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

William P. Meade

The Herndom Group, Inc.
209 North Columbia St.
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Sponsored by:
U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Building and Fire Research Laboratory
Gaithersburg, MD 20899

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Notice

This report was prepared for the Building and Fire Research Laboratory of the National Institute of Standards and Technology under Contract No. 525BNB1C6678. The statements and conclusions contained in this report are those of the authors and do not necessarily reflect the views of the National Institute of Standards and Technology or the Building and Fire Research Laboratory.

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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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 Sates 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 CRF program is $6-9 billion per year. Under the proposed enhanced CRF 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 CRF 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 CRF 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.

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

- 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 aquafer.

- The United States appears to 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 aquafer 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 there 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 pro-active 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 ***FIREJournal*** 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.

Most losses are covered by insurance. Unfortunately, the insurance industry is not a good source of accurate fire loss data. Its policy losses are cumulated by type of coverage. That is, by Fire Insurance, by Homeowner Multiple Peril Insurance, and by Commercial and Farmowners Multiple Peril Insurance. Thus, when the Insurance Service Office (ISO) prepares its annual fire loss estimate it estimates the portion of Homeowner and Commercial Multiple Peril losses due to fire and adds to that pure Fire Insurance property losses. That adjusted total is then further adjusted to include the industry's estimate of appropriate allowance for uninsured losses and unreported losses. Uninsured losses can include industrial firms such as General Motors and General Electric, which self insure, or maintain a large deductible. According to Mr. Robert Currin, an Actuarial Consultant at ISO, the 1989 direct property losses were $ 9.3 billion. 60% of that total, $5.6 billion, ***residential*** and 40%, $3.7 billion, ***industrial***. According to Mr. Currin, an additional $0.9 billion in losses were incurred due to ***business interruption***. Business interruption is discussed in the next section.

A number of attempts were made to identify other sources of fire loss data. Mr. Gerald F. Donahoe, Chief, National Income and Wealth Division, Bureau of Economic Analysis (BEA) explained that the only relevant data series is its estimate of ***Accidental Damage to Fixed Capital*** which in 1986 was an estimated $1.8 billion. That total has been adjusted to reflect the BEA's estimate of losses in excess of depreciated capital, i.e., capital not written off. Also, the $1.8 billion total applies only to industrial property, and includes losses due to floods, fires, earthquakes, etc.

The Internal Revenue Service (IRS) was also contacted. The IRS publishes a report entitled ***Corporation Income Tax Returns—Statistics of Income***, Publication 16. That report includes fire losses under ***Other Deductions*** along with corporate administrative, general and selling expenses, bonuses, etc. Once again, a wide category of losses are included; fire, flood, currency loss, shipwreck, etc. In short, it is impossible to isolate fire data. For the reader's information, 1986 ***Other Deductions*** totalled $1.6 trillion. [90-32]

B. Interruption

Business

In the manufacturing, distribution, retail and service sectors of the U.S., property damage does not reflect all losses due to fire. The greatest loss might be that of business interruption or the inability to return to ***business as usual*** following a fire. Mr. Charles R. Dittman, a Loss Control Representative for Shield Insurance Agency, Grand Rapids, Michigan, stated in his October 1988 article in *Professional Safety*: [10-22]

> " ... 40% of all insured (small) businesses never reopen following a fire. This is a result of skilled personnel moving to other companies, customers lost to competitors, records destroyed or lives lost—all losses for which insurance cannot compensate."

While Mr. Dittman explained, in a telephone conversation, that he was primarily referring to major fires in small businesses, the losses he enumerated are also experienced by larger companies. Mr. Brian Sherin, Safety and Health Services Manager for Hewlett-Packard Company's Components Group, confirmed this in the December 1989 issue of ***Professional Safety***: [69-16]

" ..the loss of a single ion implanter or photomasking stepper can run well above a million dollars."

"Replacing a major piece of process equipment can take from 3 to 18 months. The business interruption caused by water and smoke damage can run into the millions very rapidly. Additionally, business interruption can quickly lead to lost market share because of the intensely competitive nature of this industry."

The danger of losing market position was made clear in the 1970's by Wabasso Ltd.'s experience as detailed in a videotape obtained from Factory Mutual Engineering Corporation. Wabasso, a $35- $40 million textile firm was the largest employer in Three Rivers, Quebec. It was the industry leader with a 40% market share. Fire destroyed 50% of its Three Rivers manufacturing facility. One thousand of its skilled workers were out of work indefinitely. Wabasso's Vice President and General Manger, Mr. A. J. Fyfe, explained that the first order of priority was *to get rollin· gain*. However, his associates explained the complexity of that task. Mr. R. G. H. Knight, Vice President Operations, noted: [82]

"Having insurance only provides a means of getting money. The problems of reconstruction fall on all of the people involved. We had to plan for provisional operation of the undamaged portion of the plant while also planning the new facility. Outside consultants were required which add to the expense. We had one year to plan and build a plant which normally took two years to design."

Mr. Bernard Methot, Group Divisional Manager, added: [ibidem]

"Within a week we had established temporary services to the undamaged portion of the plant. Then we had to deal with issues I normally do not have to deal with; construction, layout, ordering new machines, demolition while preserving what's usable, material delivery, machinery installation, and machinery startup and adjustment. Also, the equipment was new and required extensive retraining of workers."

Mr. R. H. Travers, Vice President and Comptroller, explained the difficulties Wabasso had financing its operations while trying to rebuild its facility within a very tight one year timeframe: [ibidem]

"We lost $4.5 million in inventory including raw materials, goods in process and finished goods. We were experiencing one monetary crisis after another. We had to rebuild and finance inventory and we had to finance construction of the new facility. In addition our margins were lower. We had to use outside contractors for services we normally performed. Also, we had very little finished goods to sell."

Mr. A. E. Warden, Director of Marketing, explained how the fire had altered Wabasso's position in the marketplace: [ibidem]

"We had large orders on the books which had to be cancelled. We had major promotion programs which had to be withdrawn. We were having difficulty with our sales force. It became increasingly obvious a substantial increase in advertising expenditures would be required to regain the market position we formerly enjoyed."

Wabasso, Ltd. never regained that position. It could only recapture 8% of the market, one fifth of its former market share. Wabasso is no longer in business. Its weakened cash flow did not support its former production capabilities. Wabasso had to declare bankruptcy.

The consequences of losing market share were known to Phillips Petroleum's management as it attempted to continue to serve its customers while taking steps to recover from the catastrophic $750 million fire which destroyed its Pasadena, Texas polyethylene plant on October 23, 1989. That facility was a fully integrated manufacturing facility. It was the low cost producer in its industry allowing Phillips to capture 18% of the nation's high-density polyethylene (HDPE) market and 22% of the plastic used in blow-molded products such as Clorox bottles, milk jugs, and containers for motor oils and pharmaceuticals. During an August 29, 1990 telephone conversation with Mr. John Van Buskirk, Phillips' Vice President, Plastics, he outlined the impact of that fire:

> "As a result of the fire we lost property, lost inventory, had business interruption expenses, realized personal liability for the workers who died or were injured, and experienced significant property claims in the surrounding area for damages to automobiles, houses, etc."
>
> "Also a fire of that magnitude places demands on every function of the company as they are called upon to immediately make additional effort to rebuild and restore. In addition we had to bring in a lot of outside help, particularly in the area of human resources, engineering, and environmental management. We have also had a lot of outside legal expenses."
>
> "In addition to all of that we had the expense of retaining as much of the market share as possible. The Pasadena facility was our only U.S. manufacturing facility. We did have some offshore capacity to turn to. However, we had to go to our competition for most of our needs."
>
> "We were very concerned about the downstream impact of the fire, i.e., the impact on our customers. Some of the resins we produced were proprietary and tailored to customer use. When we could not locate other sources we had to share technology with our competition, ignoring the long-term consequences of educating our competition."
>
> "We maintained our full selling and development operations despite the loss of the Pasadena facility. We had to retain those services to minimize the downstream impact and to reenter the market running. We are publicly on record that we will rebuild that production facility."
>
> "In short the cost of that fire goes way beyond the actual cost of property or product lost in the fire. I can not tell you our insurance will make us whole and I do not know if we will recover our market position."

Author's Notes:

1. Phillips was insured for $ 1. 3 billion including business interruption.

2. Mr. Alyssa A. Lappen, in a November 27, 1989 ***Forbes*** article estimated it would take two years to completely rebuild that facility. He also points out that long before that, new polyethylene plants will have come on line at Union Carbide, Mobil, Exxon and Occidental Petroleum. He stated: [45-206]

   > "That capacity will be more than enough to fill the needs of the Phillips customers that are now begging. In other words, even if Phillips gets back on its

feet, regaining market share won't be easy."

3. In the January 1990 issue of ***Plastics Technology*** it was reported: [34-97]

"Phillips, hastening to re-establish its domestic HPDE production announced that completion of a new 300-million-lb/yr plant already under construction had been moved up from the end of 1990 to July, and would be followed by another 300-million-lb increment in October. Last month, Phillips approved a plan to construct an additional 600-million-lb plant to come on stream in July, 1991. In the first quarter of this year, the company expects to announce plans for a third 600-million-lb facility bringing planned capacity back up to where it was at the time of the explosion."

During a telephone conversation with Mr. Len Bogner, Prudential Bache's chemical industry analyst, the bottom-line impact of everything Mr. Van Buskirk discussed began to emerge. The starting point for that discussion was Mr. Alyssa A. Lappen's article: [45-203]

"There are 8 billion pounds of HDPE sold in the U.S. at an average price of 40 cents per pound. As reported in ***Forbes***, before the fire there was little extra polyethylene to go around. U.S. polyethylene capacity had been cut more than three percent by small accidents at Mobil and Quantum. Prices were beginning to inch up and with demand rising inventories were scare. In short, the industry was sold out. Within a week of the fire, market prices gained sharply. Quantum Chemical, the country's largest polyethylene producer raised prices by 13% to an average of 44 cents per pound and industry insiders expected prices to rise another 7% to 50 cents per pound. That is a ten cent a pound increase or an $800 million increase in costs, that had to be absorbed by the market."

"Phillips lost margin on the business it was able to protect, probably losing at least 5 cents per pound. If they protected their entire 1.2-1.5 billion pound position they lost profit of $75 million."

"Another thing to keep in mind is that the price of a feedstock for Phillips' competitors, ethylene, has weakened because Phillips makes some 2.5 billion pounds a year of ethylene in order to manufacture hydrogen used in its oil refineries. Normally, Phillips would use most of the ethylene in the Pasadena facility. The company has been forced to shut down 25% of its production and sell as much as it can at depressed prices. They have lost 23 cents per pound on the 750 million pounds withdrawn from the market. That is an annual loss of $161 million. Assuming a margin loss of 5 cents per pound on the remaining capacity of approximately 2.0 billion pounds, that's an added hit of $100 million per year."

The above losses total $1.136 billion, which is 1-1/2 times the $750 million property damage reported by NFPA in its July/August 1990 issue of ***FIREJournal***. [15-63] To that total, $1.36 billion must be added the costs outlined earlier by Mr. Van Buskirk, perhaps an added $500 million after including legal costs which may not be covered by insurance. Also, if Phillips does not recapture its market position it will permanently lose the estimated $225 million annual operating profit generated by its Pasadena facility. A big unknown is the loss due to the consequences of Phillips' having to reveal proprietary knowhow to its competition. Its entirely possible that when Phillips prepares the final accounting on the Pasadena, Texas, fire the total business interruption losses will total $3.0 billion, or four times the property damage. Some of that would have been absorbed by the market in price increases but the balance would fall on Phillips.

Added business interruption factors were identified during a September 13, 1990 telephone conversation with Mr. Edward Brennan, Vice President Finance and Information Services, Hoechst Celanese.

> "In November 1987 we lost 50% of our Pampa, Texas facility in a fire. We are still negotiating with our insurance carriers."
>
> "From a market standpoint we came out whole. We were able to replace most of our lost production through some excess capacity within Hoechst Celanese and by turning to our competitors. That does not mean we came out whole in other areas. The Pampa facility was built in 1953 for an estimated $100 million. It cost us $200 million to rebuild one half of the plant. We had to use our own money since we were still negotiating with our insurance carriers and the new facility proved extremely expensive because of new safety and environmental rules and because of the inefficiencies of having to rebuild a new facility within and around the remnants of the old facility."
>
> "Also, as a result of the explosion we face a major lawsuit for $100's of millions claiming injuries and impaired health as a direct result of the explosion. Starting six months after the incident, our General Counsel has been full time on that suit. We also have a whole battery of lawyers from three major law firms. Our monthly legal fees are seven digits. Finally, It has cost us millions of dollars to prepare our insurance claim. I have several people working on it and I spend half my time."

A totally different business interruption perspective emerged from discussions with Sherwin-Williams regarding the $49 million loss of its Dayton, Ohio warehouse in May 1987. That was one of two warehouses for automotive refinish products sold to body shops through distributors. It was the biggest warehouse, storing two thirds the division's total U.S. inventory. While able to protect its market by expanding the operation of its manufacturing facilities, Sherwin-Williams' management realized the vulnerability created by one major warehouse. Instead of rebuilding one warehouse, it was decided to rebuild three. While Sherwin-Williams declined to discuss the impact of that decision, it is believed that its distribution costs have been permanently increased by 3-5%. Since, the automotive refinishing market is a competitive market, the company may not have been able to pass the increase onto its customers. Instead, it may have had to accept a 3-5% reduction in margin.

The impact of the fire did not stop there. After learning the warehouse was built on the an aquafer serving Dayton communities the firefighters stopped pouring water on the fire to avoid further runoff. The fire was allowed to burn itself out. It took six days. Sherwin-Williams is now working with local officials to resolve the groundwater issue. There was some pollution and some well systems had to be shut down.

Finally, that fire provide added impetus to revise NFPA's ***Flammable and Combustible Liquids Code***. The Sherwin-Williams facility was a highly protected facility with state-of-the-art protection but the sprinkler system could not contain the fire at the early stages of the fire.

The sprinkler system was overwhelmed. Under the revised code, it will cost an added 20-30% to install fire suppression systems at warehouses storing combustible and flammable liquids. A major part of that increase is the containment systems for water runoff. That added expense will be added to the distribution costs for flammable and combustible products.

The above related business interruption experiences confirmed rules-of-thumb provided by insurance industry representatives. Mr. Herb Hildebrandt, Past-President, Loss Executives Association, stated:

> "Business interruption is at least three to four times physical damage. The MGM Hotel fire is a good example. Property damage was $400,000. Business interruption was $1.3 million, a multiple of 3.25."

Mr. Sean F. Mooney, Senior Vice President and Economist, Insurance Information Institute indicated claims people tell him business interruption is normally twice property damage.

Mr. Roger Bassett, Protection Mutual, when discussing the 1953 GM/Livonia fire stated:

> "In 1990 dollars the GM/Livonia fire was a $1 billion fire. The property damage, $32 million in 1953, would be $200 million today. As a rule of thumb we always estimate business interruption at 5-6 times property damage."

Given the above, U.S. 1989 business interruption losses appear to be 3-4 times property damage of major fires. Since there are industrial fires, mainly small fires, which do not precipitate business interruption losses, a 3-4 times multiple cannot be applied to total industrial property damage.

An important benchmark is the large-loss analysis prepared each year by the NFPA. In the November/December 1989 issue of ***FIREJournal***, 1988 large-loss fires defined as $5 million or greater, totalled $1 billion [78-59] and represented approximately 40% of the $2.6 billion 1988 industrial fire total reported in the September/October 1990 issue of ***FIREJournal***. [2] [37-27]

Since there are many industrial fires with property damage less than $5 million but with significant business interruption losses, it appears appropriate to increase that percentage to 50%. Thus, it is estimated that at least 50% of industrial fire property damage involves attendant business interruption losses equal to 3-4 times property loss.

Residential

In July 1979, the National Fire Data Center, U.S. Fire Administration, published "Indirect Costs of Residential Fires," a report prepared by Princeton University and Mathematica Policy Research, Incorporated. The authors were Michael J. Munson and James C. Ohls. [89-3]

The report, based on a survey of 883 households which had experienced fires within four months of the survey, presented national estimates of indirect losses associated with interruption to daily routine precipitated by residential fires in the U.S. Indirect losses were defined as costs other than direct property

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2 Industrial includes ***manufacturing and industrial, storage***, and ***stores and offices***.

damage and includes expenses for temporary meals and lodging, lost wages, medical care, transportation, child care and legal fees. The report estimated total indirect losses due to residential fires as 16% to 24% of total residential fire losses. Thus, in 1989, with the NFPA reporting residential fire losses of $4.0 billion, indirect residential interruption losses ranged from $640 million to $960 million.

C. Fire-related Products Liability—Litigation and Insurance

In the July 13, 1987 issue of *Forbes*, Mr. Peter W. Huber, author of *Liability—The Legal Revolution and Its Consequences*, wrote: [32-56]

> " ... Until the early 1960's liability in U.S. courts depended on negligence. The negligence standard inquired whether the technologist was careful, prudently trained, properly supervised. The technologists best able to meet this standard were often the ones at the leading edge."
>
> "But the liability system's focus shifted profoundly in the 1960's and early 1970's to 'strict liability.' This tells juries to assess technology, not the conduct of those who create and manage it. The good faith, care and training of the technologists is irrelevant."

In the December 11, 1988 issue of *The New York Times*, Mr. Richard J. Mahoney, Chairman and Chief Executive of Monsanto Company, wrote: [49-3]

> "... Punitive damages are an anomaly peculiar to the United States and are virtually unknown in the world's remaining civil-law countries. They also depart from the usual American legal practice in that defendants are afforded few of the traditional safeguards. The result: Conduct liable for punitive damages is whatever a single jury says it is."
>
> "'Across the board, modern tort law weighs heavily on the spirit of innovation' concluded Peter Huber in his book *Liability—The Legal Revolution and Its Consequences*."
>
> "A 1988 survey of chief executive officers by the Conference Board showed that uncertainty over potential liability had led almost 50 percent to discontinue product lines and nearly 40 percent to withhold new products including beneficial drugs. Half said product liability had a dramatic impact on our international competitiveness and 75 percent expected it to grow in significance."
>
> "The punitive-damages system makes it too easy for lawyers to persuade a jury—possessing little scientific background but believing in the possibility of a risk-free society—to enrich the plaintiffs and contingent—fee lawyers with multimillion-dollar windfalls."

The changes in the U.S. tort system discussed above have had an impact on the costs of fire in the United States. This is evident from an article appearing in the May 30, 1988 issue of *Business Week* which discussed a fire at the Du Pont Plaza Hotel: [80-102]

> "First came the human disaster. On New Year's Eve, 1986, an inferno swept through San Juan's Du Pont Plaza Hotel, killing 97 and injuring more than 140 ..."
>
> "Then came the legal disaster: Personal-injury lawsuits quickly choked the

courts of San Juan. All told, the victims and their families—some 2,200 people—seek $2.6 billion in damages from 265 defendants. An insurance squeeze left the hotel with only $1 million in coverage. So nearly everyone connected with the building has been sued: the builder, the fire-alarm maker, companies that supplied furniture, even the manufacturer of the casino's slot machines."

Mr. Cary Mitchell, Director, Technical Services, Shaw Industries, a major U.S. carpet manufacturer, during an August 22, 1990 provided a manufacturer's perspective on the current U.S. tort system:

> "We have flammability testing facilities at each of plants. We comply with federal and state standards. Our carpets don't burn. However, that doesn't prevent our becoming party to suits such as the Du Pont Plaza situation you described. When the Los Vegas Hilton burned, we were sued. Seven years later later we agreed to a minimal settlement of $150,000 but our legal fees were $ 1.5 million. More recently, the Ramada Inn burned in Fort Worth, Texas. Our carpet was still in rolls. After two hours into the fire, the rolls were still intact, with only a slight char on the ends. We had photographs. We also had seven years of history. We wanted to go to trial. The plaintiffs were looking for $10 million. Our insurance company settled on the court house steps for $8 million. They wanted to avoid a trial by jury."

As with fire property damage, it is impossible to obtain accurate fire-related product liability data. Dr. Deborah Hensler, Research Director of The Institute For Civil Justice at The RAND Corporation, Mr. Peter Huber, a noted authority on the tort system and author of ***Liability: The Legal Revolution and Its Consequences***, Mr. John L. Jablonsky, Vice President Engineering and Safety Services, American Insurance Services Group, Inc., and Mr. John Kollar, Insurance Services Office, all explained that insurance companies collect liability loss experience by lines of coverage rather than by circumstance. Thus, for example, the Shaw Industries settlement would lose its fire-circumstances distinction as the settlement is recorded under Commercial Multiple Peril, or Product Liability, or General Liability and possibly Workers Compensation Insurance. Thus, for the Du Pont Plaza Hotel fire the only loss that can be isolated as fire related is the property loss claimed under the fire insurance. The product liability settlements will be recorded elsewhere.

Since most liability claims are injury related, fire as an incidence of accidental injury is a logical starting point for any attempt to calculate the cost of fire-related product liability. According to ***Cost of Injury in the United States—A Report to Congress***, based on 1985 data, fire and burn injuries accounted for 3% of total U.S. accidental injuries. [63-***Summary*** xxix] A December 1989 Tillinghast Study entitled ***Tort Cost Trends: An International Perspective***, estimated the total cost of the U.S. tort system at $117 billion. [76-1] That total included litigation expenses, administrative fees, claims expense and payments to claimants. Three percent of $117 billion is $3.5 billion. To that figure was added a share of total annual product liability insurance premiums. According to Robert Currin, Actuarial Consultant, Insurance Services Office, (ISO), 1989 product liability premiums totaled $2 billion. Mr. Currin cautioned that total does not include self-insured firms such as Ford, GM and the major pharmaceutical firms. According to the 1989 Tillinghast study, self-insured costs came to 50% of the insured commercial lines portion. [76-2] Thus, it appears appropriate to increase total product liability premiums to $3.0 billion of which 3% or $90 million are fire related. Therefore, fire-related product liability costs are estimated to be $3.6 billion.

D. Net Fire Insurance

Net fire insurance is the excess of insurance premiums over insurance losses and was determined using the formula accompanying the National Fire Protection Association's (NFPA) biennial calculation of the total cost of fire in the U.S. [24-71] That is, to total premiums for fire insurance were added 21% of total premiums for Farm, Commercial and Homeowner Multiple Peril premiums. Total direct property losses were subtracted from that total to determine net fire insurance.

According to the Insurance Information Institute, fire insurance premiums were $4.6 billion in 1988, the latest data available. [35-26] The combined total premiums for all multiple peril coverage in 1988 was $40.4 billion. [35, 23-26] Twenty-one percent of that total is $8.5 billion. Thus, total fire insurance premiums were $4.6 billion plus $8.5 billion or $13.1 billion. Using the NFPA fire loss data data published in the September/October 1990 issue of ***FIREJournal***, property losses in 1989 totaled $7.5 billion. [37-58] Thus, net fire insurance in 1989 was $5.6 billion.

E. Fire Protection in New Construction

Structure Related

In Mr. William E. Koeffel's article, ***How Can We Harmonize Building & Fire Codes?***, appearing in the November-December 1988 issue of ***FIREJournal***, he wrote: [41-22]

> "Two-thirds to three-fourths of the provision of a building code apply to fire-safety."

Mr. Philip DiNenno, a fire protection safety engineer with Hughes Associates, in an August 22, 1990 telephone conversation, added:

> "Today, 80% of building codes are fire related in some way. Ten years ago the number was lower. Twenty years ago it was lower still. The thing to remember about building codes is that they are additive. As new ideas are introduced to the code nothing is deleted."

Codes are legal requirements that must be met by all new construction. The codes relate to all aspects of a structure. The most visable fire protection specified are items such as fire extinguishers, fire sprinklers, fire doors, fire alarms, fire pumps, standpipes and fire hoses. However, they are only the tip of the iceberg. The greatest specified fire protection is hidden in the walls and floors and above the ceiling. It is not apparent to most people. Thickness of concrete floors is specified. Net usable space and exit systems are spelled out. Fire walls, and fire stops might be required. The code might also state whether return air will be via hallways or duct work.

In attempting to evaluate the impact of these fire prevention code requirements on the cost of a structure the National Fire Protection Association's (NFPA) methodology was used as a bench mark. The NFPA estimates fire protection as a per cent of new construction as follows: [24-70]

Residential	2.5
Private nonresidential	9.0
Other	3.0

Those percentages were derived from a study conducted in the late 1970's by three students from Worcester Polytechnic Institute (WPI).

While those estimates were acceptable to Messrs. DiNenno and Mr. Peter Lund, Executive Director, Society of Fire Protection Engineers, a number of leading U.S. industrial firms were contacted to determine whether issues such as life safety and the environment may have altered the fire protection formula established by WPI students in the 1970's.

Mr. Harold Maxson, Risk Engineering Management, Procter & Gamble, Cincinnati, Ohio, stated:

> "We have 300 facilities worldwide. We try to maintain the same level of fire safety in all our facilities. Requirements such as four-hour free- standing parapet walls, and 300,000 gallon tanks and pumps cost a lot of money. It is not unusual for us to spend $1.5 million for fire protection on a new $50 million plant."

According to Mr. Patrick H. MacAuley, Editor, *Construction Review*, U.S. Department of Commerce, 70% of new construction is equipment. The balance is the structure. Therefore, the structure portion of Procter & Gamble's new $50 million facility cost $15 million. One and one-half million dollars is 10% of that total, a figure very close to NFPA's 9%.

Mr. Tony Richter, Fire Protection Engineer with The Boeing Company, believed life safety and environmental requirements were increasing the cost of built-in fire protection:

> "Local jurisdictions are having an increasing impact on the cost of built-in fire protection. Requirements for items such as smoke detectors, manual pulls and smoke alarms, in addition to sprinklers, for every building over 10,000 square feet add significantly to the cost of fire protection. Other examples of local requirements include transmitters on every sprinkler riser instead of every fifth sprinkler riser, and water flow switches. In addition to increasing our upfront fire prevention expenses, the added requirements of local jurisdictions also result in a permanent increase in monthly maintenance expenses."

> "Following adoption of Article 80 all kinds of exotic protective devices are required for hazardous materials. We now have to store hazardous materials in separate areas away from the rest of the plant. In the dispensing room we can only have one day's usage. There can't be any storage in the processing rooms. All these locations need to be protected with sprinkler systems and containment facilities for the water runoff. Also, recent legislation is going to produce a additional increase in costs. That legislation calls for two sprinkler heads, a 100 gallon-minute flow, and a 2000 gallon tank. We will have to bury a containment tank and piping and pumps."

"The new codes will result in fire equipment being 15% to 30% of the cost of rooms in containment processing, depending on the size of the room. We have fires every day, but we have not experienced a major loss in five years. We had one $500,000 loss and that was a piece of equipment you could put on your desk. For many years Boeing has worked safely with chemicals just now becoming designated as hazardous—oxidizers, chromates and trichloroethane."

Mr. Jeff Martin, Industrial Engineering Manager, at Motorola's Phoenix facility was interviewed twice. During the August 23, 1990 conversation he was introduced to the question. He asked for one week to prepare his answer arguing he had never looked at fire protection in that manner, and wanted to thoroughly research his answer. In an August 29, 1990 telephone conversation, Mr. Martin related:

"Well, I have done my homework. I included in my fire protection total items such as: containment, outside gas storage, coaxial dispense lines, exhausted environment, and gas cabinets with plumbing manifolds equipped with excess flow shutoff and leak detection with automatic shutoff. I included chemical dispense systems with minimal containers in the dispense area and the use of pumps and pipes to get the chemicals from storage to the dispense area. I also looked at items such as corridor service. Some can't be used for the transport of flammable materials. As a result, in the fab area we wind up with 1/3 more corridor than is required for the number of people working in that area. Putting all this together I estimate fire protection costs at 15% of our new wafer fabrication facilities. That doesn't include fire protection that comes with the building such as fire sprinklers. Those are adders."

During a telephone conversation with a Sherwin-Williams spokesperson, it was learned the Dayton, Ohio warehouse fire had caused a significant increase in the cost of fire protection for warehouses storing flammables. While unwilling to discuss specifics, the spokesperson did add that the new NFPA codes when coupled with local jurisdiction requirements, such as in those in California, were adding such significant costs to warehouse structures that it made sense to include total fire protection costs in the analysis used to select sites for new warehouses.

In light of the above, it was decided to increase the built-in fire protection for private non-residential construction from 9% to 12% since manufacturing, warehouse, telecommunication and other utilities, which are likely to be most affected by the above life-safety and environmental trends, and which represent approximately 50% of private non-residential construction are experiencing fire prevention expenses of 15% and greater.

According to the U.S. Department of Commerce 1990 new residential construction, in current dollars, is estimated at $200 billion. 2.5% or $5.0 billion of that total is represented by built-in fire protection. Total private non-residential construction, in current dollars, is estimated at $130 billion. Twelve percent or $15.6 billion was for built-in fire protection. Other private construction is estimated at $4.0 billion of which 3% or $120 million is fire protection. Thus, it is estimated that in 1990 a total of $20.7 billion was invested in built-in fire protection in new construction.

Equipment Related

The equipment installed in factories, in airports, in hotels and telephone switching centers is all ***fire grade***. That is, standard commercial designs have been altered to provide products which are not sources of fire and when exposed to fire are not flammable and sources of hazardous fumes.

Mr. James R. Beyreis, Vice President, Fire Protection, Underwriters Laboratories, Inc. readily acknowledged product design to achieve fire prevention represents an upfront investment in fire protection. However, Mr. Beyreis was not in a position to estimate the added cost of a fire-grade product over a standard commercial product. He suggested the manufacturers of such products are the best source.

Mr. Richard Dugan, Vice President and Senior Scientist, Industrial Drives, Radford, Virginia, was contacted on August 28, 1990. He related the following:

> "We just received UL approval on an explosion-proof motor. Our costs for that motor are double those of our standard explosion-proof motor. In addition, we paid UL $100,000 to develop the standard they used to evaluate our motor and now pay for the monthly visit of a UL representative reviewing our manufacturing procedures."
>
> "The trend in product design is minimum foot print, i.e., small packaging. We are working on putting our power boards in smaller packages. That requires the use of multilayer printed circuits boards (PCBs). In order to achieve the component spacing called for in the UL standards, our PCB costs could increase by 4 to 5 times."

A spokesperson for Allen-Bradley, when discussing the impact of UL 508 on the Division's programmable logic controller related:

> "UL 508 has had a major impact on the design of our product, particularly the board. Not only must it be flame-rated, but the code has specific spacing requirements for components carrying voltage. Those spacing requirements cost a lot of real estate on boards. We are forced to go to nested multilayer boards and each time you jump to another board you double your costs."
>
> "The biggest cost component in our product is the board. As a result, the UL requirements we must meet have increased the price of our final product by at least 20%."

During an August 30, 1990, telephone conversation with Mr. Chester W. Schirmer, President, Schirmer Engineering Corporation, a fire protection engineering firm, he shared some thoughts on the impact of codes on product price:

> "In the recent past we were involved in an effort to come up with cost-effective residential sprinkler systems. We wanted to keep the price of the system as low as possible to minimize the financial burden on the home owner. We made it a point to specify that where a pump was needed a pump with a commercial motor controller would suffice because we knew it would be 1/3 to 1/2 the cost of a listed pump motor controller."

During the same telephone conversation, Mr. Schirmer also cited the dramatic increase in the cost of communication cables installed in the plenum space above ceilings:

> "The cable that used to be installed cost about 5 cents per foot. Then, a ***fire-grade*** communication cable was developed for installation above ceilings. It costs $1 per foot. That's a twenty times increase."

Given the above, it appears that some equipment installed in U.S. factories, office buildings, communication centers, etc., costs a great deal more in order to achieve maximum fire protection. It was mentioned earlier that the U.S. Department of Commerce estimates that 70% of total New Plant and Equipment expenditures are equipment related. An input-output analysis entitled ***New Structures and Equipment by Using Industries, 1977*** appearing in the November, 1985 issue of ***Survey of Current Business*** used Private Purchases of Producers' Durable Equipment to obtain a breakdown of total equipment expenditures by equipment type and using industries. [71-26] The July 1990 issue of ***Survey of Current Business***, page 74, provided a more recent tabulation of that data series. Table 1, based on the July 1990 Current-$ tabulation, provides the basis for determining what per cent of total equipment purchases are comprised of products whose design are influenced by UL and other standards.

The design of products falling within ***Informationing Processing and Related Equipment*** and ***Industrial Equipment***, see Table 1, are affected by UL and other standards to achieve fire-grade products. Those two product categories, combined, totaled $195 billion and represented 49% of total private purchases of producers' durable equipment in 1989.

On a dollar basis, however, it is estimated that only 30-50% of the above total expenditure of $195 billion is for equipment influenced by fire-safety product design standards, as there is a lot of sheet metal, forgings, castings, etc. included in the products in those categories. However, over the last ten years there has been a decided increased in the ***intelligence*** component of such equipment as a direct result of the shift to automation and computer-aided processes. Today, every step of a process has to communicate, sending or receiving data and instructions. The microcomputer is imbedded in more and more equipment, placing more equipment drives, clutches, brakes, etc. under the control of the computer. In short, the electrical and electronic content of the equipment in those categories has increased dramatically as ***brains*** have replaced ***brawn***. Therefore, it considered reasonable to assume that, on a dollar basis, 40% of the product falling within the above product categories, are impacted by UL and other codes. Thus, $78 billion of the $195 billion expenditures total was comprised of products whose design has been enhanced to produce fire-grade product.

Earlier narrative indicated the incremental price impact of fire-grade design on product price ranged from 20% to 20 times. Given such a wide range, it was decided a reasonable price premium for fire grade design is 30%. Thus, $18 billion, of the above $78 billion was the premium paid in 1989 for fire-grade equipment.

The above discussion and conclusions are based on the assumption that electrical codes are fire related. Mr. Robert J. Vondrasek, NFPA's Assistant Vice President, Engineering stated during a telephone conversation:

> "If there is an electrical shock potential there may be a potential for fire. If a chance current going through a person can cause a shock then that current could also go through something metallic and cause heating and heating could cause fire."

Table 1. Private Purchases of Producers Durable Equipment by Type
(Billions of Dollars)

Category			1989 $	% Total
Information processing and related equipment			$103.9	26.2
Office, computing, and accounting machinery			40.1	
Communication Equipment			46.5	
Instruments			17.3	
Industrial Equipment			91.6	22.9
Metalworking machinery			18.9	
Special industry machinery, n.e.c.			26.7	
General industrial, incl. material hndlg			21.7	
Electrical transmission, distribution and industrial apparatus			14.6	
Electrical equipment, n.e.c.			9.7	
Transportation and related equipment			76.2	
Other equipment			97.2	
Less:	Dealers margin on used equipment		2.1	
	Net purchases of used equip. from government		.9	
	Sale of equipment scrap		3.1	
Plus:	Net sales of used equipment		31.7	
	Net export of used equipment		1.3	
	Sale of equipment scrap		3.1	
		Total	$398.9	

n.e.c. Not elsewhere classified.
Source: ***Survey of Current Business.***

F. The Ongoing Costs of Voluntary Codes and Standards

While the codes and standards established in the U.S. for fire safety are consensus standards established on a voluntary basis, and are maintained by not-for-profit organizations such as Underwriters Laboratories, Inc. and The National Fire Protection Agency, there are costs associated with the voluntary standards activity in the U.S. which are a cost of doing business in the U.S.

In addition to the cost of maintaining organizations such as the above, individual companies incur ongoing standards-related expenses. Mr. Dugan, Industrial Drives' Vice President and Chief Scientist, related earlier a $100,000 payment to UL to establish a new standard and the cost of the monthly inspection by the UL representative.

Mr. Jim Crapser, S.C. Johnson & Son, Inc., Racine, Wisconsin, was contacted to discuss the line of Glade Plug Ins recently introduced by that company. Mr. Crapser related:

> "The Plug Ins product line took five years to develop. The main challenge was the development of an inexpensive, cool, safe heater. After all, this is an appliance. We are responding to the move away from aerosols. The Plug Ins are plugged into an outlet, like a night light, and the heater warms an air freshner in a cartridge. The cartridge is changed every month. It cost us $3,000 to obtain UL approval. However, we benefitted from our excellent safety standards and that of the supplier for the heaters. UL has past experience with our supplier's heaters and was able to provide rapid approval."

Similarly, when Mr. Michael Connan, Mid-American Electro-Cords was contacted to discuss his company's new line of power cords, he shared the following:

> "UL approval for us is a minor expense, ranging from $2,000 to $6,000 per item. We must apply for approval for the cord, the plug and the manufacturing process. For example, for the power cords we just introduced we needed UL listing for the molded plug on the end and the type of wire. It probably cost us $12,000, in total, which we consider a very minor expense."

Allen-Bradley's Division related:

> "We have 2-1/2 people in this department who do nothing but work on standards. Perhaps we spend $100,000 per year to support their activities."

It is not necessary to compute the national costs of standards activities by cumulating those costs at the individual company level. Instead, an excellent source for such data is a 1977 publication of the National Academy of Sciences' National Materials Advisory Board. That publication, entitled ***Materials and Process Specifications and Standards***, estimated that in 1977 the U.S. private sector spent $320 million preparing and maintaining standards. In 1990 dollars, that is approximately $600 million. [55-83]

Only a portion of the $600 million is related to fire standards, including electrical codes. Given the complexity of electrical and fire codes and the earlier indications that 66% to 80% of building codes are fire related, ***see Fire Protection in New Construction—Structure Related***, it is estimated that 25% of the annual cost of U.S. standards activity, or $150 million, is fire related.

G. Fire Retardants and Flammability Testing

Fire retardants are chemicals topically applied to fabrics or added to plastic resins. Mr. Russell Kidder, Executive Director, Fire Retardant Chemicals Association indicated during a telephone conversation that his members sell $500 to $600 million worth of fire retardant chemicals each year.

Mr. Roy Briggs, Upholstered Furniture Action Council, indicated its voluntary program of standards for smoldering heat-source ignition adds $300 million to the retail price of its members' products. According to Mr. Kidder, the cost of the fire retardant chemicals for the above program are considerably below that figure and the high total cost must reflect application of the traditional markups at both the manufacturing and retail levels.

Mr. Michael O'Mara, Manager of Chemical Research at GE's Corporate Research and Development Center in Schenectady, New York, thought Mr. Kidder's $500-$600 million figure was low but added:

> "While retardants have increased our material costs by 20-30% our greatest expense is the initial upfront startup costs to get products reformulated. We must spend $300 million per year on R&D, formulation, market testing, and toxicity testing."

GE has an estimated 30% of the U.S. market for engineered plastics, sharing the lead with Mobay and Dow. It is believed those firms must spend a comparable amount on R&D, testing, etc. raising the industry total close to $1 billion.

Unlike the upholstered furniture industry, discussed earlier, GE and its competitors may not be able to pass on the added material cost. Their's is a competitive industry with both domestic and offshore suppliers serving the U.S. market. Mr. Harley Henry, President, Styrex Industries, High Point, North Carolina, a successful customer injection molder, serving major U.S. companies, related:

> "We operate in a very competitive business. Our margins are very low. While we can expect to recover the added material costs of a fire retardant we don't routinely expect to pickup our normal margin on those retardants. Rather, we have to look for other added-value contributions we can make to a product to improve our operating results."

There are other flammability and testing activities routinely conducted in the U.S. For example, Shaw Industries has testing laboratories at each of its 13 plants and according to Mr. Cary Mitchell, Shaw's Technical Director, Shaw spends $1 million per annum testing the output of those plants for compliance with federal and local codes. Also, the Brominated Fire Retardant Industry Panel has asked Triangle Laboratories (TL), Research Triangle Park, North Carolina, to conduct additional tests. TL just completed tests which checked for generation of toxic furans and dioxins during molding and other thermal processing. The new tests will cost an estimated $500,000.

In sum, it would appear that the greatest costs associated with retardants and flammability are those of formulation and testing. It is estimated that in addition to the $600 million cost of chemical retardants, another $1.5 billion is spent by all sectors of the U.S. private sector formulating and testing for flammability and toxicity. If the $300 million market cost of the upholstered furniture industry's program is included, the total approaches $2.5 billion.

H. Fire Maintenance

In addition to the above investments in fire protection, U.S. industry, including building owners and operators, must pay for the routine servicing and maintenance of the fire detection and fire suppression equipment installed in factories and office buildings. In addition, many U.S. manufacturing companies maintain their own independent industrial fire brigades or emergency response teams for immediate response to emergencies. Mr. Martin F. Henry, Director, Public Fire Protection, National Fire Protection Association, indicated there are over 4000 members in the NFPA's Industrial Fire Protection Section.

Mr. Richard Boeman, formerly with VLSI Technology and now with Marsh & McLennan, during an August 21, 1990 telephone conversation, discussed the the need for emergency response teams in the semiconductor industry:

> "Each wafer fab in the U.S. semiconductor industry has its own emergency response team (ERT) to put out incipient fires. There are eight people per shift assigned to an ERT. There are three shifts in a day. In addition, you have equipment and training expenses. It costs between $250,000 to $300,000 to train those people and another $25,000 each year to maintain each ERT."

Similarly, Mr. Harold Maxson, Risk Engineering Management at Proctor & Gamble stated during an August 9, 1990 telephone conversation:

> "We have a very intensive maintenance program for fire sprinklers, detectors, alarms, extinguishers, etc. as well as an intensive safety training program which every employee attends at least once a year. We have 50,000-60,000 employees worldwide. On-going fire costs probably represent 1/2% to 1% of our manufacturing costs."

Mr. Tony Richter, Fire Protection Engineer, The Boeing Company, related:

> "We have a paid 120-man fire department for our buildings. We also have the ongoing monthly servicing prescribed by code for fire prevention and fire suppression systems. In the past, our fire maintenance expenses never exceeded 1/2% of our manufacturing costs. Today, I believe the increasingly more stringent requirements of life-safety and environmental protection are increasing that closer to 2% of our costs."

In an article entitled *Nissan and the Security Zone*, which appeared in the August 1989 issue of *Security Management*, Mr. Wess Smith, Manager, Safety, Medical and Security, for Nissan Motor Manufacturing Corporation U.S.A.'s 782-acre manufacturing complex in Smyrna, Tennessee, stated: [1-49]

> "As part of preemployment training for prospective employees, security officers conduct a four-hour program on safety requirements and fire prevention. They show how to find and use fire extinguishers and where to evacuate in the case of emergency."
>
> "Fire prevention is on the top of the list for training and for security officers. This highly automated plant has 351 robots that, along with other duties, spot and arc weld. When welding is combined with other activities involved in manufacturing a vehicle the fire potential is enormous."

Mr. Peter Briers, Nissan's Section Manager of Security and Fire Protection, added: [1-49]

> "Five to ten small fires occur every month. It's part of the manufacturing process. That is why we are keen to make sure people know what to do about it. So far we have had no major industrial fires."

The article's author, Ms. Terry Abrams, included the following particulars: [1-49]

> "Preventing fires is a tremendous undertaking. The facility has 3.4 million square feet in three plants—trim and chassis; paint; and body, frame and stamping—and an administrative building. ... The E-shaped main facility stretches over two-thirds of a mile on its longest side and is open 24 hours a day."
>
> "How to combat fire hazards in this mini-city? The answer for Nissan is volunteer fire brigades. Each shift in each plant has a volunteer fire brigade with a

coordinator, and security officers train the brigade. Fire prevention classes are held four or five times a week on an ongoing basis."

During the telephone conversations with Messrs. Richter and Maxson, referenced earlier, they estimated the ongoing fire prevention expenses such as training, maintenance and fire brigades represented 1/2% to 1% of their manufacturing costs, with Mr. Richter predicting a trend to 2% given the increased influence of life safety and environmental protection. Mr. Dennis Longworth, Executive Director, International Facilities Management Association (IFMA), found those estimates reasonable:

> "I participated in the management of facilities for over fifteen years before joining IFMA. I was with Armco Steel for fifteen years and Johnson Controls for five years. Fire is definitely an ongoing cost. It is a line item included somewhere in a company's budget. I do not know exactly the cost of these activities but 1% seems reasonable to me."

In order to convert the above estimates of the ongoing expenses of fire as a percent of manufacturing costs to an annual national cost, Dr. Robert S. Kaplan, a noted authority on activity-based cost and a professor at the Harvard School of Business was contacted. Dr. Kaplan advised:

> "Manufacturing as a percent of sales will vary all over the lot. For Apple Computer, manufacturing, as a percent of sales, is low but its R&D expenses are very high. For a consumer good company, manufacturing costs will will represent 25-30% of sales. Conversely, for a capital intensive industry, manufacturing is 50-70% of sales. If I had to pick a number representative of all industries, I would use 50% of sales to pick up things like corporate overhead and selling expenses."

According to the U.S. Department of Commerce's ***Quarterly Financial Report For Manufacturing, Mining and Trade Corporations--First Quarter 1990*** the annualized net sales, receipts and operating revenues of all manufacturers were $2.7 trillion. [86-2] Using the low end of Dr. Kaplan's estimate, 25%, total U.S. manufacturing costs were approximately $675 billion. 1/2% to 2% of that total is $3.4 billion to $13.6 billion.

According to the U.S. Bureau of Economic Analysis, in 1987 the manufacturing sector represented approximately 20% of U.S. Gross National Product (GNP). By comparison, the combined GNP contribution of the transportation and public utilities, wholesale and retail trade, financial, and service sectors, in 1987, was 60%. [*Survey of Current Business*, July 1990, Table 6.3] However, there is no direct correlation between contribution to GNP and ongoing cost of fire. Rather, the key determinant is hazard levels. Therefore, since most companies, other than warehousing, operating in the non-manufacturing sectors of the U.S. economy do not have exposure to the hazard levels common to manufacturing, such as Nissan's 351 robots generating five to ten small fires per month, it is estimated that the total ongoing fire costs of the non-manufacturing sector is one-fourth the $3.4 billion—$13.6 billion annual fire maintenance cost of the manufacturing sector, or $850 million to $3 billion.

Thus, the total annual fire maintenance costs are estimated to range from $4.3 billion to $16.6 billion.

I. Disaster Recovery Expenditures

Increasingly, the U.S. manufacturing and service companies realize they can not afford to allow operations to be disrupted by such catastrophic events as fire, floods, hurricanes, earthquakes, etc. For example, a 1987 University of Texas study found that by the seventh day of a computer outage an average service company would be losing nearly a fifth of its daily revenue, a typical manufacturer would be losing close to a quarter, and an average bank would be losing nearly 40%. [19-47]

The most common way to prevent computer outage, due to fire, is to install special fire suppression systems within computer facilities. For example, when Illinois Bell Telephone Company installs a replacement $16 million computer at its Hinsdale switching center, fire-protection experts estimate that it will cost $350,000, an added 2.2%, to install and maintain a Halon extinguishing system. [19-50] In 1989, according to the January 1989 issue of *Electronics*, page 59, the U.S. market for mainframes, supercomputers and minisupercomputers was $19.4 billion. Two and two-tenths percent of that total is an added investment of $425 million.

In 1983, the Comptroller of the Currency, required national banks to have a recovery plan in case of computer disruptions. [73-63] According to Mr. John Jackson, Executive Vice President, Comdisco Disaster Recovery Services, Inc., Rosemont, Illinois, other industries besides banking have instituted backup regulations. Insurance companies, health care providers and public utilities now must have disaster recovery facilities. [43-46]

Rather than build their own backup facilities most companies contract with organizations such as Comdisco, to provide backup in offsite facilities. In fact, a new industry, disaster recovery, has emerged over the past decade to provide computer backup services. An article entitled, ***How to Avoid Disaster With a Recovery Plan*** appearing in the February 1990 issue of ***Software Magazine*** discussed this new industry: [ibidem, 47]

> "Mr. Richard Vancil, a consultant at the Ledgeway Group Inc., a Lexington, Massachusetts consulting firm, indicated disaster recovery is the fastest growing segment in the service market. He estimated that the total disaster recovery revenue was $425 million in 1989."

Since disaster recovery plans protect against all disasters, only a portion of the $425 million can be attributed to the total cost of fire.

In the June 1990 issue of ***Computers & Security***, Charlotte Klopp discussed disaster recovery in an article entitled ***Vulnerability Awareness Improves Contingency Planning.*** Ms. Klopp cited fire as the leading cause of individual disasters that have destroyed a company's computer system. [40-309]

Similarly, Mr. Robert E. Johnston, data security manager for a major regional bank in the Northeast stated in his article ***Fire Prevention: Are you up to the Challenge?***, which appeared in the May 7, 1990 issue of ***MIS Week***: [36-23]

> "Fire is one of the most common forms of computer interruptions. The majority of the disruptions that cause a business to use its hot site or other alternative resource for processing are caused by fire."

Given the above, it is estimated that 60%, or $255 million, of the $425 million invested in disaster recovery in 1989 is attributable to the total cost of fire in the United States.

Thus, the combined investment of U.S. industry for systems to protect computers from fire and to backup computers in the event of fire totaled $680 million.

J. Volunteer Fire Services

Volunteer fire fighters are an avoided cost of fire. But, as evidenced by the following thoughts of Bill Hamilton, a 20-year veteran Latrobe, Pennsylvania volunteer firefighter, which appeared in the May 1990 issue of ***Pennsylvania Fireman***, such costs can no longer be taken for granted. More and more villages and towns across the U.S. are having to convert to paid firefighters or hybrid services comprised of paid and volunteer firefighters: [27-142]

> "When I joined Hook and Ladder Co. No. 2 of the Latrobe Fire Department in 1972, the company had a waiting list for membership. Its roster of 40 members was full. We had to wait for someone to die or retire before we could join ..."
>
> "It's now 1990, and my former 40-member company has dwindled to less than 20 in a good month ..."
>
> "When I joined Hook and Ladder Co. No. 2 of the Latrobe Volunteer Fire Department in 1972, I was required to train to department standards, and they could be considered rigorous. But in 1972 I didn't have to be haz-mat certified, emergency-medical certified and state-rescue certified. It's now 1990 and I do."

In many communities, volunteer firefighters are the first line of defense against hazards, other than fire, which have emerged over the past two decades. Those hazards are more life threatening than fire and have made it more difficult to attract and retain volunteer firefighters.

According to the U.S. Fire Administration (USFA), there are 1.2 million firefighters in the United States. 80%, or 964,500 are volunteer. The USFA also estimates there are 34,300 fire departments in the U.S., with 27,400, or 80%, staffed by volunteers. In short, there are four times as many volunteer as paid firefighters. [56-297]

The Municipal Fire Service Workbook, one of the products of a 1977 study carried out by the Research Triangle Institute in partnership with the National Fire Protection Association and The International City Management Association (ICMA), found that 73 % of the U.S. population in cities over 5,000 is protected by paid or mostly paid firefighters. 27% of the U.S. population in cities over 5,000 is protected by volunteer and mostly volunteer fire departments. [58-73]

The U.S. Department of Commerce, Bureau of Census, based on the 1980 United States Census, provided the following estimates of the U.S. population in places of less than 5,000: [83-39]

Inside Urbanized Areas	
Urban Fringe	
places of less than 2,500	1,260,246
places of 2,500 to 5,000	2,424,502
other urban	12,662,718
Outside Urbanized Areas	
places of 2,500 to 5,000	6,943,324
Rural	59,494,813
Total	82,785,603

Given a 1980 U.S. population of 226,545,805 inhabitants, 36.5% or 82,785,603 lived in communities of less than 5,000 inhabitants. The remaining 63.5% of the population, 143,856,585 inhabitants, lived in cities of 5,000 or greater.

The Bureau of Census estimates that the 1990 U.S. population is 250,885,000. Assuming no significant change in residence inside/outside cities of 5,000 between the 1980 and 1990 census, 63.5% or 159 million people resided in cities of 5,000 or greater and 73%, 116 million, were protected by paid firefighters. 36.5% or 91.5 million resided in places less than 5,000.

The U.S. Department of Commerce, Bureau of Census, Governments Division, in its ***Government Finances in 1987-1988*** reported that all state and local governments spent $11.8 billion on fire protection. [84-2] Between 1984/1985 and 1987/1988 total fire protection expenditures for state and local governments grew at a compound annual rate of 9.5%. [ibidem, 1] Assuming the same rate of growth, in 1989/1990 fire protection expenditures will total $14.1 billion. An expenditure of $14.1 billion for paid firefighters to protect 116 million is an annual expenditure of $121,500 per person. At the same level of expenditure for fire protection, it would cost $16.3 billion to protect the remaining 134.5 million inhabitants currently protected by volunteers. That total includes 91.5 million in places of less than 5,000, plus the 27% of the population in cities of 5,000 protected by volunteer fire fighters.

The above computation does not adjust for the lower population density in places of less than 5,000. Since there are fewer structures with greater distances between structures, to get from the fire house to a fire as rapidly as in cities of 5,000, more fire houses, equipment and firefighters will be required. Thus, it is estimated the above $16.3 billion total should be increased by an added 25% to $20.4 billion to allow for the lower population density in places less than 5,000.

A September 18, 1990 report on volunteer fire services by Delaware's State Auditor, R. Thomas Wagner, Jr., provides an opportunity to project a national cost of volunteer firefighter service conversion based on Delaware's actual firefighting expenditures.

Delaware has a total population of 670,000 people. A high percentage of that population lives in places of less than 5,000. Only 70,000 people residing in Wilmington are protected by paid firefighters. The remaining 600,000 citizens are protected by volunteer firefighters. In a recent press conference Mr. Wagner stated:

> "I conducted a comparative analysis using the City of Wilmington Fire Service as a paid constant, and projected a conservative estimate of what it would cost (Delaware) taxpayers to convert our volunteer fire companies to paid companies. ***I found the numbers to be staggering.***" (Author's Emphasis)

The following is a review of Mr. Wagner's findings:

State Population excl. Wilmington	600,000
Number of stations needed (per 10,000)	60
Total employees needed (32 per station)	1920
Total Salaries & Fringes ($35,750 ea.)	$68,640,000
Total Equipment Purchases & Maintenance	3,763,200
Total Building Purchases & Maintenance	660,000
Total Employee Apparatus	274, 286
Total Cost to Convert from Volunteer to State-Operated Employed Service	$73,337,486

Mr. Wagner, based on Delaware's actual expenditures, estimates an added cost of $73.3 million per annum for 1920 paid firefighters. That represents $38,196 per firefighter. On a national basis, $38,196 per annum per firefighter, for each of the estimated 964,500 volunteer firefighters currently serving, represents a national conversion cost of $36.8 billion. $36.8 billion is considerably higher than the earlier estimate of $20.4 billion. Given Delaware's large population in places of less than 5,000, the $36.8 billion estimate is probably closer to what it would cost the U.S. to convert volunteer firefighters to paid firefighters.

K. Tabular Summary

Table 2 provides a tabular summary of all computations discussed in this chapter. In addition to recording the range of estimates appearing in the preceding narrative, the ***Most Likely Estimate*** column contains what are believed to be the best estimate for each fire cost component. The footnotes following the table explain some table entries. Chapter IV--***Analyzing The Cost of Fire***, provides an analysis of the ***Most Likely Estimate*** column entries.

Table 2. Cost of Fire Tabular Summary

Cost Component	Range of Cost Estimates $—Billions	Most Likely Estimate $—Billions
Category A: Losses[3]		
Residential Property	$ 4.0	$ 4.0
Industrial Property	4.2	4.2
Other Property	0.7	0.7
Residential Interruption	0.6-1.0	0.8
Business Interruption	6.1-8.4	8.4
Product Liability	3.5	3.5
Category B: Insurance		
Product Liability	0.1	0.1
Net Fire Insurance	5.6	5.6
Category C: Fire Service		
Paid[4]	9.6	9.6
Volunteer Conversion	16.2-36.8	30.0
Category D: Preventative		
Built Into Structures	20.7	20.7
Built Into Equipment	13.5-22.5	18.0
Standards Activity	0.1-0.6	0.2
Retardants/Testing	1.9-4.0	2.5
Fire Maintenance	4.3-16.6	6.5
Disaster Recovery	0.6	0.6
Total	$91.7-$138.9	$115.4

3 ***Residential Property*** and ***Other Property*** entries based only on NFPA data as it is recognized within the firefighting community as the most accurate. [37-56] Given the findings of the Tillinghast study that self-insured costs represent 50% of insured commercial lines, NFPA's ***Industrial Property*** losses, $2.8 billion, were increased 50% to $4.2 billion to adjust for self-insured losses. [76-2]

4 Based on NFPA's March/April 1989 ***Total Cost of Fire in the U.S.*** [24-71]

IV. ANALYZING THE COST OF FIRE

Table 3, based on the ***Most Likely Estimate*** column of Table 2, provides the contribution of each fire cost component to the $115.4 billion national cost of fire. The table also indicates the rank order of the fire cost components and fire cost categories.

Table 3. Cost of Fire in The United States
Cost Components/Contribution and Ranking

Cost Component	Cost—$ Billions		Contribution—%		Rank Order	
	Category	Component	Category	Component	Category	Component
Category A: Losses	$ 21.6		18.7%		3	
Residential Property		$ 4.0		3.5		9
Industrial Property		4.2		3.6		8
Other Property		0.7		0.6		13
Residential Interruption		0.8		0.7		12
Business Interruption		8.4		7.3		5
Product Liability		3.5		3.0		10
Category B: Insurance	5.7		5.0		4	
Product Liability		0.1		0.1		16
Net Fire Insurance		5.6		4.9		7
Category C: Fire Service	39.6		34.3		2	
Paid		9.6		8.3		4
Volunteer Conversion		30.0		26.0		1
Category D: Preventative	48.5		42.0		1	
Built Into Structures		20.7		17.9		2
Built Into Equipment		18.0		15.6		3
Standards Activity		0.2		0.2		15
Retardants/Testing		2.5		2.2		11
Fire Maintenance		6.5		5.6		6
Disaster Recovery		0.6		0.5		14
Total		$115.4	100.0	100.0		

A. Analysis of the Total Cost of Fire

Category Based

Category D, the Preventative measures taken each year to prevent fires and to minimize the human and economic consequences of fire, represent 42% of the cost of fire and is the highest ranked category. In fact, the combined cost of the Preventative measures ***Built into Structures*** and ***Built into Equipment***, $38.7 billion, represent 80% of total Preventative costs and one-third of the total annual cost of fire.

The second ranked category, Category C: Fire Service, accounts for approximately one third of the total cost of fire. The Conversion Cost of Volunteer Fire Fighters account for 76% of the category total and 26% of the total cost of fire.

Losses associated with fire, Category A, fall a distant third behind Categories C and D, with Category A representing approximately one-half the respective costs of Fire Service and Preventative. Business Interruption accounts for almost 40% of ***Losses*** and exceeds the combined total of Residential and Industrial Property losses.

The final category, Insurance, represents 5% of the total annual cost of fire in the United States.

Component Based

Table 4 provides the cumulative contribution of the component costs of fire and clearly demonstrates that over 80% of the cost of fire in the United States is represented by six cost components: 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.

Table 4. Cost of Fire in the United States
Cumulative Contribution of Fire Cost Components

	Cost $-Billions		Contribution-%	
Cost Component	Component	Cumulative	Component	Cumulative
Volunteer Fire Service Conversion	$ 30.0	30.0	26.0	26.0
Built into Structures	20.7	50.7	17.9	43.9
Built into Equipment	18.0	68.7	15.6	59.5
Paid Fire Service	9.6	78.3	8.3	67.8
Business Interruption	8.4	86.7	7.3	75.1
Fire Maintenance	6.5	93.2	5.6	80.7
All Other	22.2	115.4	19.3	100.0

B. The Human Cost of Fire

As discussed in Chapter III, 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 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 ***FIREJournal*** in an article prepared by Mr. Michael J. Karter, Jr. [37-56]

Every two years the NFPA publishes ***The Total Cost of Fire in the United States***, an excellent analysis prepared by Dr. John R. Hall, Jr., Director of NFPA's Fire Analysis and Research Division. Dr. Hall's latest analysis, based on 1986 data, appeared in the March/April 1989 issue of the ***FIREJournal***. Dr. Hall included provisions for the costs of building construction for fire protection, career fire departments, fire insurance in excess of losses and the dollar equivalent of human fatalities and injuries. The article explained in great detail how a value of $1.5 million dollars was placed on human life and $35,000 on fire injury: [24-70]

> "The specification of a dollar equivalent for human losses, particularly for loss of life, remains an extremely controversial subject. It is important to reemphasize that no one means to suggest that there is an acceptable price for losing one's life. Rather, these figures are intended to reflect a social consensus on the value of changes in the risk of death by fire. For example, if most people say they would be willing to pay $1,500 to reduce their life-time risk of dying in a fire from, say one chance in 500 to one chance in a 1,000, then a simple way of restating that is that people value a life saved at $1,500 for 1/1000 of a life, or $1.5 million per life."
>
> "The latest broad-scope study of the value of life used in assessing proposed federal regulations concluded that 'there has recently been some convergence around a figure of $1 to $2 million per statistical life.' They specifically cite U.S. Consumer Product Safety Commission (CPSC) staff economists as one source for this range, which is appropriate here because the CPSC is one of the few national organizations involved in fire safety to have ventured into the terrain of assigning values to a statistical life. As part of the recent two-year study of the ignition-resistant cigarette, CPSC economists also developed an estimate for the value of a fire injury, including equivalent values of pain and suffering, which may be rounded off to $35,000."

The entries in Table 5 reflect Mr. Karter's 1989 data and Dr. Hall's values of $1.5 million and $35,000.

Table 5. The Human Costs of Fire
Economic Cost of Fire Death and Injuries

1989 Civilian deaths*	5,410
1986 Firefighter deaths	113
Total deaths	5,523
1989 Civilian injuries*	28,250
1986 Firefighter injuries**	96,450
Total injuries	124, 700
Dollar equivalent of deaths	$8.3 billion
Dollar equivalent of injuries	$4.4 billion

*Source: NFPA, September/October 1990 issue *FIREJournal*. [37-64]

**Last year available. [24-71]

V. IMPACT OF CFR PROGRAM ON TOTAL COSTS OF FIRE

The following section is extracted from the Executive Summary of a companion paper, ***Estimated Impact of Center for Fire Research Program on the Costs of Fire****, P. S. Schaenman, TriData Corporation, January 1991.*

CFR's research has had a huge impact on reducing casualties and losses from fires. It also has helped stimulate new industries, and saved industry enormous sums by engineering fire safety better, averting business disruption, reducing liability, and in a number of other ways. The ***annuity*** of the past continues; CFR's budget has been ***paid*** through the Year 2100 from even the most conservative estimates of its impact.

The following summarizes a first, brief effort to estimate the magnitude of the CFR impact, and how it is distributed across the major components of the total cost of fire. More work is needed on virtually every aspect of the estimating procedures used here.

Impacts

1. By even crude first estimation, the CFR program has an enormous impact on the cost of fire: on the order of \$5-9 billion annually in cost-benefits for the base program, and \$16-26 billion annually at the proposed enhanced level Fire-Year Plan. The savings would be considerably greater if secondary impacts were considered on business interruption, insurance, and fire service costs. A summary of the CFR impacts versus the costs of fire are shown in Table 1.

2. The CFR Base Program stimulates at least \$350 million—\$1.4 billion in added industrial sales annually. The enhanced budget would result in \$1.7-5.2 billion in sales per year.

3. CFR's impacts tend to be long-lasting. Virtually every major contribution from the 1970's still is paying off.

4. Though CFR work touches virtually all aspects of the fire problem, the largest impacts of the base program fall into two areas:

   - Built-in fire protection of structures
   - Residential life safety

   Under the baseline budget CRF would not have a major impact on the costs of the fire service and of fire protection built into equipment—two of the largest components of the total cost of fire.

5. Under the proposed enhanced CFR budget, the largest additional impacts would again be in built-in protection of structures and residential life safety. There would also be some significant impact on the built-in safety of equipment, and firefighting costs, but CFR might consider whether larger impacts are possible in these two major cost areas.

6. The large cost of the fire service—mainly labor costs of the paid service and the equivalent cost of labor for volunteers—is not much affected ***directly*** by CFR's program. However, the cost of fire services might be higher if there was not as much built-in safety in buildings today. In the long run, a safer built environment reduces the need for manual suppression. Nevertheless, as noted above, CFR should consider whether it could play a larger role in the equipment and operation of the fire service.

Table 1. Summary—Impact of the Center for Fire Research Program

	Total Costs ($ Billions)		Savings ($ Billions)	
	Category	Component	CFR Base Budget	CFR Enhanced Budget*
A. ***Losses***	30.7			
Residential Losses				
Property		4.0	1.7-4.2	1.6-3.8
Death and Injuries		7.3		
Non-residential Losses				
Property		4.9	.6-.8	.4-1.2
Civilian Deaths and Injuries		1.8		
Residential Interruption		0.8	Not Estimated	
Business Interruption		8.4	Not Estimated	
Product Liability		3.5	.2-.3	.1
B. ***Insurance***	5.7		Not Estimated	
C. ***Fire Service***	43.2			
Costs		39.6	.2-.5	.6-2.2
Deaths and Injuries		3.6		
D. ***Preventative***	48.5			
Built-in Structures		20.7	2.6-3.6	6.6
Built-in Equipment		18.0	.1+	.8-1.6
Standards		0.2	N/A	.02-.04
Retardants/Testing		2.5	.02	.2-1.1
Fire Maintenance		6.5	N/A	
Disaster Recovery		0.6	.1+	
TOTAL	**128.1**		**5.6-9.4**	**10.4-16.7**

Notes*: Total corrected for roundoff error. ***Savings* include cost of injuries and deaths. Non-residential Property loss includes ***industrial*** and ***other***. The ***Enhanced Budget*** impacts are over and above those of the base budget.

7. Costs of insurance are significantly affected by reduced fire losses, especially in non-residential buildings. Though not estimated, CFR's large contribution to built-in safety undoubtedly affects this cost, too.

8. Business interruption costs likewise are reduced by preventing fires and keeping them small. Though not estimated, CFR's impact on built-in safety undoubtedly plays a role in reducing or holding the line on these costs.

9. Fire maintenance costs may be increased or decreased as a result of the CFR program. Built-in systems required monitoring and testing. However, as the built-in safety is made more reliable, and proven to be reliable, the costs of fire maintenance could decrease. The impact of CFR on this area deserves more consideration in the future. Just as the military now consider the total cost of systems as including their maintenance, so should fire protection systems.

Estimating Methodology

Among the major methodological problems estimating impacts of the CFR program are:

- How to apportion credit to CFR viz a viz other players, e.g., in reducing costs of automatic sprinklers, or the lives saved by smoke detectors.
- How to compute secondary impacts on insurance, fire service labor, fire system maintenance, and business interruption.
- Distinguishing continued savings from past achievements versus savings from the continuing baseline CFR program. We have grouped the two effects, here, on the grounds that most of the contributions since 1975 seem to be still producing savings.

All of these methodological issues need further attention. A second pass at estimating the cost benefit of the program, using this report as a starting strawman, is recommended.

REFERENCES

1. Abrams, Terry. "Nissan and the Security Zone." *Security Management*, August 1989.

2. Anderson, Mark. "Protecting Wet Chemistry Work Stations Against Fire." In ***Papers Presented at the Summer National Meeting of the American Institute of Chemical Engineers***, New York, NY: The American Institute of Chemical Engineers, 1988.

3. Atkin, Ross. "Fighting Fires Before They Start." ***The Christian Science Monitor***, June 27, 1990.

4. Baker, David Ralph. "Meeting High-Rise Requirements for Fire Detection, Alarm, Suppression." ***Consulting-Specifying Engineer***, February 1988.

5. Bolemen, Richard A., Jr. "Emergency Response Teams." ***Solid State Technology***, July 1989.

6. Bolemen, Richard A., Jr. "Managing the Integration of Safety in Semiconductor Manufacturing." ***Solid State Technology***, July 1989.

7. Boring, Delbert F., James C. Spence and Walter G. Wells. ***Fire Protection Through Modern Building Codes.*** 5th ed. Washington, D.C.:American Iron and Steel Institute, 1981.

8. Bradford, Michael. "Smoke, Corrosives Damaging in Fires." ***Business Insurance***, May 28, 1990.

9. Concrete and Masonary Industries. ***A Balanced Design Approach to Firesafety for Low-rise Multifamily Construction.*** No. 18 of a series, Fire Protection Planning Report. Skokie, Illinois, 1990.

10. Dittman, Charles R. "Selling Management the Best Possible Fire Protection Available." ***Professional Safety***, October 1988.

11. Eads, George, and Peter Reuter. ***Designing Safer Products: Corporate Response to Product Liability Law and Regulation.*** Santa Monica, CA: Rand, The Institute for Civil Justice, 1983.

12. Editor. Additives in The Environment: A Challenge for the Nineties." Additives In The '90s. ***Plastics Technology***, July 1990.

13. Emmett, Arielle. "Apocalypse Now?" ***Network World***, September 4, 1989.

14. Factory Mutual Engineering Corporation. Norwood, MA: ***Research--Into the Nineties: Five Research Programs That Will Advance Industrial Loss Control in the 1990's***, 1990.

15. Fahy, Rita F., Kenneth J. Tremblay, and John J. Barry, III. "The Catastrophic Fires of 1989." ***FIREJournal***, July/August 1990.

16. Fahy, Rita F., and John J. Barry, III. "Why Were The Catastrophic Fires of 1987 So Deadly?" ***FIREJournal***, July/August 1988.

17. *Fire in New York—1988*. Albany, NY: New York State, Department of State, Office of Fire Prevention and Control Fire Reporting System, 1989.

18. Franklin, Frederick F. "Circuit Breakers: The Myth of Safety." *Professional Safety*, June 1990.

19. Gauthier, Michael R., and Julie K. Buchanan. "Planning for Data Doomsdays." *Across The Board*, October 1989.

20. Grant, Casey C. "Halons and the Ozone Layer: An Overview." *FIREJournal*, September/October 1989.

21. Grant, Casey C. "Life Beyond Halon." *FIREJournal*, May/June 1990.

22. Gregerson, John. "A 'Model' Approach to Life Safety Design." *Building Design & Construction*, February 1990.

23. Haack, Marr T. "Risk Management: Changes For The Information Age." *Crisis*, January/February 1990.

24. Hall, John R.,Jr. "Calculating the Total Cost of Fire in the United States." *FIREJournal*, March/April 1989.

25. Hall, John R., Jr. "The Elderly, the Sick, and Health Care Facilities." *FIREJournal*, July/August 1990.

26. Hall, John R., Jr. "The Latest Statistics on US Home Smoke Detectors." *FIREJournal*, January/February 1989.

27. Hamilton, William. "Pennsylvania's Greatest Natural Resource... It's Volunteer Fire Fighters." *The Pennsylvania Fireman*, May 1990.

28. Harrison, Ben. "Planning for Disaster." *Telecommunication Products & Technology*, September 1988.

29. Harwood, Beatrice, and John R. Hall, Jr. "What Kills in Fires: Smoke Inhalation or Burns?" *FIREJournal*, May/June 1989.

30. Hensler, Deborah R. *Summary of Research Results on Product Liability*. Santa Monica, CA: Rand, The Institute for Civil Justice, 1986.

31. Hinds, Michael deCourcy. "The Drive for a Fire-Safe Cigarette." *The New York Times*, January 28, 1989.

32. Huber, Peter, "Who Will Protect Us From Our Protectors." *Forbes*, July 13, 1987.

33. Huntley, Glenn, "L.A. Bank Collects on Emergency Plan." *Business Insurance*, July 25, 1988.

34. Industry--News Focus, "Phillips Hurries to Restore HDPE Production." *Plastics Technology*, January 1990.

35. Insurance Information Institute. *Property/Casualty Insurance Facts*. New York, NY, 1990.

36. Johnston, Robert E. "Fire Prevention: Are You Up to the Challenge?" *MIS Week*, May 7, 1990.

37. Karter, Michael J., Jr. "Fire Loss in the United States During 1989."

FIREJournal, September/October 1990.

38. Kiley, Martin D., and Will Moselle. ***1990 National Construction Estimator***. Craftsman Book Company, 1989.

39. Kiley, Martin D., John Svalina, and Shanna Walborn. ***1991 Building Cost Manual***. Craftsman Book Company, 1990.

40. Klopp, Charlotte. "Vulnerability Awareness Improves Contingency Planning." ***Computers & Security***, June 1990.

41. Koffel, William E. "How Can We Harmonize Building & Fire Codes?" ***FIREJournal***, November/December 1988.

42. Koffel, William E., and David M. Birk. "Staff Training Critical for Fire Management." ***Health Facilities Management***, May 1990.

43. Korzeniowski, Paul. "How to Avoid Disaster with a Recovery Plan." ***Software Magazine***, February 1990.

44. Ku, Ellen. "1989 BOMA International Fire Survey-- Commercial Buildings Uphold Fire-Safety Record." ***Skylines***, August 1989.

45. Lappen, Alyssa A. "Profiting From Disaster." ***Forbes***, November 27, 1989.

46. Locke, Adrienne C. "Current Technology Used New Ways in Loss Control." ***Business Insurance***, May 28, 1990.

47. Lucht, David A. "Fire Protection Engineering: Facing the Challenge." ***FIREJournal***, March/April 1989.

48. MacAuley, Patrick. "Construction Outlook for 1990." ***Construction Review***, November/December 1989.

49. Mahoney, Richard J. "The Courts are Curbing Creativity." ***The New York Times***, December 11, 1988, Section 3.

50. Mauzerall, Denise L. "Protecting the Ozone Layer: Phasing out Halon by 2000." ***FIREJournal***, September/October 1990.

51. McMorrow, Eileen. "FR Fibers & Fabrics Sanction Fire Regulations." ***Facilities Design & Management***, March 1990.

52. Mincavage, Rita. "Automated Advances Extend Fire/Life Control Reach." ***Facilities Design & Management***, January 1988.

53. Naitove, Matthew H. "Where will You Be in 1999?" ***Plastics Technology***, January 1990.

54. Naj, Amal Kumar. "GE Pushes to Develop Recyclable Plastic." ***The Wall Street Journal***, August 13, 1990.

55. National Academy of Sciences. ***Materials and Process Specifications and Standards***. Report of The Committee on Materials Specifications, Testing Methods and Standards. National Materials Advisory Board, 1977.

56. National Emergency Training Center. ***Directory of State Fire Service Training Systems 1985 Update***.

Emmitsburg, MD: Federal Emergency Management Agency, 1986.

57. National Safety Council. ***Accident Facts***, Chicago, Illinois, 1989.

58. National Science Foundation, Research Applied to National Needs. Washington, DC: ***Municipal Fire Service Workbook***. Report prepared by Research Triangle Institute, and the International City Management Association, and The National Fire Protection Association, 1977.

59. Newton, Jim. "Building Owners Consider Fire Safety." ***The Atlanta Constitution***, July 24, 1989.

60. Orey, Walter J. "Equipment Readiness & Reliability as Key Safety Ingredients." ***Building Operating Management***, June 1987.

61. Pawar, Prakash. "Flame-Retardant Polyolefins Don't Need Halogen." ***Plastics Technology***, March 1990.

62. Quintiere, James G. "State of Fire Research and Safety," ***Proceedings of the 2nd Fire Safety Science International Symposium***, Tokyo, Japan, June 1988.

63. Rice, Dorothy P., Ellen J. MacKenzie and Associates. ***Cost of Injury in the United States: A Report to Congress.*** San Francisco, CA: Institute for Health and Aging, University of California and Injury Prevention Center, The Johns-Hopkins University, 1989.

64. Riswadkar, A.V. "Safer Products, Fewer Claims." ***Best's Review***.

65. Rudolph, Clifford G. "Business Continuation Planning/Disaster Recovery: A Marketing Perspective." ***IEEE Communications Magazine***, June 1990.

66. Sabatini, Joseph. "Ensuring Code Compliance in High-Hazard Buildings." ***Plant Engineering***, May 10, 1990.

67. Schladweiler, John. "The Strategic Value of Network Disaster Recovery Planning." ***Networking Management***, September 1989.

68. Shelby, Jean. "Fire Suppression Retrofit." ***Building Operating Management***, June 1988.

69. Sherin, Brian. "Work Station Fire Protection for a Semiconductor Facility." ***Professional Safety***, December 1989.

70. Shurtleff, George F. "Focus: Plastics." ***Appliance***, September 1990.

71. Silverstein, Gerald. "New Structures and Equipment by Using Industries, 1977." ***Survey of Current*** Business, November 1985.

72. Singer, James W. "Who Will Set the Standards for Groups That Set Industry Product Standards?" ***National Journal***, May 3, 1980.

73. Stamps, David. "Disaster Recovery: Who's Worried?." ***Datamation***, February 1, 1987.

74. Straus, Hal. "High Technology, Human Vigilance Protect IBM Tower." ***The Atlanta Constitution***, July 24, 1989.

75. Steiner, Vera M. "Building Codes--Bane or Blessing?" *Plant Engineering*, July 21, 1988.

76. Sturgis, Robert W. *Tort Cost Trends: An International Perspective*. New York, NY: Towers Perrin, Tillinghast, 1989.

77. Taylor, Kenneth T., and Alison L. Norton. "Large-Loss Fires in the United States During 1987." *FIREJournal*, November/December 1988.

78. Taylor, Kenneth T. and Kenneth Tremblay. "Large-Loss Fires in the United States During 1988." *FIREJournal*, November/December 1989.

79. Technology News—Urethane Foams. "New Regulations, New Addatives for Flame- Retardant Urethane Foams." *Plastics Technology*, March 1989.

80. Tell, Lawrence J., "United They Stand""At the Defense Table." *Business Week*, May 30, 1988.

81. Transue, Ralph E. "Fire Management: Intelligent, Integrated, Informed." *Consulting/Specifying Engineer*, April 1988.

82. *The X-Factor*, A Videotape, Factory Mutual Engineering and Research, Norwood, MA.

83. U.S. Department of Commerce. Bureau of the Census. *1980 Census, Number of Inhabitants, U.S. Summary*. Washington, DC PC-80-1-A-1.

84. U.S. Department of Commerce. Bureau of the Census. *Government Finances in 1987-1988*. Washington, DC, 1990.

85. U.S. Department of Commerce. Bureau of the Census. 1990. *Plant and Equipment Expenditures and Plans--First Quarter 1990*. Washington, DC, 1990.

86. U.S. Department of Commerce. Bureau of the Census. *Quarterly Financial Report for Manufacturing, Mining and Trade Corporations--First Quarter 1990*. Washington, DC, 1990.

87. U.S. Department of Commerce. U.S. Fire Administration. *America Burning, The Report of the National Commission on Fire Prevention and Control*. Washington, DC: Federal Emergency Management Agency, 1989.

88. U.S. Department of Commerce. U.S. Fire Administration. *Fire in the United States--Sixth Edition*. Washington, DC: Federal Emergency Management Agency, 1987.

89. U.S. Department of Commerce. U.S. Fire Administration. *Indirect Costs of Residential Fires*, Washington, DC: Federal Emergency Management Agency. National Fire Data Center, 1979.

90. U.S. Department of Treasury. *Corporation Income Tax Returns--1986 Statistics of Income*. Washington, DC: Internal Revenue Service, 1989.

91. U.S. Market Report. The PC Juggernaut Bogs Down. ***Electronics***, January 1989.

92. U.S. Senate. Committee on Commerce, Science, and Transportation. June 29, 1990, Report, ***Product Liability Reform Act, S.1400***. Commerce Clearing House, Chicago, Illinois.

93. Vining, Edward K. "New Look in Sprinklers Answers Fire Demands." ***National Safety and Health News*** August 1985.

94. Warren, Lilli W. "Combustion Toxicity: The Burning Issue." ***Plastics Technology*** July 1988.

95. Wigotsky, Victor. "Hot Issues Challenge Flame-Retardance Industry." ***Plastics Engineering***, October 1987.

96. Wilmot, Tom. "National Fire Costs--A Wasteful Past but a Better Future." ***Proceedings of the 1st Fire Safety Science International Symposium.***

97. Wood, A. Stuart. "Will Toxicity Concerns Doom Workhorse Flame-Retardant Systems?" ***Modern Plastics***, May 1990.

98. Woodford, Jim. "Microprocessor-Based Fire Alarm Systems." ***Building Operating Management*** June 1988.

99. Young, John A. "An American Giant Rethinks Globalization." ***Information Strategy***. Spring 1990.

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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.

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