort to obtain a first-order estimate of these costs and much of what is reported in these two reports is anecdotal. Nonetheless, the central conclusions one comes to in reading them are that the burden of fire on our society is substantially greater than previously realized and that significant reductions in this burden may be readily achievable through the continued development of fire science and the rapid transfer of fire research results. These findings are particularly relevant as the U.S. economy and its manufacturing infrastructure adjust to the competitive challenges of the global marketplace.


John W. Lyons
Director

I. EXECUTIVE SUMMARY

The total cost of fire in the United States is estimated at \$115 billion, plus another \$13 billion for the economic cost of fire deaths and injuries. This is considerably higher than previously estimated. Several major components of the problem had not been explicitly estimated before. Also, the costs of fire to industry have been increasing because of the vulnerability of high technology to even small fires.

The Center for Fire Research (CFR) at the National Institute of Standards and Technology has had a major role in helping to control losses from fire, and the costs of fire to society. A first cut estimate of the annualized impact of the CFR program is \$6-9 billion per year. Under the proposed enhanced CFR budget the impact would be on the order of \$16-26 billion per year. The impact may well be larger because of the difficulty in computing some major secondary impacts of the program on this first cut. (*Discussed further below.*)

The CFR program has had its largest impacts on the costs and effectiveness of built-in fire protection in buildings, and on smoke detection and consumer product safety in residences.

CFR plays a role directly or indirectly in most aspects of the cost of fire, but needs to consider whether it could affect to a greater degree the two large cost pools of (1) the cost of fire service, and (2) the cost of built-in fire protection of equipment (in addition to fire protection of buildings.)

The secondary impacts of the CFR on the major cost areas of insurance, business interruption and fire maintenance remain to be estimated, but are probably large.

Findings on Costs of Fire

This report describes the major components of the total cost of fire, and provides new estimates for each. (A companion report estimates the impacts of the CFR program on the various cost components.¹) While the scope of this effort permitted only rough estimates to be made, the order of magnitude that emerges is clear. Some highlights follow.

- The toxic fumes and hazardous products of combustion, long known to threaten human life, have introduced a new hazard to U.S. industry. Factory Mutual Engineering Corporation refers to this hazard as nonthermal fire damage and cautions that the smoke and corrosive products of fire may do more damage than the flames.
- The U.S. has very few \$1 billion fires, and when such fires occur they involve extensive physical damage. An example is the \$750 million October 23, 1989 fire at Phillips Petroleum's Pasadena, Texas chemical plant. That fire was the fourth largest fire loss in U.S. history. It will take one to two years to rebuild. By comparison, a localized fire in a Class 1 wafer lab might involve little apparent damage yet could expose the insurance industry to property damage and business interruption losses exceeding \$1 billion. Such a loss will drive up the cost of insurance, if it remains available.

¹ *Estimated Impact of the Center for Fire Research Program on the Costs of Fire*, P. S. Schaenman, TriData Corporation, 1991.

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- Environmental issues such as ozone layer protection and groundwater contamination have brought into question continued reliance on water and halon as the primary fire suppressants. The November 27, 1987 Sherwin-Williams warehouse fire burned for six days after the local Fire Chief's decision to turn off the sprinklers and to stop spraying water on the fire because the warehouse was inadvertently built on an aquifer.
 - The United States appears to be losing the lead in flame retardants. With the emergency of a Pan-European market Europe is now establishing the flame retardant standards U.S. industry must meet. In Europe, flame retardants must allow for two-way use, that is, remelt and recycling without release of toxic gases such as dioxin.
 - In today's business environment with U.S. industry confronting increased competition in its home market it is becoming more difficult to establish and maintain market share. A loss of production facilities, or product in place, to thermal or nonthermal fire damage may prove threatening to the very survival of companies. Fires are becoming less acceptable as an ongoing business risk as decisionmakers realize lost production or warehoused product will be replaced immediately by U.S. and foreign competitors. In short, they know they may never regain that lost business.
 - Forty percent of small businesses with major fires never reopen.
 - Eighty percent of the total cost of fire in the United States, \$115 billion, is represented by six fire cost components, in rank order: Volunteer Fire Service Conversion; Preventative Measures Built Into Structures; Preventative Measures Built Into Equipment; paid Fire Service; Business Interruption, and Fire Maintenance. The combined total of the remaining ten fire cost components account for less than 20% of the total cost of fire in the United States.
 - Business interruption loss, the fifth largest cost component of fire, is estimated to be three to four times greater than business property loss.
 - Because of increasing concerns about life safety and the environment, local jurisdictions are enacting codes which have increased the cost of built-in fire prevention, detection and suppression systems. Preventative Measures Built Into Structures now represents the second largest cost component of fire. The cost of such measures may make it prohibitive to place future production and warehouse facilities in the U.S. particularly in those high value-added high-technology industries where the U.S. has been able to maintain worldwide leadership.
 - The products liability costs of fire, \$3.5 billion, is almost equal to the total property damage of residential fires, \$4.0 billion.
 - The \$18 billion cost premium for the *fire-grade* equipment installed in new facilities appears to be the third largest cost component of fire in the United States.
 - The new codes being implemented in response to increased environmental and life safety concerns have increased the cost of ongoing fire maintenance to an estimated \$6.5 billion making fire maintenance the sixth largest cost component of fire.
 - Because of firefighters role as society's first line of defense in hazardous material spills and emergency rescues, in addition to fires,

volunteer fire companies are finding it difficult to attract and retain volunteers. Therefore, volunteer firefighters will be converted to paid firefighters, changing what has been historically an implicit cost into an enormous explicit cost. On a national basis, the annual cost resulting from that conversion could represent the largest cost component of fire in the United States.

- The most terrible costs of fire are human death and injury which is why much of fire prevention has focused on reducing human loss. Because some people find it repugnant to place a value on the loss of human life and the consequences of human injury, this analysis makes no provision for those losses.

II. THE CHANGING FACE OF FIRE SAFETY

Introduction

Fire deaths and injuries continue to cause a tremendous amount of human suffering in the United States. The recent drop in fire deaths in the U.S. may indicate that fire safety programs introduced in the past are having the desired effect and that sometime in the near future the U.S. will no longer experience one of the highest fire death rates in the world.

This report is a preliminary attempt to determine whether there are new fire safety challenges confronting the U.S. as it continues to adjust to the requirements of the information age, namely, instant communication, global markets and rapid response. An attempt is also made to provide an initial quantification of each of the emerging fire safety factors in order to rank the factors and to allow calculation of the benefits to be expected from corrective programs.

Nonthermal Damage

Nonthermal damage can exceed property damage

The toxic fumes and the hazardous products of combustion, long known to threaten human life, have introduced new hazards to some of the most valuable production of U.S. industry. Factory Mutual Engineering Corporation (FMEC), an insurer of industrial facilities which promulgates fire safety standards and practices for industrial properties, refers to this hazard as nonthermal fire damage and considers it to be a relatively unexplored area. In its 1990

publication *Research—Into The Nineties*, FMEC noted: [14-11]

"Fires generate not only heat, which causes thermal damage, but also gaseous, liquid and solid products, some of which may be corrosive and electrically charged. The mixture of these products is generally called smoke... During a fire, smoke may be carried throughout a building, and its various products will cover the internal and/or external surfaces of walls, floors and equipment. This can cause chemical reactions (corrosion); pathways for electrical conduction (electrical damage); discolored surfaces and the deposits of products with unpleasant odors. The result is nonthermal fire damage."

"Depending on what's burning the *resulting smoke and corrosive products may do more damage to the equipment and storage than the flames* (author's emphasis). Even when sprinklers act quickly to control the fire, the nonthermal fire damage can be extensive."

"... losses from nonthermal damage are expected to continue and even increase. High-value production machinery as well as finished goods in storage are especially susceptible to nonthermal damage."

Semiconductor manufacturing, one of this country's strategic industries, is also wrestling with nonthermal damage.

Ansul Fire Protection, in its 1988 white paper entitled *Protecting Wet Chemistry Work Stations Against Fire* discussed clean rooms, enclosed areas where the amount and size of particulate matter in the air, temperature and humidity are closely controlled. The paper noted: [2-1]

"Clean rooms exist because of the industry's concern with contamination of wafers from which semiconductors are made. A two-micron bacteria can be large enough to render a chip's microcircuitry useless. Air is continually cycled through the purification system to prevent the suspended particles from settling on the wafers. The rooms are designated by the number of particulates per cubic foot, thus a room with less than 100 particles larger than .5 microns per cubic foot of air is a Class 100 room, etc. HEPA filters are capable of removing as much as 99.99 percent of all airborne particles larger than 0.3 microns and the trend is towards Class 1 clean rooms."

*A Class 1 wafer fab loss
to nonthermal damage
could exceed \$1 billion*

Mr. Richard Bolmen, Jr., then with VLSI Technology, discussed the startling implications of nonthermal damage in Class 1 wafer fabs, in the July 1989 issue of *Solid State Technology*: [6-66]

"Insurance industry experts estimate that in a Class 1 wafer fab the insurance exposure *due to smoke contamination from a localized fire* (author's emphasis), could approach \$1 billion in property damage and business interruption and could impact insurance costs and availability for the entire industry." Even a localized fire such as a burnt coffee pot can cause this much damage (author's example).

Author's note: The U.S. has very few \$1 billion fires. The October 23, 1989 fire at Phillips Petroleum's Pasadena, Texas chemical plant was estimated at \$750 million making that fire the fourth largest in the history of the United

States. That facility experienced tremendous physical damage and will take one to two years to rebuild. The scenario Mr. Boleman has described, which involves little, if any, physical damage, exceeds the loss experienced at the Phillips Petroleum facility.

On Mother's Day, 1988, a fire in the Illinois Bell Hinsdale central office resulted in complete outage of telephone service in 10,000 private lines and 35,000 residential phones. Phones service to 450,000 outlying lines was degraded. Cellular and 800 line service was also severely constrained. O'Hare's airport lines were affected with delayed flights resulting in over three days of repairs. Full service restoration took 30 days.

Some have called that fire the worst disaster in United States telecommunication history. Mr. Bill Weiss, the Chairman of Illinois Bell's parent holding company, Ameritech, called the disaster a *watershed event* in the history of telecommunications in the U.S. He added, "the incident provided the industry's first real-life example of the specific damage fire and related damages can do to a major electronic and fiber-based office." [28-23]

In the May 28, 1990 issue of *Business Insurance*, Mr. Kenneth Dungan, President, Professional Loss Control, Inc., Oak Ridge, Tennessee stressed the nonthermal aspects of the Hinsdale fire stating: [8-6]

"The corrosive nature of the smoke and gases released when wiring in the switching station caught fire contributed to the severe property damage."

In the same issue, Mr. John Davenport, director of research at Industrial Risk Insurers, Hartford, Connecticut, when discussing property damage from smoke and corrosives observed: [8-6]

"Nonthermal damage pose a particular threat to food. A very, very small *fire that seemingly does no damage can condemn an entire warehouse* (author's emphasis) because of a slight taste problem."

An Environmental Perspective

Environmental issues have increased concerns regarding continued reliance on water and halon for suppressing fires

The most common mode of fire suppression is water. Water is used in water hoses and in automated sprinkler systems. Water spent suppressing a fire runs off the fire site. There is no guarantee that the water runoff has the same purity as the spent water. In fact, water used to suppress fires in warehouse and facilities storing toxic and flammable liquids and gases frequently produces polluted water runoff. The November 27, 1987 Sherwin-Williams warehouse fire is a good example. It took six days for firefighters to get that fire under control. While the fire was intense because of the 1.5 million gallons of paint, paint thinner and related chemicals, the delayed suppression of that fire was due to the Fire Chief's decision to turn off the sprinklers and to stop spraying water on the fire because the warehouse was inadvertently built on the aquifer used by local water utility systems.

The Montreal Protocol on Substances that Deplete the Ozone Layer became effective January 1, 1989. Halons were affected by that protocol. Halons appear to be the perfect fire suppressant. They are electrically non-conductive, dissipate rapidly, leave little harmful

residue and because of their low toxicity levels do not endanger people in structures or rooms protected by halon systems. Halon systems are commonly found in computer rooms containing mainframe and super computers. Motorola Corporation uses halon in its wafer fabrication facilities. The Boeing Company uses halon systems to protect the airplane hulls being assembled within its factories. By the year 2000, the phaseout of halon production established in the June 1990 revision of The Protocol, Motorola and Boeing, and many others, must be supplied alternative means of protecting high-value property.

Flame retardants must be designed to allow for two-way use

Plastics are light in weight but high in volume. The September 1990 issue of *Appliance*, reported that according to the Plastic Recycling Alliance, a joint venture between DuPont and Waste Management, plastics currently total 20 billion pounds of the waste stream in the U.S. and make up 7% by weight and 20% by volume of the waste materials processed by landfills. [70-81]

Flame retardants are added to plastics to produce plastics which burn slower and generate less smoke. Bromine compounds are the most common retardants used in the United States but their continued use is brought into question by the increasing pressures throughout the United States to recycle plastics. Plastic recycling is an infant industry. Most methods involve separating plastics at recycling centers to obtain compatible resins followed by a remelt process. Mr. John S. Razzano, Manager of General Electric's high-performance polymers and coatings reported in a recent article in *The Wall Street Journal* that when plastics containing

certain bromine fire retardant compounds are remelted they give off harmful dioxin. Mr. Glen Hiner, GE's Senior Vice President of Plastics, added: [54-B5]

"Four or five years ago, we didn't have to worry about recycling, but the society is taking a different view of the manufacturers as to how they account for the final disposition of the material. What we are doing is to try to develop a mechanism to make plastics a two-way material."

*BMW is building its
first disassembly plant*

In the *Appliance* issue referenced earlier, Mr. Mike Martin, Marketing Programs Manager for GE Plastics cited recent developments in Europe as the forerunner of what U.S. industry must prepare for: [70-81]

"What we look to in the area of recycling are the trends we see in Europe. BMW, for example, is building its first disassembly plants. They will be taking automobiles back at the end of their lives and disassembling them. In the appliance industry, we feel that engineering thermoplastics offer manufacturers the opportunity to design their products not only for manufacturability, but to also take proactive steps towards designs that will be more conducive to recycling in the future."

A Global Market Perspective

*In today's competitive
environment companies
can't afford to lose
production facilities
to fire*

As evidenced by GE's indication that it looks to Europe to identify trends expected to emerge in the U.S. market, U.S. corporate decision makers are becoming aware their competition in the domestic U.S. market includes manufacturers located all over the world. It is becoming more difficult to establish and maintain market position. A loss of production facilities, or product in place, to the thermal or nonthermal fire damage may prove more threatening to the very survival of companies than in the past. Fires are becoming less acceptable as an ongoing business risk as decisionmakers realize that if they lose production or warehoused product, that loss will be filled immediately by capacity and product of U.S. or foreign competitors. They may never recover that lost business.

III. COMPUTING THE COST OF FIRE

Introduction

The most terrible costs of fire are human death and human injury, which is why much of fire prevention focuses on reducing human loss. Because some people find it repugnant to place a value on the loss of human life and the consequences of human injury, this analysis makes no provision for those losses. Chapter IV, *Analyzing the Cost of Fire*, does include a brief discussion of the human costs of fire.

This analysis is focused on the consequences of fire, including: loss of property; business interruption; products liability; insurance; fire fighting services, and the many measures developed to prevent fires. Costs resulting from forest fires and fires in federal, state and defense facilities have been excluded from this analysis.

The object of this analysis is to prepare, within a very limited budget and tight time frame, a first-pass estimate of the total economic consequences of fire on the U.S. economy as it continues to adjust to the demands of global markets, world-class products and instant communication. The analysis is based on a limited number of telephone interviews and public documents and data series published by private sector associations and government agencies.¹

The findings of the analysis indicate that the non-human cost of fire in the United States exceeds \$100 billion per annum. The tabular summation at the end of this chapter contains a most-likely-estimate for each fire loss component and may be of some use in identifying areas which merit further study.

A. Property Damage

There is no national census for fire loss data. As a result most fire loss data are estimates. The U.S. Fire Administration's *National Fire Incident Reporting System* is based on reports submitted by 14,000 fire departments in 39 states and the District of Columbia. Its fire loss estimate includes an adjustment for nonreporting states.

Every year The National Fire Protection Association (NFPA) conducts the *National Fire Experience Survey*. It surveys a sample of fire departments in the United States. The survey is stratified by the size of the community protected. The results are used to prepare an estimate of the fire loss in the United States for that year. The 1989 fire loss estimate appeared in the September/October 1990 issue of *FIRE Journal* in an article prepared by Mr. Michael J. Karter, Jr. The NFPA's estimate of direct property loss due to fire for 1989 was \$7.5 billion. \$4.0 billion *residential*, \$2.8 billion *industrial* and \$0.7 billion *other*. *Industrial* includes stores and offices, storage in structures, and, industry, utility and defense. The NFPA data does not include fire incidents handled by private fire brigades or fixed fire suppression systems. [37-56]

¹ Quotes of telephone interviews in this report are based on the author's notes rather than direct transcription.

