REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 1992	Final Report

4. TITLE AND SUBTITLE
Investigation of Cause and Effects of Fires Following the Loma Prieta Earthquake

5. FUNDING NUMBERS
BCS-9003557

6. AUTHOR(S)
Jamshid Mohammadi, Sam Alayasin, and D.N. Bak

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Illinois Institute of Technology
Department of Civil Engineering
Chicago, IL 60616

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Division of Industrial Science and Technological Innovation (ISTI)
Directorate ofr Scientific, Technological, and International Affairs (STIA)
National Science Foundation, Washington, DC 20550

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NSFENG-92007

11. SUPPLEMENTARY NOTES
Prepared under grant awarded to the Illinois Institute of Technology, Chicago, IL; appears as item IIT-CE-92-01, Structural Engineering Series

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This study investigated the causes and effects of the 41 San Francisco fires following the October 1989 Loma Prieta earthquake, and examined the risks for future post-earthquake fire in this city. Using data gathered from fire departments and other sources, the authors found that these fires were due to damages to electrical wiring or electrical equipment, overturned or disrupted appliances, and several isolated causes. For each fire, they examined the classification type, intensity of ground motion, soil type, and type of structure burned, and with this information constructed a risk model for simulating initiation of other potential post-earthquake residential fires. Employing event trees and other models for gas and electrical fire initiation, in conjunction with probabilities associated with various earthquake ground acceleration levels, the authors computed the probabilities for future occurrences. The study noted that such information can provide the basis for earthquake preparedness, such as in helping to plan fire fighting strategies, alternative transportation routes, shelter and hospital services, evacuation procedures, and also aid in assessing which residential services and/or equipment are needed to reduce risk in localities vulnerable to earthquakes.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Earthquake Fire Mitigation	181
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

PB93-12C C46

Illinois Institute of Technology

Chicago, Illinois 60616

Department of Civil Engineering
Armour College of Engineering

IIT-CE-92-01
STRUCTURAL ENGINEERING SERIES

INVESTIGATION OF CAUSE AND EFFECTS OF FIRES FOLLOWING THE LOMA PRIETA EARTHQUAKE

BY

JAMSHID MOHAMMADI

SAM ALYASIN

D. N. BAK

A Report to the
NATIONAL SCIENCE FOUNDATION
Research Grant BCS-9003557

MAY, 1992

IIT-CE-92-01
STRUCTURAL ENGINEERING SERIES

INVESTIGATION OF CAUSE AND EFFECTS OF FIRES FOLLOWING THE LOMA PRIETA EARTHQUAKE

BY

JAMSHID MOHAMMADI

SAM ALYASIN

D. N. BAK

A Report to the
NATIONAL SCIENCE FOUNDATION
Research Grant BCS-9003557

MAY, 1992

ABSTRACT

The objective of this study was to investigate the cause and effects of fires following the October 17, 1989 Loma Prieta Earthquake. The study also examined the potential risks of post-earthquake fire hazard in San Francisco. The Fire Incident Reports from local fire departments were obtained and reviewed. The number of fires following the Loma Prieta Earthquake versus the type of soil in the area, the population density of the region , and the types of fires in terms of their severity was analyzed. The causes of fires were studied and classified. A variety of causes were identified. It was found that of the 41 fires in San Francisco 14 were due to electric wiring and equipment, 11 were the result of stoves (gas/electric), 2 from water heaters, and from other gas appliances. The rest of the fires were due to other causes. Using an event tree analysis, occurrence of gas and electric wires were modeled. The risk associated with various events following an earthquake that may lead to a fire were quantified using simulation analysis (where possible), and available data. The results were then used to estimate the probability of post-earthquake fire occurrence in single family residential buildings. These results were depicted in the form of risk contour maps for a repeat of the Loma Prieta event in the city of San Francisco.

DISCLAIMER

This Material is based upon work supported by the National Science Foundation under award number BCS-9003557 to the Illinois Institute of Technology. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

ACKNOWLEDGEMENTS

This report is based on the Master of Science thesis of Sam Alyasin. The writers wish to express their appreciation to Chief Dennis Callahan of the San Francisco Fire Department for the fire data and his guidance. The study was supported by the National Science Foundation through the Research Grant BCS-9003557 to the Department of Civil Engineering of the Illinois Institute of Technology.

TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

TABLE		Page

LIST OF FIGURES

CHAPTER I

BACKGROUND

1.1 Introductory Remarks

The majority of research conducted on fires following earthquakes has been carried out in both Japan and the United States. An abridged review of past studies conducted on the subject is presented in this chapter, with the notion that the models developed may translate well into our investigation of the fires following earthquakes.

Urban post-earthquake fires are serious problems that have the potential to cause immense losses in terms of life and property. Almost all recent earthquakes in Japan and the U.S. have caused fires in both residential and commercial areas. In Japan fires were reported following 1923 Kanto, 1948 Fukui, 1964 Niigata, 1968 Tokachi-oki, 1978 Miyagiken-oki, and the 1983 Nihonkai-chubu earthquakes. Similarly American earthquakes of modern times have resulted in numerous fires. Table 1.1 summarizes the statistics of fire occurrences for several major U.S. earthquakes (Scawthorn 1986).

Despite their great damage potentials and importance in structural engineering and risk management, post-earthquake fires have not been fully investigated. Studies of post-earthquake fires have been in most part concentrated on:

(i) Investigation of fire incidents and, to certain extent, cause of post-earthquake fires.

Table 1.1 Statistics of Earthquake-Related Fires for Several Fires in the U.S.

Event	Date	Number of Fires	MMI	Magnitude
San Fransisco	1906	58	VII 1/2-IX	8.3
Santa Barbara	1926	1	VIII 1/2	6.2
Long Beach	1933	13	IX	6.3
San Fransisco	1957	1	VI 1/2	5.3
Alaska	1964	7	X	8.4
Puget Sound	1965	1	VII 1/2	5.6
San Fernando	1971	109	VII - IX	6.6
Coalingo	1983	1	VIII	6.7
Morgan Hill	1984	6	V 1/2 - VII	6.2
Whittier-Narrows	1987	6	VIII	5.9
Loma Prieta	1989	67	VI - VII	6.9

(ii) Modeling of fire spread in urban areas.

The latter, however, has been very limited and mainly conducted in Japan.

The statistics presented in Table 1.1 and reports of post-earthquake fires in most Japanese earthquakes (Scawthorn 1987) suggest that post earthquake fire hazard remains as a serious threat and a potential problem in many seismic areas in the United States. The problem is even more critical in urban areas where wood is a primary construction material. Furthermore, the post-earthquake hazard is specially critical because despite other earthquake-initiated hazards (e.g. structural collapse) that are normally drastically reduced when the earthquake stops, post-earthquake fire hazard continues even up to several days after the main event. For example it is not unusual for a gas-related fire to occur one or two days after an earthquake due to undetected gas leaks caused by the earthquake.

In this chapter an overview of past studies on earthquake fire hazard is presented. The review specifically focuses on:

- Fires following past earthquakes.
- Causes of post-earthquake fires.
- Available models on fire hazard estimation and evaluation.
- Fire investigation after the Loma Prieta earthquake of 1989

1.2 Fires Following Past Earthquakes

An investigation of fires after many earthquakes has been done by Scawthorn (1981,1985,1986,1988); Table 1.1 presents a summary. Additional such studies have been also conducted by others; Schiff (1988), Steinbrugge et al.(1973). Based on statistics of Table 1.1 , the number of fires occurring following some of North America's major earthquakes is summarized in Fig. 1.1. Although this figure does not display a definite trend in occurrence of fires following earthquakes, it serves as a reminder of post-earthquake fires' immense hazard potentials. A review of data presented here points to the fact that even with great technological advances in safety of utilities, such as gas and electrical distribution systems, large spread fires such as the 109 cases reported following the 1971 San Fernando earthquake, and the 41 fires reported in the city of San Francisco as a result of the Loma Prieta earthquake of 1989, are to be expected.

Considering the rapid growth of cities and quick pace of urbanization of small towns in the seismically high risk areas of the United States (such as California) in the past century, risk of widespread fires and conflagrations has drastically increased. Steinbrugge et al. (1973) discuss numerous problems involved with emergency response following earthquakes in a report on the San Fernando earthquake. This earthquake affected the city of Los Angeles, the Los Angeles County, San Fernando, Pasadena, Glendale, and Burbank. As a result of the earthquake, numerous gas and electrical fires occurred on the

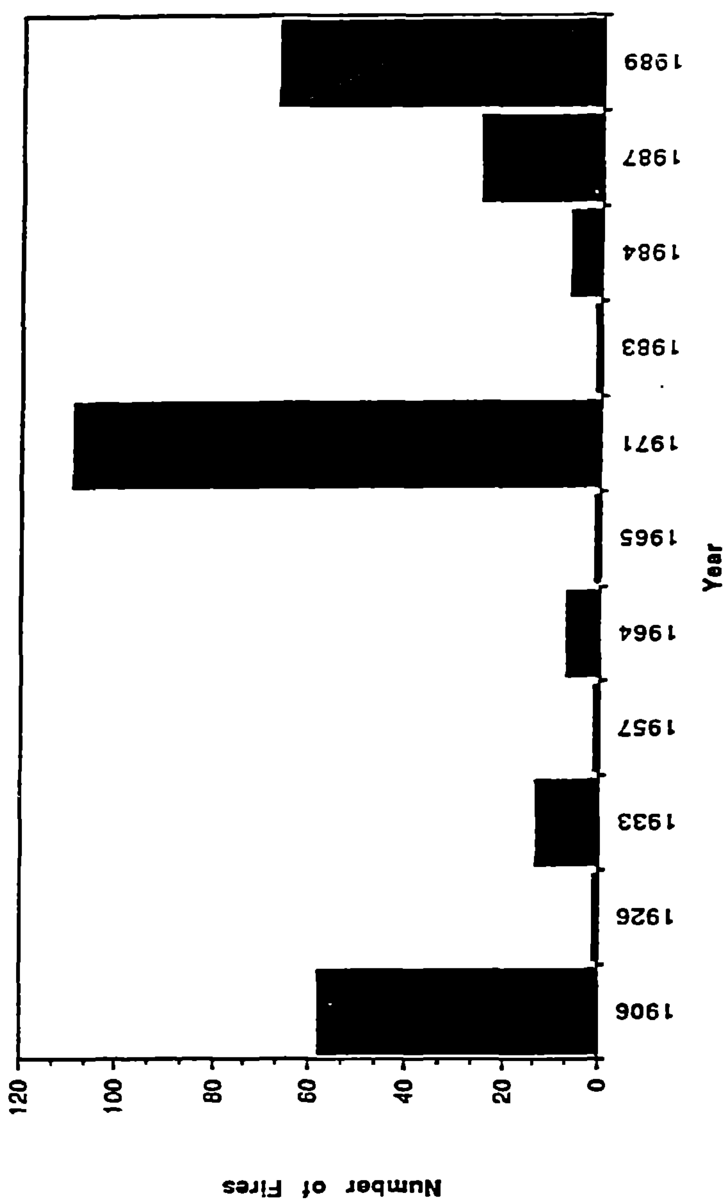


Figure 1.1. Fires Following Some Major North American Earthquakes

day of the event and several days after it. Potential problems in dealing with post-earthquake fires range from damage to lifelines, such as damage to utilities, to damage to emergency response systems. This report specifically points to:

- disruption of public telephone communications
- damage to gas and electric supply facilities
- damage and obstruction of roads and highways
- overloading of emergency communications
- structural collapse or severe damage to some fire stations, fire fighting equipment, and hospitals

Such events hamper emergency response and rescue efforts, thus increasing the probability of conflagration of fires which would otherwise be controllable.

Further examination of data in Table 1.1 reveals that in almost all cases fires occur following earthquakes with intensities above VI on the MMI scale (see Appendix A). The largest concentration of post-earthquake fires is seen in the upper intensity ranges. Although no specific trend in the number of fires versus MMI can be seen from this data it is evident that the number of post-earthquake fires increases with an increase in the magnitude of the ground motion. It is however emphasized that there are other factors, such as population and the type of soil in the affected sites, that influence the number of fires.

The 1989 data mainly shows fires initiated by the Loma Prieta earthquake. This data is discussed in detail in Chapter

II of this report.

1.3 Causes of Post-Earthquake Fires

Fires following the Santa Cruz (Loma Prieta) earthquake are an indication of the diversity in the possible sources of fire in an urban area. Reports from the area fire departments list gas leaks, electrical wiring problems, overturned water heaters, overturned hot plates, and candles as major causes of fire. Stussman and Kosowatz (1989) report a fire that leveled a block in the Marina district of San- Francisco as a result of a single broken gas distributicn pipe.

Post-earthquake gas leaks are a primary source of fires in urban areas. Various researchers, Schiff (1985,1988); Scawthorn et al. (1985); Longinow, Mohammadi, and Williams (1989); Longinow et al. (1990) have investigated different aspects of gas system response.

In his investigation of lifelines' performance in the Morgan Hill Earthquake, Schiff (1985) concluded that most of the failure in gas systems had occurred beyond the service connections. In his report he estimates 1400 gas leaks beyond the service lines. Several of these leaks caused fires. Scawthorn et al. (1985) confirms Schiff's findings in a detailed review of the fire related events during and after the Morgan Hill earthquake. A major part of these studies also dealt with mitigation efforts and actions taken by support personnel dealing with leaks and resulting fires.

Study of gas system failure and its consequences following an earthquake has provided a useful database for new research. Longinow, Mohammadi, and Williams (1989) developed methods for estimating risks associated with residential and commercial interior piping systems failures and analyzed the potential risks in interior gas piping systems of selected low and high-rise buildings. Expert opinion polls, collection of experimentally derived performance data, and literature search were used to gather data on gas leaks. Mean probability and standard deviations of each data group were calculated and using information on consequences of these leaks fault and event tree risk analyses were performed on a selected group of buildings. The event tree analysis lead to an estimation of a measure of damage caused by different levels of gas leaks and an understanding of the risk involved in different types of piping systems and their components.

Longinow et al. (1990) studied the effects of seismic forces on interior gas piping systems. Using simulation analyses the potential damaging effects of earthquake forces on the interior piping system was determined by computing stresses developed in various components of the piping systems. Different modes of failure in gas piping systems were identified as buckling, local yielding, and loosening of joints which could all result in leaks and consequently fire. Furthermore, employing reports on the Whittier-Narrows and San Fernando earthquakes a causal chain of events was introduced to explain the reason for relatively few numbers of gas related fires given the large number of reported leaks. The authors also support previous findings that the higher incidents of electrical fires in the San- Fernando earthquake was the result of the spontaneity of occurrence of such fires in contrast to the dramatic chain of events needed for a gas fire to initiate.

Smith and McCorskie (1990) studied causes of wiring fires in residential buildings. Although in their study they did not directly investigate the effects of earthquakes on residential wiring, by pin pointing trouble spots in residential wiring and categorizing different modes of failure they provide a good understanding of the modes that may be critical in case of an earthquake. They site such specific problems as friction wear of cables, loosening of aluminum conductor connections at service panels, and point to the most frequent problem cited as "loose connections." It is emphasized that the risk of failure of connectors can be multiplied by cyclic movements such as those experienced in an earthquake.

1.4 Available Models on Fire Hazard Estimation

An in depth study of post-earthquake fire hazards which would lead to development of a model simulating initiation and spread of fires in urban areas would rely on a good statistical base encompassing aspects such as types of fires, intensity of the ground motion and soil type at the site of fire, and type and location of the structure. Employing such data any trends in occurrence of post-earthquake fires could be identified. An understanding of these trends, in conjunction with a probabilistic study of the causal chain of events necessary for the fire spread in the structures, would provide for formulation of a procedure to be used in mitigating the risk of post-earthquake fires.

A primary work important to the direction of this study was the methodology developed by the URS corporation (1988) for estimating the risk of earthquake induced gas fires in residential housing. In order to estimate the probability of ignitions and flashovers following an earthquake, the method incorporated the Whittier-Narrows earthquake data as well as expert opinion and analytical studies. The collected data included damage to residential gas systems, United States Geological Survey isoseismals for the 1987 Whittier Narrows earthquake, distributions of residential gas appliances, distribution of different gas space heaters, distribution of pilots and IIDs (intermittent ignition devices) in residential gas components, and fire incident reports for the city of Los Angeles. Using the MMI scale, the effects of ground motions on gas burning appliances and their circumstances along with other potential causes of fire were investigated. A time-based event tree was developed to explain the causal chain of events from the time an earthquake occurs to the possible fires. The event tree contained five nodes with the earthquake occurrence as the initiating event, followed by component failure, ignition, availability of fuels, flashover and fire spread, and ending with categorizing the fire types.

Conditional probabilities were calculated for every branch of the tree by equating the conditional probability of every event along the tree to the product of the conditional probabilities of the preceding branches to that event. These conditional probabilities were based on analytical studies of the response of gas appliances to ground shaking and expert opinion questionnaires. Using a Bayseian updating method the Whittier-Narrows earthquake data was also combined with the analytical and expert opinion data. This study lead to the development of a computer program which can estimate the maximum probable number of fires due to damages to gas systems by an earthquake.

Scawthorn (1987) introduces an alternate method for computer simulation of fire outbreaks following earthquakes. Four important aspects in computer modeling of post-earthquake fires; namely, intensity, ignitions, fire spread, and fire service operations are introduced and discussed.

Relations for fire growth in urban areas considering wind speed and direction as well as building density, materials, and time of occurrence have been taken into consideration. The problem of fire department response is also introduced, and using a time line scheme possible response scenarios and delays have been considered. The computer program was then tested by applying the model to the city of San Francisco for an earthquake with an 8.3 magnitude and number of initial fire outbreaks was estimated.

Other models for fire spread in urban areas such as " the stochastic model for fire spread in urban areas based on fire brands effect" by Itoigawa and Tsukagoshi (1988), and Mizuno's (1978) method of correlating building collapses and ignitions have also been reported. These models, however; do not consider the risk of post-earthquake fire for a specific residential unit due to such factors as gas leaks, electric wiring problems, etc.

1.5 The Loma Prieta Event

Since the attempt here is not only to develop a general model for analysis of the risk of post-earthquake fires but also to corroborate the findings with actual statistics obtained from the Loma Prieta earthquake, it is in order to study the quake itself and the damages caused by it.

The Loma Prieta earthquake occurred at 5:04 p.m. local time on October 17th, 1989 as a result of a slippage of some 40 km of the San Andreas fault producing an estimated average surface wave magnitude of 7.1 on the Richter scale measured by the USGS. Its epicenter was located in the Santa Cruz mountains, 16 km North-East of Santa Cruz and 30 km South of San Jose. The quake resulted in widespread losses of life and property. The toll was reported as 62 deaths, Nearly 3800 injured, in excess of 7500 homeless, and property damages of $5.6 billion dollars. Additionally in San Francisco alone 41 fires were reported. Figure 1.2 shows the ground motion records of the earthquake obtained from NISEE (National Information Service for Earthquake Engineering).

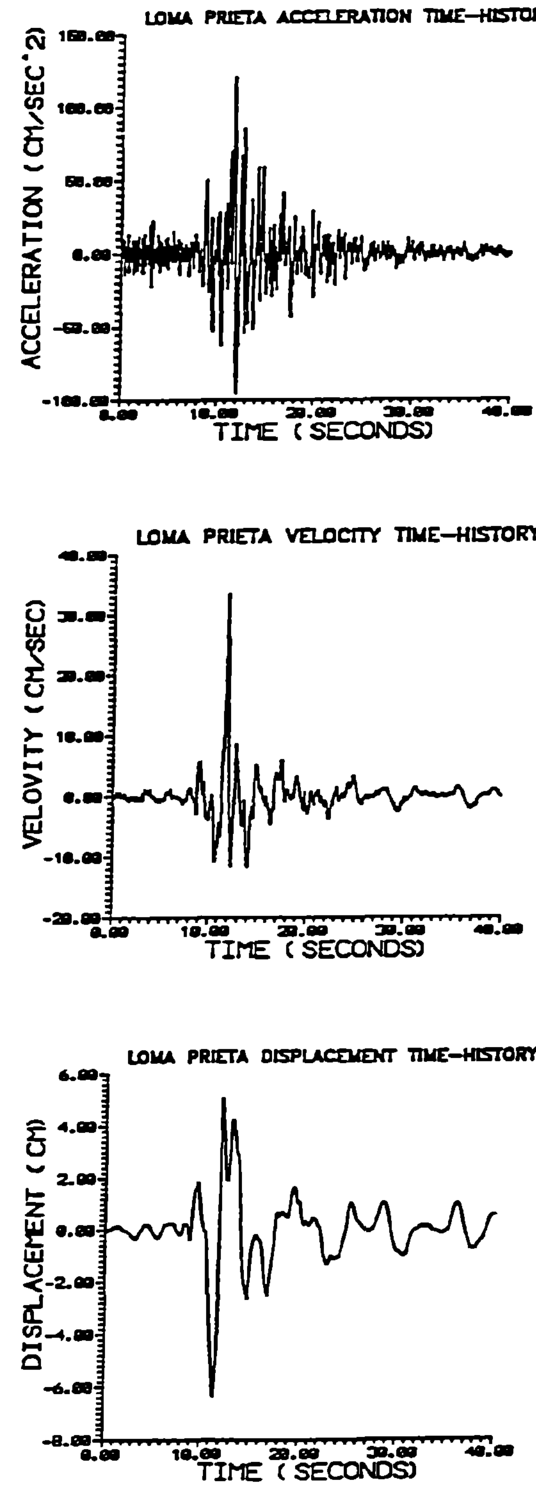


Figure 1.2. Time Histories for the Loma Prieta Earthquake of 1989

The Marina District of San Francisco was one of the hardest hit areas by the earthquake as a result of a significant ground motion amplification with intensity estimations of as much as 0.35 g's. In addition to the heavy structural damages in this area, an intense post-earthquake fire also completely destroyed one block of buildings in the Marina district. Such incidents demonstrate the urgency and the great need for comprehensive planning and hazard mitigation programs.

1.6 Contents of This Report

Chapter II presents a comprehensive evaluation of causes and effects of the Loma Prieta earthquake. Models for the sequence of events in a post-earthquake fire are described in Chapter III. In Chapter IV, risks of gas and electric-related fires are quantified. Chapter V focuses on estimating the risk of fires for San Francisco. Conclusions and Recommendations for additional studies are presented in Chapter VII.

CHAPTER II

EVALUATION OF CAUSES AND EFFECTS OF FIRES FOLLOWING THE LOMA PRIETA EARTHQUAKE

2.1 Introductory Remarks

One of the most dramatic scenes after the earthquake on October 17, 1989 was the fire in the Marina District. As people viewed this event live on television, it appeared to many that the fire was one of the most severe consequences of the earthquake in terms of its destructiveness. Despite this dramatic event, the number of fires following the earthquake was relatively low for an earthquake with 7.1 Richters in magnitude and with about 0.3g maximum ground acceleration hitting some very populated areas. Several factors contributed to the relatively low number of fires. These are:

- Nearly zero wind speed in affected areas.
- Relatively short duration of the earthquake (about 40 seconds).
- Awareness on the part of fire departments in San Francisco and other localities on the potential fire hazard, quick response by fire departments to the emergency calls and well-managed fire fighting efforts.

An investigation into the origin and effect of the fires occurring after the earthquake is important especially for the purpose of preparedness for future earthquakes and risk mitigation. Presented in this section are: (i) a brief description of the characteristics of the earthquake as it pertains to post-earthquake fires and fire fighting activities; (ii) a review of the numbers, locations, cause and effects of fires following the earthquake; and (iii) an analysis of the reported fires in terms of such parameters as site ground accelerations, types of soil and population concentration in affected areas.

2.2 The Loma Prieta Earthquake -- Fire Incidents

The event is considered as the most far-reaching and intense earthquake in California since the 1906 San Francisco earthquake and conflagration. Between 5:04 p.m. (when the earthquake occurred) and midnight on October 17, 1989, over 500 incidents were dispatched by the Communication Center of the San Francisco Fire Department alone. Due to the intensity of damage as a result of the earthquake, fire units, that were called upon to respond to emergencies, were often flagged down by citizens on the street for help. Accordingly, any one dispatch easily turned into three to four incidents according to the San Francisco Fire Department (SFFD) records. It is reported that telephone calls were being received at a rate of 500 to 600 per hour and that about 80% of the responses made by SFFD units on October 17 were to check on hazardous conditions such as natural gas leaks, falling chimneys and structural damage (SFFD Contacts 1990-1992).

The SFFD's first call was for a four-story 21-unit apartment building that collapsed. While responding to the emergency at this location, fire fighters at the scene noticed the fire in the Marina District, several block away at Beach and Divisadero. Fire fighters responded to this fire and arrived at the scene at about 5:45 p.m. As a result of exposure to this fire, several other buildings in the area also caught on fire. The description of these and other fires is presented later.

The number of fires in the affected areas following the earthquake is summarized in Table 1.1. Most fires occurred on October 17 immediately after the earthquake. Additional fires also occurred on October 18, 19,and 20 (fire accident reports are provided in Appendix C).

2.3 Causes of Fires

A variety of reasons caused fires following the earthquakes. These causes are categorized in the following four groups:

- Gas leaks due to failure of pipes (interior or exterior gas mains) or gas appliances. Appliance failure is due to sliding or overturning of, for example, a water heater.
- Electrical system distribution problems or electrical appliance failure. Wiring problems are associated with overloaded cables and cords and electric shorts at joints, receptacles, etc.
- Flammable material spills.

- Overturning of burning candles, table lamps, gas grills, etc.

2.4 Types of Fires

For the purpose of this study, fires are categorized into four types. Each type is identified using fire department reports. This categorization is entirely based on the available data and can be changed subjectively.

Type 1. Fire only spreads into the immediate area around its point of origin.

Type 2. Fire catches on an ignitable material in the room of origin, spreads all over the room; however, it is only confined to the room of origin.

Type 3. Fire catches on an ignitable material in the room of origin, spreads all over the room and throughout the building.

Type 4. This type has the same characteristics as Type 3; however, it also spreads to adjacent buildings.

2.5 Investigation of Fires in San Francisco

As described in Table 2.1, 41 fires occurred in San Francisco. A complete listing of the locations of these fires is provided in Table 2.2, using the data acquired from SFFD. The four fire categories were used to determine the number of fires in terms of their severity. Additionally, Table 2.3 presents a distribution of fires versus their types and Figure

Table 2.1 Number of Fires by Area

Area	No. of Fires
San Francisco	41*
Berkeley	1
Santa Cruz County	20
Watsonville	3
Santa Clara County	1
Nisene Marks State Park	1

*Twenty-seven (27) fires occurred within seven hours after the earthquake; seventeen of which immediately after the earthquake.

Table 2.2 Locations of Fires in San Francisco

Location	Date	Origin
354 Byxbee St.	10-17-89	Electrical failure
350 Byxbee St.	10-17-89	Exposure to above
150 Font Blvd.	10-17-89	Electric lamp
69 Castenada Ave.	10-17-89	Gas explosion
3701 Divisadero St.	10-17-89	Not known
3717-19 Divisadero St.	10-17-89	Exposure to above
3723-25 Divisadero St.	10-17-89	Exposure to above
3729-35 Divisadero St.	10-17-89	Exposure to above
3735-37 Divisadero St.	10-17-89	Exposure to above
2130 Beach St.	10-17-89	Exposure to above
2136-38 Beach St.	10-17-89	Exposure to above
3739 Loyola Terrace	10-17-89	Stove
445 Bayshore Blvd.	10-17-89	Generator
428 Grove St.	10-17-89	Generator
965 Chenery St.	10-17-89	Candle
3999 Noriega St.	10-17-89	Stove
630/632 Cole St.	10-17-89	Wiring
1138 Valencia St.	10-18-89	Coffee pot
2095 Hayes St.	10-18-89	Hot plate
1954 McAllister St.	10-18-89	Stove
3867 Jackson St.	10-18-89	Lamp
1256 6th St.	10-18-89	Stove
300 16th St.	10-18-89	Stove
5 Galilee	10-18-89	Stove
754 Grant st.	10-18-89	Candle
818 30th Ave.	10-18-89	Stove
1020 Larkin St.	10-18-89	Barbecue
1308 Larkin St.	10-18-89	Candle
1 Daniel Burnham Court	10-18-89	Barbecue
1040 Bush St. #303	10-18-89	Candle
74 New Montgomery St.	10-19-89	Wiring
74 New Montgomery St.	10-19-89	Wiring
241 6th St. #231	10-19-89	Lamp
237 Post St.	10-19-89	Wiring
989 Post St.	10-19-89	Generator
1950 Stockton St.	10-19-89	Water heater
172 6th Ave. #401	10-19-89	Stove
1040 Sutter St. #62	10-19-89	Stove
5 George St.	10-20-89	Stove
299 Peru Ave.	10-20-89	Stove
48 Waller St.	10-20-89	Water heater

Table 2.3 San Francisco's Fires by Type

Location	Type
354 Byxbee St.	4
350 Byxbee St.	3
150 Font Blvd.	2
69 Castenada Ave.	1
3701 Divisadero St.	4
3717-19 Divisadero St.	4
3723-25 Divisadero St.	4
3729-35 Divisadero St.	1
3735-37 Divisadero St.	3
2130 Beach St.	4
2136-38 Beach St.	3
3739 Loyola Terrace	2
445 Bayshore Blvd.	1
428 Grove St.	2
965 Chenery St.	1
3999 Noriega St.	2
630/632 Cole St.	4
1138 Valencia St.	3
2095 Hayes St.	3
1954 McAllister St.	1
3867 Jackson St.	2
1256 6th St.	1
300 16th St.	1
5 Galilee	1
754 Grant st.	1
818 30th Ave.	1
1020 Larkin St.	1
1308 Larkin St.	2
1 Daniel Burnham Court	1
1040 Bush St. #303	2
74 New Montgomery St.	2
74 New Montgomery St.	1
241 6th St. #231	1
237 Post St.	1
989 Post St.	1
1950 Stockton St.	1
172 6th Ave. #401	1
1040 Sutter St. #62	1
5 George St.	3
299 Peru Ave.	1
48 Waller St.	2

2.1 depicts these fires on the San Francisco map. Shown on the map arc also stations from which the earthquake ground acceleration data was recorded. In terms of causes, the fires were arranged in groups and the percentage of total number of fire in each group is summarized in Table 2.4. These percentages are also graphed in Fig. 2.2.

The largest fire started in the densely populated Marina District. This fire originated in a four-story wood-frame building at the corner of Divisadero and Beach St. The building was built in the 1920's. It contained 21 apartments and a parking garage on the ground floor. As a result of the earthquake, the two lower floors collapsed and the top floors leaned out for several feet. The cause of this fire is unknown; but it is believed to have originated at the rear of the building. Fire fighters arrived at the scene at approximately 5:45 p.m. The first engine connecting to a high pressure hydrant directly in front of the building found it to have no water pressure. Shortly after an explosion shook the building. Flames shot 100 feet into the air and the building wall fell onto the hydrant. The engine was then immediately repositioned across the street and continued to operate on the fire. Several exposed buildings were also ignited; fortunately, water was found and relayed from both a more distant hydrant and a lagoon at the Palace of Fine Arts. However, the attempt by a pumper to draft from the Marina Lagoon was unsuccessful due to low tide. To complicate matters several more explosions then occurred and the affected

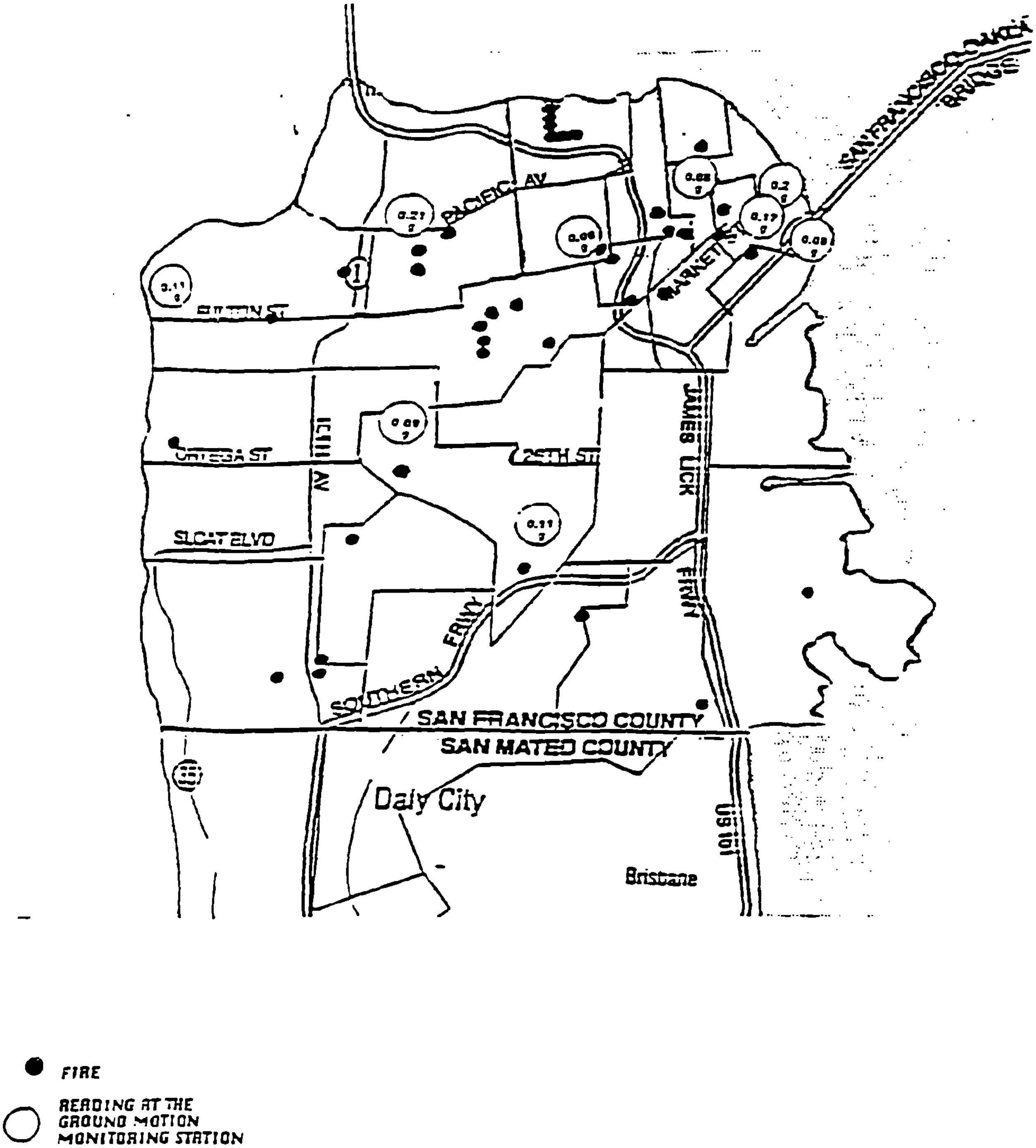


Figure 2.1. Location of San Francisco's Fires

Table 2.4 Classification of San Francisco's Fires by Cause

No. of Fires	% of Total	Cause
6	14.62	Electric wiring
8	19.51	Electric equipment
11	26.83	Stove (gas/electric)
7	17.00	Not known
1	2.44	Gas explosion
2	4.87	Water heater
2	4.87	Other gas appliances
4	9.76	Miscellaneous

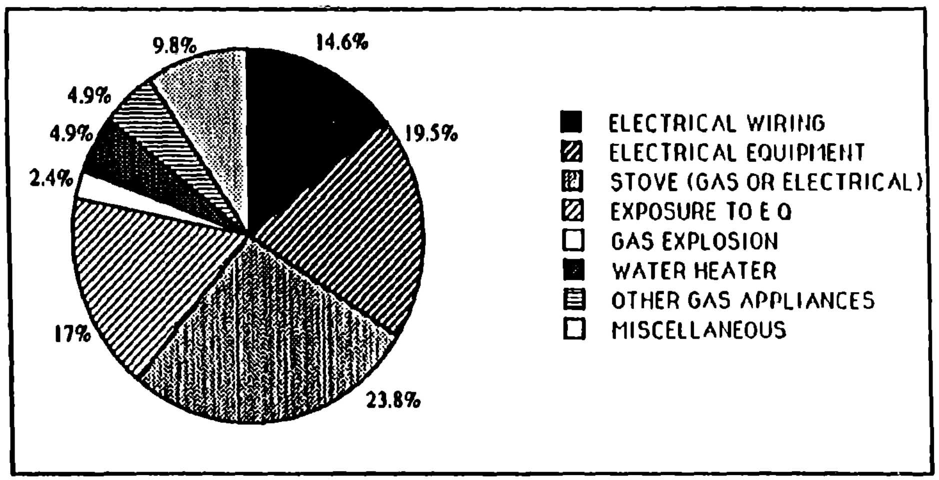


Figure 2.2. Percentage Distribution of the San Francisco Fires by Cause

buildings collapsed destroying a number of hose sections. At this time additional water had become available from the San Francisco Bay at the Marina Waterfront only two blocks away. Fire ground commanders called for the fireboat *Phoenix* and the portable water hose tenders. The fireboat and three hose tenders arrived at 6:00 and crews set up four major runs (a total of 6,000 feet) of 5-inch hose between the fire and the boat using nine portable hydrant. At least 10 engines were operating on the fire at this time. Water from the boat had a positive effect, and this fire was under control by about 8:00 p.m. Before all fire operations were concluded in the Marina District, the boat pumped 6,000 gpm for more than 18 hours (information excerpted from FEMA 1991).

Significance of Ground Acceleration -- Ground accelerations were only recorded at a few stations in San Francisco. These accelerations have been estimated and reported for the Marina District in (Shakal 1989). This information has been added to the measured values at the stations appearing on Fig. 2.1. Using linear interpolation, the ground accelerations at the location of the 41 fires in San Francisco were then estimated. Table 2.5 presents the number of fires and their types versus the ground acceleration in units of g. Although no strong correlation between the total number of fires and ground acceleration is obtained, the data in Table 2.5 does indicate a correlation between the number of Types 3 and 4 fires (combined) and the ground

Table 2.5 Number of Fires vs Ground Acceleration

Acceleration (g)	Type 1	Type 2	Type 3	Type 4	Total
0.05-0.10	2	1			3
0.11-0.15	13	6	3	3	25
0.16-0.20	4	1			5
0.21-0.30			3	5	8

Table 2.6 Number of Fires vs Ground Acceleration and Soil Types

Acceleration (g)	SB	USB	US	M&F	Total
0.05-0.10			3		3
0.11-0.15			2	23	25
0.16-0.20			5		5
0.21-0.30			3	5	8

SB: Stable Bedrock
USB: Unstable Bedrock
US: Unconsolidated Soil
M&F: Mud and Fill

acceleration. Furthermore, the largest number of Type 4 fires occurred in the areas with relatively high ground acceleration. These fires, a total of 5, were all in San Francisco's Marina District - a highly populated area where numerous buildings were severely damaged.

Significance of the Type of Soil -- An examination of soil types reveals that the affected areas are mainly made up of four major types. These are:

1. Stable bedrock (SB). Ground shaking is not increased; ground failure is unlikely.
2. Unstable bedrock (UB). Ground shaking is slightly increased; this type is prone to land slides if present on steep slopes that are decomposed or water saturated.
3. Unconsolidated soil (US). Ground shaking is increased especially if is made of thick layers that are water saturated.
4. Mud and fill (M&F). Ground shaking is strongly increased; this type is prone to ground failure including liquefaction.

Figure 2.3 shows the 41 fires and their locations in reference to these four soil types.

The earthquake shock transmitted to the areas with unconsolidated soil and mud and fill is expected to be strongly amplified; whereas, the shock in unstable bedrock is only slightly amplified and in stable bedrock is not

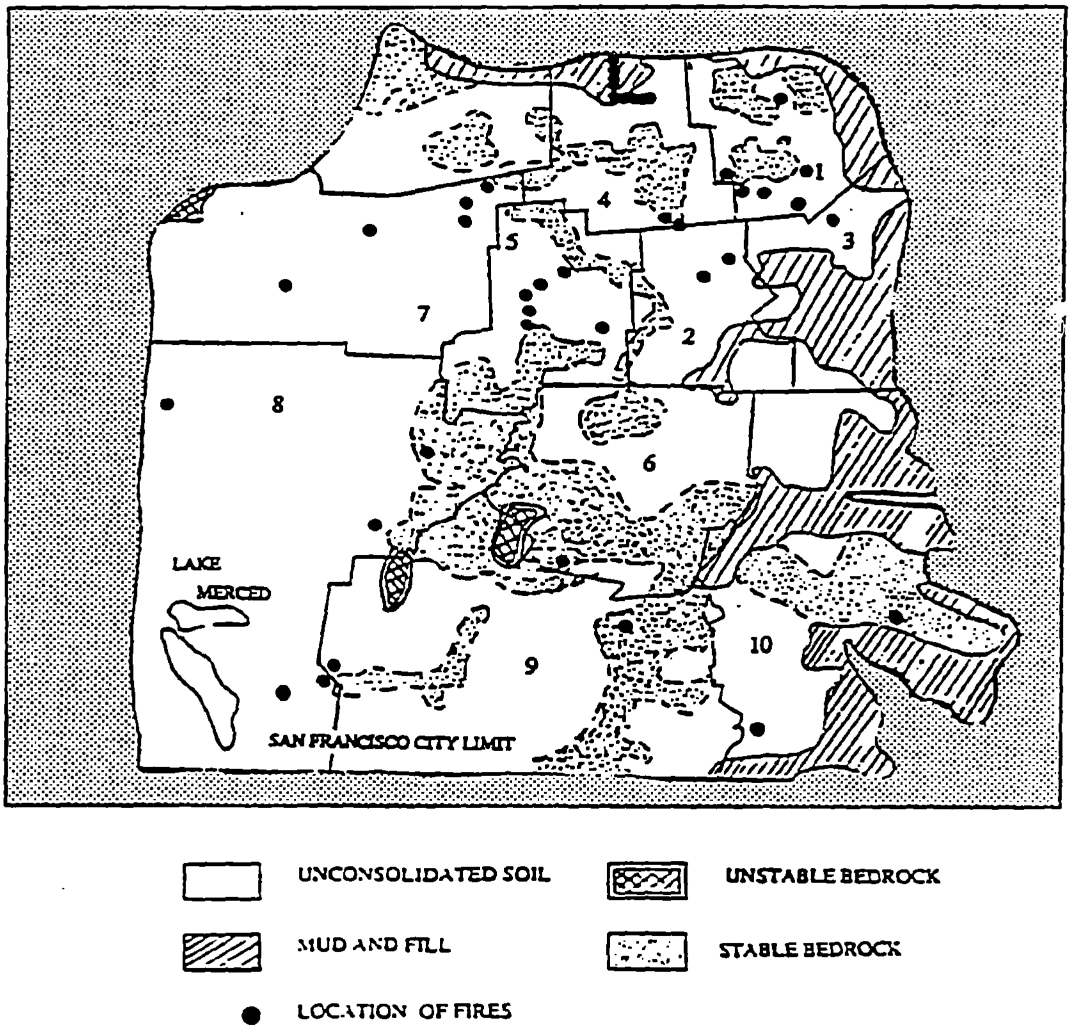


Figure 2.3. Various Soil Types in San Francisco

amplified. Accordingly, because of a greater potential for building and lifelines damage in areas with unconsolidated soil or mud and fill, more number of fires are expected in these areas. An investigation of the 41 reported fires indicated that most fires (33 out of 41) occurred at sites on unconsolidated soil, 5 at sites on mud and fill, and the rest on stable bedrock. (see Table 2.6).

In regard to the large number of fires reported at sites on unconsolidated soil, the vastness of coverage of this soil type, compared with others, may be an important factor. Areas along the San Francisco Bay area are mainly mud and fill. However only a few fires were reported in these areas. This is attributed to the relatively less concentration of housing units (which means less population concentration) in these areas.

Significance of Population Density -- The city of San Francisco, excluding Presidio, has been divided into ten fire battalion districts by SFFD (see Fig. 2.4). Each district has been appointed mass care and casualty care facilities. At the time of the earthquake, San Francisco had 500 fire fighters. In response to a recall broadcast over radio and television, 651 members returned to duty to respond to emergency calls from all districts.

Using the ten districts as the basis for a geographical break down of the city, area, population, population density and the number of fires in each district are summarized in

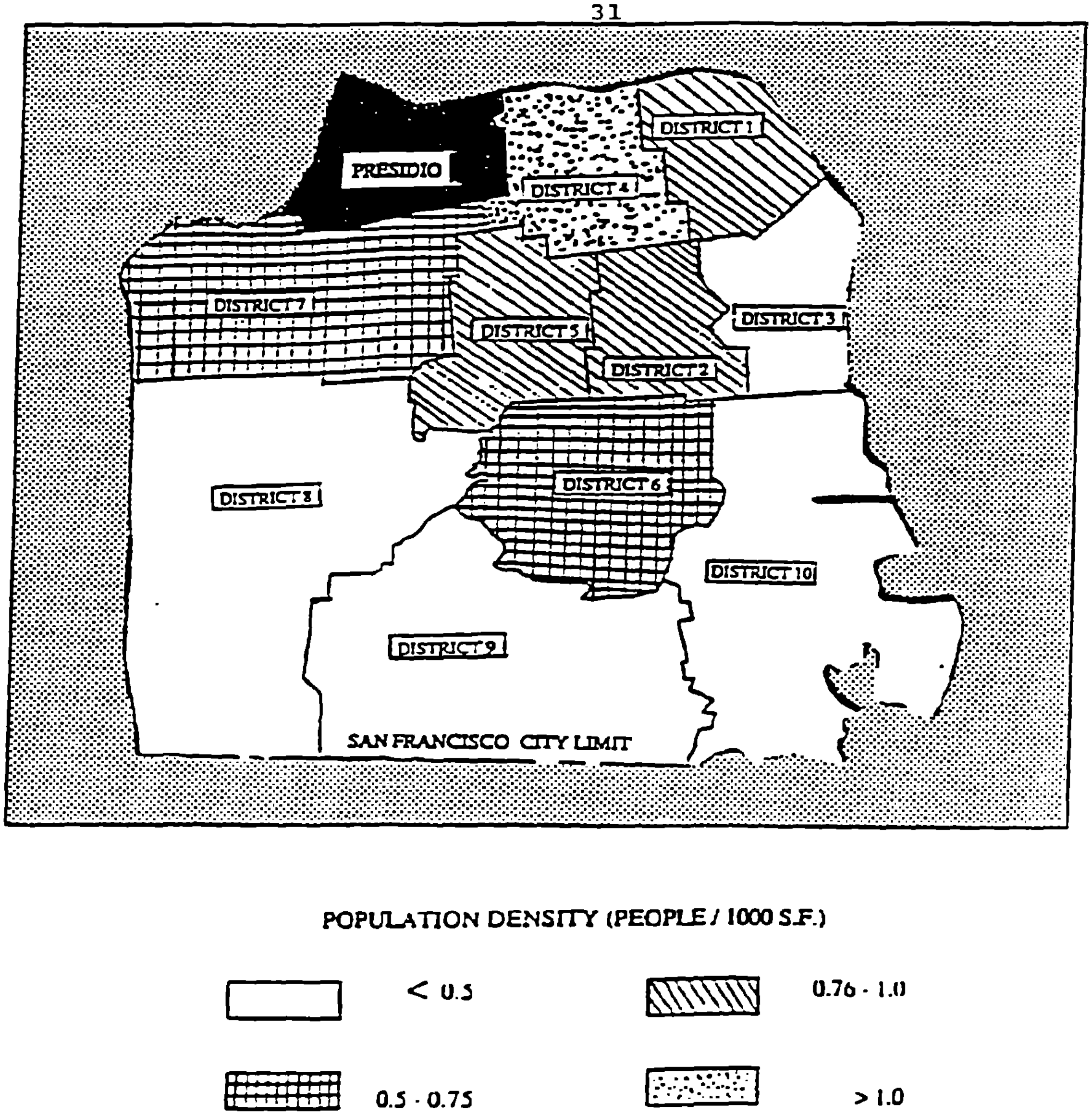


Figure 2.4. Population Density of San Francisco

Table 2.7. Reviewing the data in Table 2.7, it is observed that more fires occurred in Districts 1, 2, 4, 5, 7 and 8. Furthermore by examining Figures 2.3 and 2.4, it becomes evident that over 51% of fires occurred in Districts 1, 2, 4 and 5 covering 20% of the total area. These serve to point to the fact that the population density of an area is a major factor in the number of potential post-earthquake fires. With no other factor considered, a correlation coefficient r=0.65 between the number of fires and population density was obtained.

In order to incorporate both the type of soil and the population intensity in the analysis of fires, a "soil type index" is introduced. The index signifies the effect of soil type in magnifying the ground acceleration at a given site. First a numerical value ranging between 1 to 4 is assigned to each soil type. This numerical value will be referred to as the "amplification capability value." A value equal to 1 means no appreciable amplification of ground acceleration occurs; whereas, a value of 4 indicates that a strong amplification is possible and expected. Within each district, surface areas covering each of the four types of soils are measured and multiplied by their respective amplification capability values (1 to 4) and summed up. The soil type index for the district is an average value obtained by dividing the sum by the total coverage area of the district. The results appear in Table 2.8. For all indices greater than 2.7 (this value is used as a cut-off), a multiple correlation analysis

Table 2.7 Number of Fires vs Population per District in San Francisco

Dist.	Area (Sq mile)	Population	Population Density*	No. of Fires
1	2.568	64,000	0.894	6
2	2.202	53,000	0.863	3
3	2.652	23,000	0.311	1
4	2.594	77,000	1.064	10
5	2.826	70,000	0.889	6
6	4.335	90,000	0.745	1
7	5.440	80,000	0.527	5
8	11.176	103,000	0.331	5
9	8.291	78,000	0.337	2
10	8.024	77,000	0.344	2

*Per 1,000 Sq. feet

Table 2.8 Soil-Type Index vs Number of Fires in San Francisco

Dist	Coverage Area of Soil Types* SB	USB	US	M&F	Soil-Type Index	No. of Fires
1	.85	0	1.24	.68	2.833	6
2	.13	0	1.82	.25	2.995	3
3	0	0	1.22	1.43	3.539	1
4	.55	0	1.72	.33	2.707	10
5	.90	0	1.92	0	2.362	6
6	.70	2.27	1.97	.03	2.604	1
7	.04	.09	5.32	0	2.971	5
8	.97	.02	10.19	0	2.825	5
9	2.59	.25	5.45	0	2.344	2
10	1.68	0	2.69	3.66	3.037	2

*Coverage in Sq. miles

Amplification Capability Factor =1 for SB
=2 for USB
=3 for US
=4 for M&F

between the number of fires, soil type index and population density indicates r=0.87. This emphasizes the significance of the combined soil type and population density in number of fires. The importance of these factors in earthquake preparedness and development of appropriate post-earthquake fire risk maps is explained later.

2.6 Fires in Other Areas

Aside from San Francisco, fires were also reported in Berkeley, Santa Cruz, Santa Clara and Watsonville. Berkeley had a major fire in an auto-service building. The fire started from the ignition of spilled solvents and required the response of the entire fire department (FEMA 1991).

Santa Cruz County had a total of 20 fires. The City of Santa Cruz had only one residential structure destroyed by fire. At the time of the fire department arrival, the structure was fully involved. The cause of this fire is reported as a main gas leak. Furthermore, a wildfire at Niesene Marks State Park in Santa Cruz was reported to have started due to the earthquake. The California Department of Forestry and Fire Protection responded to this fire, limiting it to 50 acres in a major effort involving engines crews and aircraft (FEMA 1991).

In Watsonville, one single-family dwelling and two mobile homes were destroyed due to fire. Difficulty due to broken water mains was also reported in Watsonville.

In Santa Clara County, a residential fire was reported. This fire started due to a ruptured propane tank. The community also lost its water distribution system. The water had to be provided from the community swimming pool.

2.7 Concluding Remarks

Although the number of fires were rather small considering the relatively large magnitude and intensity of this earthquake, nevertheless fire was considered to be a major problem especially in San Francisco. Furthermore, fires following the Loma Prieta Earthquake did confirm that:

- There is a potential for casualty and property loss due to post-earthquake fires,
- There exists a risk associated with residential fires following a major earthquake, and
- An effort should be devoted to estimate this risk and plan for risk mitigation.

A large number of reported fires were initiated at residential buildings. These fires required a major fire fighting effort at a time that the fire department personnel were much needed for rescue efforts involving other earthquake-related incidents. In some cases (e.g., Berkeley) the fire required the response of the entire fire department. It is also noted that water needed for fire fighting activity was not easily available due to broken water mains and low water pressures. For example in the Marina District, loss of pressure was especially critical. Damage to the municipal water supply system in the Marina District cut off alternative sources of pipeline water and caused delay in fire fighting activities. This clearly indicates that any effort to mitigate the risk of such future fires should not be limited to development of estimates for the probability of fire but should also consider the availability of alternative sources that can quickly be utilized to detain a potential fire. This becomes especially critical at populated areas. One major consideration is to identify alternative sources to obtain water needed for fire fighting activities.

An investigation of cause of fires following the Loma Prieta earthquake revealed a variety of reasons that can cause fire after any future earthquake. As such, development of a systematic analytical approach to estimate the risk of fire following a probable earthquake becomes quite complicated. At best, any attempt to develop methods to estimate the risk can only include a limited number of fire causes. Analytical methods to estimate the probability of fire for such causes as leaks in gas distribution systems, failure of gas appliances, and electrical distribution system problems can be developed only within certain limitations. In most cases, such analytical methods need to be complemented by historic data from past occurrences or judgmental data obtained from experts. Although such models may only cover a portion of all causes, they are, nevertheless, helpful to identify the magnitude of the risk involved in post-earthquake fires. Such models are especially helpful in investigation of effectiveness of pre-earthquake planning risk mitigation. For example, the effectiveness of securing water heaters to walls using straps can be evaluated in terms of the reduction in the probability of overturning or sliding.

Chapter III

SEQUENCE OF EVENTS IN POST-EARTHQUAKE FIRES

3.1 Introductory Remarks

A systematic formulation of the sequence of events that lead to a post-earthquake fire is only possible by adopting certain assumptions, approximations and restrictions. This is due mainly to the variety of factors that contribute to post-earthquake fires. An investigation of causes of fire in several past earthquakes and especially in the 1989 Loma Prieta earthquake (see Chapter II) reveals the following reasons for fires:

- Electrical distribution system problems such as friction wear of cables and cords, loose connections, etc.
- Gas leaks due to pipe failure, sliding, or overturning of gas-fired appliances mainly water heaters.
- Flammable materials spills.
- Overturning of burning candles, table lamps, gas grills, etc.

Although these causes seem to be reasonably well-defined and easy to model, in reality each post-earthquake fire represents a unique event following a series of other events that are very much dependent upon the surrounding environment and existing circumstances. A somewhat generic approach in modeling the sequence of events in a post earthquake fire can be done only with certain limitations and approximations. Even so, the modeling cannot be accurately performed for such casual causes as, for example, flammable materials spills, overturning of burning candles, and burning cigarettes discarded by people in the state of panic. For more systematic causes, such as gas leaks and electrical problems in distribution systems, the modeling is more straightforward and involves activation of specific events that can be modeled using an event tress analysis (Ang and Tang, 1984). In the following sections, the sequence of events in the case of gas- and electric-related fires is explained. Event tree models are presented in terms of events that lead to a fire. The probabilities of these events is described in Chapter IV. Quantification of estimates for the risk of fire are obtained and presented in Chapter V.

3.2 <u>Sequence of Events in Gas-Related Fires</u>

The chain of events that may lead to a gas-related fire is summarized below:

- Following an earthquake, overstress in the piping system components or an overturning or sliding of an appliance (water heater) occurs.
- Leak develops.
- Leak is undetected; and gas is accumulated in an enclosed area.
- Gas density in the air reaches an ignitable level.
- An ignition sources is activated.

This chain of events often stops at the fourth or fifth level. In a dwelling equipped with an automatic seismic shut-off valve, the above chain of events can practically stop at the second level. It is also noted that if the house is equipped with a sprinkler system, the above sequence of events may stop short of a fire. If a right condition persists and the above chain of events is followed to the end without any interruption, a fire will develop. The right condition means development of a leak in an area susceptible to gas accumulation and fire. An investigation into the 1987 Whittier Narrows earthquake (Schiff, 1988) revealed that about 75% of gas leaks occurred at appliances (primarily at water heaters). Similar results were also noted after the San Fernando earthquake of 1971. Water heaters are normally installed in basements, garages and enclosed areas where potential combustible materials (old furniture, papers, gasoline cans, etc.) are stored. The fact that a greater percentage of leaks occur at water heaters suggests that certain precautions (e.g., using straps to secure heaters). can be helpful in mitigating the risk.

A graphic presentation of the chain of events that may lead to a gas-related fire following a probable earthquake is given in Fig. 3.1 using the "event tree" scheme. It is assumed that there is no sprinkler system in the house. This, of course, will lead to more conservative probability estimates for post-earthquake fires. The starting event (A) is an earthquake of a given intensity (in terms of MMI or ground acceleration). This is followed by various levels of "follow-up" events which ultimately lead to a fire. Within

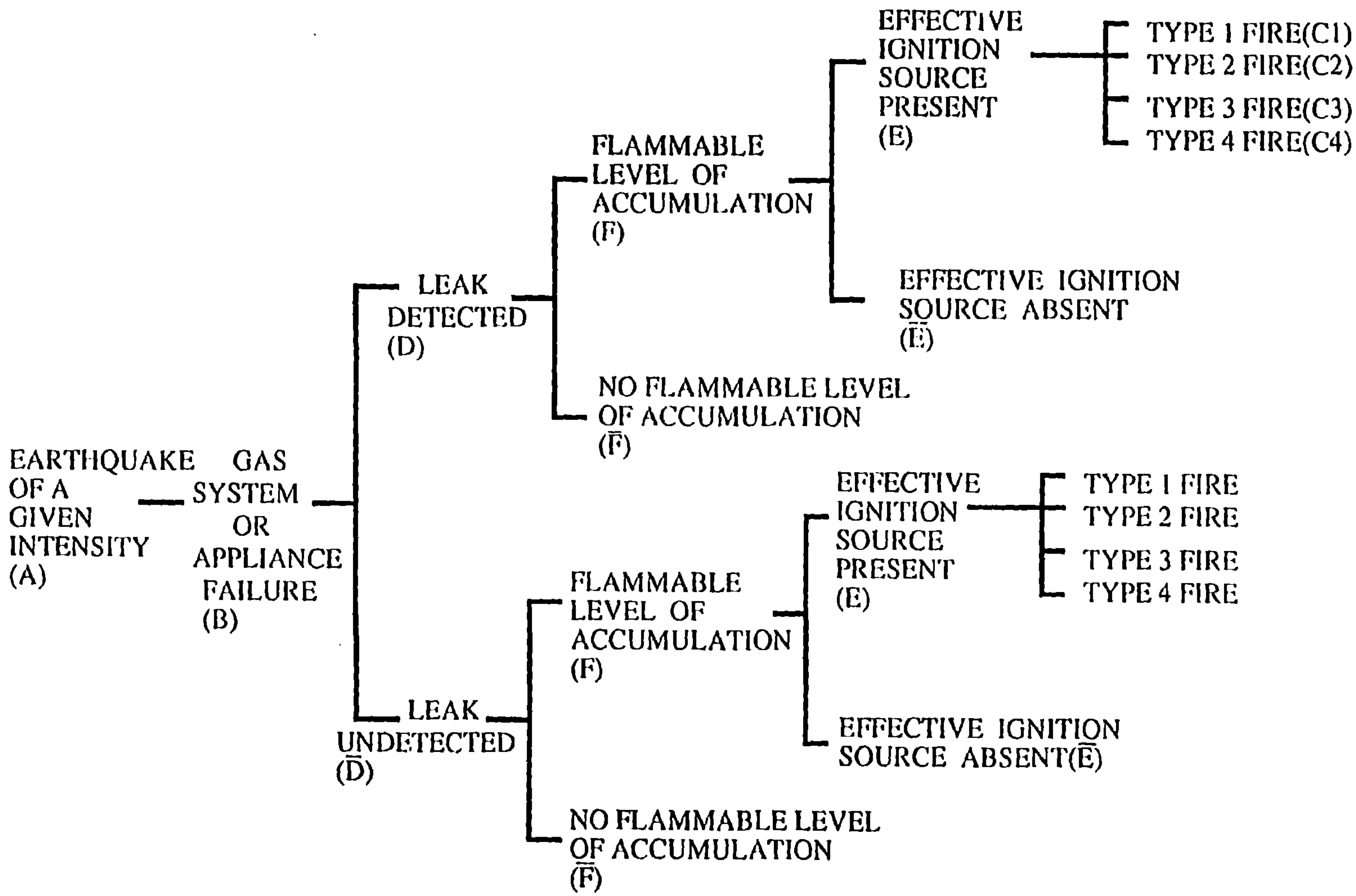


Figure 3.1. Sequence of Events in a Gas-Related Fire

each group of follow-up events, two or more mutually exclusive and collectively exhaustive events appear in the tree. Immediately following the earthquake, there may be leaks in the system (Event B). This can be the result of piping system and/or appliance failure (failure means over stress in piping system components or overturning/sliding of an appliance). The next level contains events D and $\bar{D}$ ($\bar{D}$ is the complementary event of D). These events represent leak being detected or remained undetected, respectively. The sequence is then continued at next level which contains the event of having an ignition source active in the area (Event E). Upon occurrence of E, there will be a fire.

Four types of fires are designated as C_1, C_2, C_3 and C_4 which represent the "consequences" in the tree. The description of each type of fire is explained below:

Type 1 Fire spreads only into the immediate area around its point of origin.

Type 2 Fire catches on to a combustible material in the room of origin, spreads all over the room; however, it is only confined to the room of origin.

Type 3 Fire catches on to a combustible material in the room of origin, spreads all over the room and throughout the building.

Type 4 This is a Type 3 fire that also spreads to the adjacent buildings.

Development of a specific type of fire among the four types described above depends on the location of the fire, availability of combustible materials in the area where fire starts and fire fighting efforts. Types 3 and 4 are much less expected than Types 1 and 2 mainly due to quick response time by fire departments.

The probability of occurrence of the consequences (i.e., fires) in the tree of Fig. 3.1 can be obtained using the conditional probability formulation (Ang and Tang, 1984). For a consequence such as C_i (i=1,2,3,4), the probability $P(C_i)$ is written as follows:

$$P(C_i)=P(C_i|E)P(E|D)P(D|B)P(B|A)P(A) \quad (3.1a)$$

if leak is detected.

$$P(C_i)=P(C_i|E)P(E|F)P(F|\bar{D})P(\bar{D}|B)P(B|A)P(A) \quad (3.1b)$$

if leak is not detected.

It is noted that events $\bar{B}$, $\bar{E}$ and $\bar{F}$ do not participate in the sequence of fire development. The two $P(C_i)$'s are then added, to consider the fact that there are two possible branches leading to a fire. Furthermore, it is emphasized that the tree in Fig. 3.1 is only intended to show the flow of events. A conditional probability in Eqs. 3.1 describes the occurrence of an event followed by another event. This means the two events may not necessarily be dependent. Thus the term "conditional" as used here only describes the order of events in the tree as this is needed to lead to a fire.

Estimation of $P(C_i)$ requires that all probabilities involved in Eqs. 3.1 be quantified. Mathematical modeling can be employed to quantify some of these probabilities. For example, as described in Chapter IV, an appliance failure probability can be estimated by modeling the motion of the appliance subjected to a known earthquake record (e.g., the 1989 Loma Prieta earthquake record) and investigating the possibilities of overturning or sliding. The probability of an earthquake of a given intensity (Event A in the tree), can be obtained using one of several available seismic risk analysis models (e.g., Cornell, 1968; Derkiureghian and Ang, 1977; Mohammadi and Suen, 1991).

In case where mathematical modeling are not possible, the needed probability values can be obtained by extrapolating available data that are used for representing ordinary (i.e., non-earthquake) conditions. The probability of leak development in interior piping systems under normal operative conditions has been established by Longinow, et al (1989). An earthquake can increase this probability in the sense that it will trigger certain parameters that are known to be effective in promoting leak in a piping system. One such factor is the stress generated at joints and fittings in the system. The extrapolation of probability of leak in the system accounting for the earthquake effect can be done based on the stress level induced in piping system components. This is explained in Chapter IV.

3.3 Sequence of Events in an Electric Fire

Current research results indicate that there are numerous causes for fires initiated in electrical distribution systems and/or electric appliances operating under normal (i.e., non-earthquake) conditions. Potential fire causes, among others, are ground fault, improper installation, equipment overload, loose connections, worn-out wires and electrical components, etc. Smith and McCoskry (1990) report on causes of fires in electrical distributions system in residential units. A typical electrical distribution system constitutes the following components:

- Branch circuit wiring
- Receptacle outlet and switches
- Cords and plugs
- Fixtures and lamps
- Transformers

A detailed description of distribution of electric fires among these components and various categories of fire causes as summarized by the Fire Protection Handbook published by the National Fire Protection Association, NFPA (1986) is presented in Chapter IV. In the event of an earthquake, the electrical distribution system is especially critical because the ground shaking can trigger displacements of electrical components and friction of wiring and cords against each other. Such phenomena will increase the risk of fire. However, development of a comprehensive model for the behavior of an electrical distribution system as a means to estimate the risk of fire is quite challenging. The probability of fire development depends on a variety of factors including the design of the system, the age of the electric components, installation practice, existence of faulty wiring, overloaded components, etc. In this section, the sequence of events that may lead to an electric fire is explained. The risk of fire due to an earthquake is estimated by extrapolating the risk representing the ordinary (non-seismic) condition as described in Chapter IV.

The sequence of events in an electric fire is shown in the event tree of Fig. 3.2. The tree is intended to demonstrate the role of key parameters that may accelerate the risk of fire when an earthquake occurs. As seen in Fig. 3.2, upon occurrence of an earthquake of given intensity (Event A), the first follow-up event is designated as development of a disturbance in the electrical distribution system (Event B). The disturbance comprises the occurrence of one or more of the following events:

- Excessive friction in electrical wires and cords with one another especially at joints, connections, receptacles and switches.
- Electrical shorts at connections and joints due to severe structural vibrations.
- Electrical problems arising from swinging lamps and other suspended fixtures.
- Electrical problems and overload at extension cords, cables, and receptacles due to overturning and sliding of electric appliances and equipment.

Generally, upon occurrence of one or more of these disturbances, the risk of fire is expected to increase. The extent to which the risk increases depends primarily on the

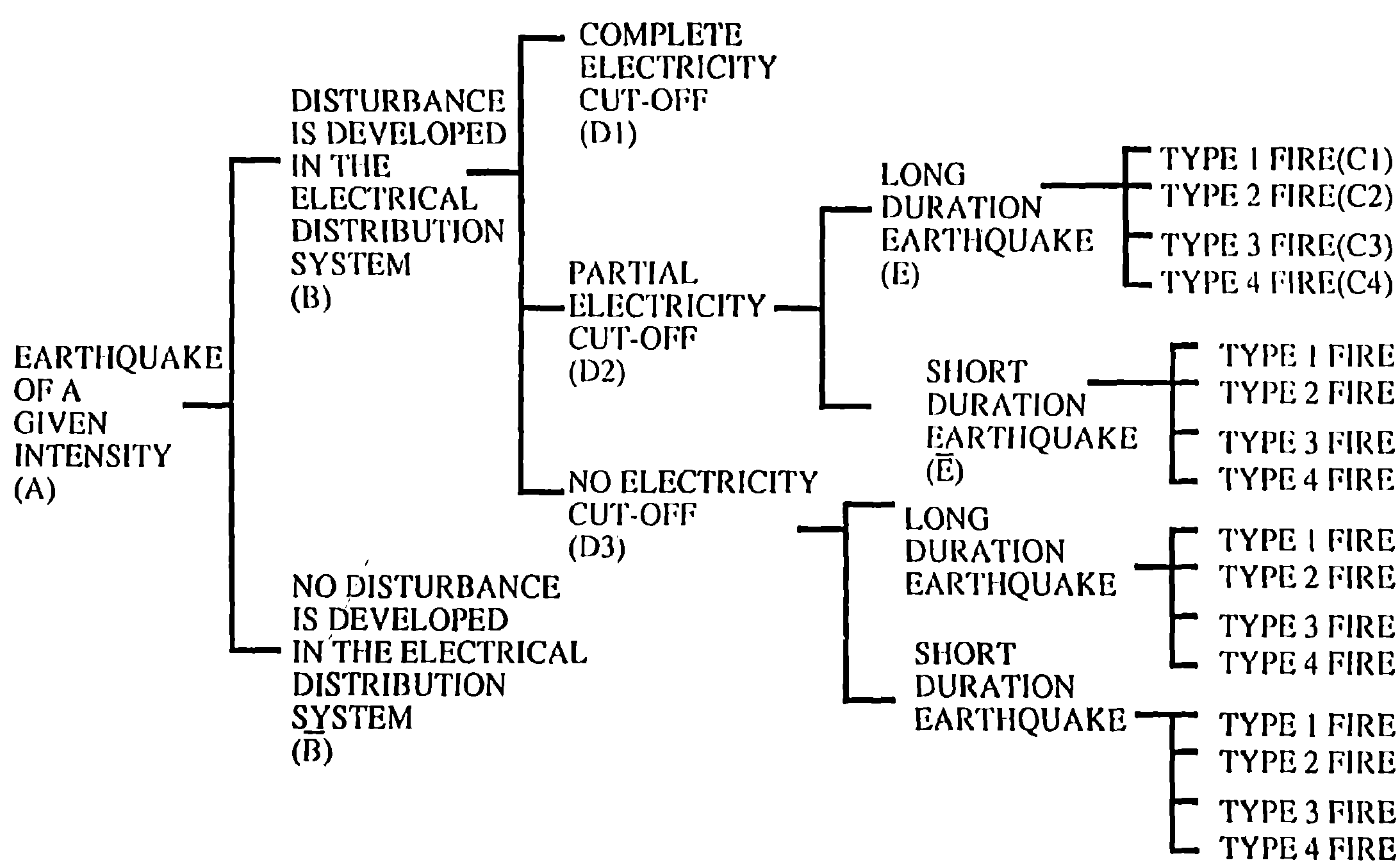


Figure 3.2. Sequence of Events in an Electrical Fire

intensity of the earthquake and the design and age of the electrical distribution system. The risk is also triggered by the follow-up events D_1, D_2, D_3, and E. Events D_1, D_2, and D_3 describe what can occur as a result of partial, full or no electricity cut-off due to either an internal control switch or the area black out. The former has a greater chance to occur. Event E (and its complementary) describe the effect of the duration of the ground shaking. The longer duration has a greater effect on development of an electric fire in the sense that it causes a longer exposure time for wires and cords to engage in friction and for swinging fixtures to get the momentum needed for them to develop an electrical problem.

The consequences are again fire types 1-4. The probability of a sequence C_i is obtained trough the following equations:

$$P(C_i)=P(C_i|E)P(E)+P(C_i|\bar{E})P(\bar{E}) \quad (3.2a)$$

$$P(E)=\Sigma_{j=1\text{-}3}P(E|D_j)P(D_j) \quad (3.2b)$$

$$P(D_j)=P(D_j|B)P(B|A)P(A) \qquad j=1,2,3 \quad (3.2c)$$

$$P(\bar{E})=1-P(E) \quad (3.2d)$$

Quantification of the risk in terms of P(A), P(B), ... is explained in the next chapter.

Again, it is emphasized that conservatively it is assumed that there is no sprinkler system installed in the house. Also it is noted that the conditional probability terms appeared in Eqs. 3.2 are only intended to describe the flow of events that are needed for a fire to occur.

CHAPTER IV

RISK QUANTIFICATION

In this chapter the risk of post-earthquake fires is estimated in terms of probabilities of various events appearing in the event trees of Figures 3.1 and 3.2. All calculations are performed for ground acceleration in the units of g. A correlation between g accelerations and intensity (MMI scale) is provided later in this Chapter (see Fig. 4.2).

4.1. Leak Probability of Gas System

An analytical approach to quantify the probability of leak in an interior gas distribution system is difficult to establish. This is mainly due to:

- Lack of adequate data on the performance of piping systems. Specifically, the data on the resistance capacity of individual piping system components and joints to leak development is scarce.
- Variety of factors (corrosion, bad installation practice, material defect, etc.) that influence leak development. In the event of an earthquake, the interaction of the dynamic force generated at a joint with these factors will increase the chance of leak development. However, the extent to which the risk may increase is not well known.

Moreover, most interior gas distribution piping systems are installed without any specific design for the effect of earthquake loadings. The geometry of the system is very much dependent on the type of structure and building plan. Thus the existence of varieties in the geometrical design of piping systems makes the development of a generic analytical modeling somewhat difficult.

Factors that contribute to leak development at a given joint were reported by Longinow, et al. (1989). These factors were identified through a comprehensive search in the literature, failure reports and expert opinion data. Among others, the following factors are especially notable.

- Poor workmanship
- Corrosion
- Tampering
- Material defect
- Pipe movement due to natural forces or due to reconstruction or remodeling

An expert opinion data acquisition technique was especially designed to obtain performance data for interior gas piping systems (Longinow et al., 1989; Mohammadi, et al, 1991). The expert opinion data revealed that "poor workmanship" has the greatest probability of causing a leak at a joint ($0.298x10^{-4}$ probability/year). The study by Longinow, et al. also established expert opinion data on the probability of leak development at various locations in a piping system. Table 4.1 summarizes these probabilities.

For a typical single family dwelling (with four bedrooms,

Table 4.1 Probability of Leak at Various Piping System Components

Components	Leak Probability (10^{-4})/year
Primary pipe	0.0303
Branch pipe	0.2097
Fitting	0.1232
Shut-off valve	0.0721
Appliance flexible connector	0.0968
Heater connector	0.0410
Threaded joint	0.1375
Welded joint	0.0037
Compression fitting	0.0470
Appliance regulator	0.0111
Service regulator	0.0071
Relief valve	0.0038

a living room, kitchen, basement and family room) the probability of leak was estimated to be 0.00132 per year. This was obtained using a fault tree analysis of the gas distribution system and the corresponding modes of failure (i.e., leak development at various gas system components).

The data presented in Table 4.1 shows the statistics of gas leak when the system is under normal conditions. Once an earthquake occurs, these probabilities will increase. The increase, of course, depends on the ground acceleration experienced by the piping system and the system interaction with the structure. An earthquake mainly causes an increase in the external load effect on the piping system components and makes the components more susceptible to leak development. However, the major question to be addressed is: "to what extent the leak probabilities will increase once an earthquake of, say, 0.20g or 0.30g occurs?" Since the leak data for different earthquake ground acceleration levels is not available, one method to quantify the risk of leak development due to an earthquake will be to augment the estimated values of Table 4.1 based on the level of force actions (bending, shear and axial force) and deflections developed at various piping system components; especially at joints, fittings, etc.). For this purpose, several piping system configurations as shown in Fig. 4.1 are considered and subjected to the Loma Prieta record. The record was adjusted to obtain different ground acceleration levels. The configurations depicted in Fig. 4.1 present portions of gas distribution systems mainly

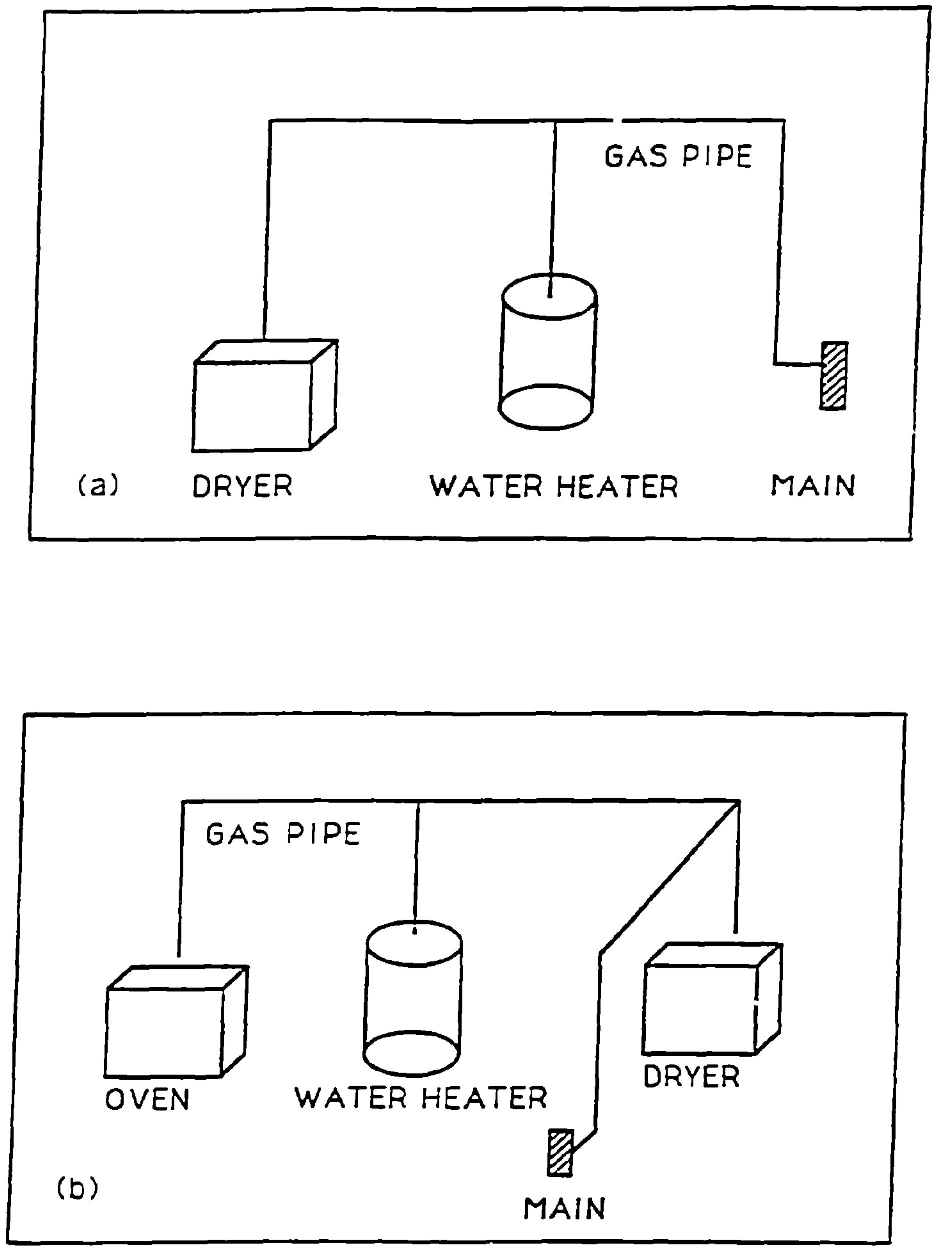


Figure 4.1. Interior Gas Piping System Configurations Used in the Dynamic Analyses

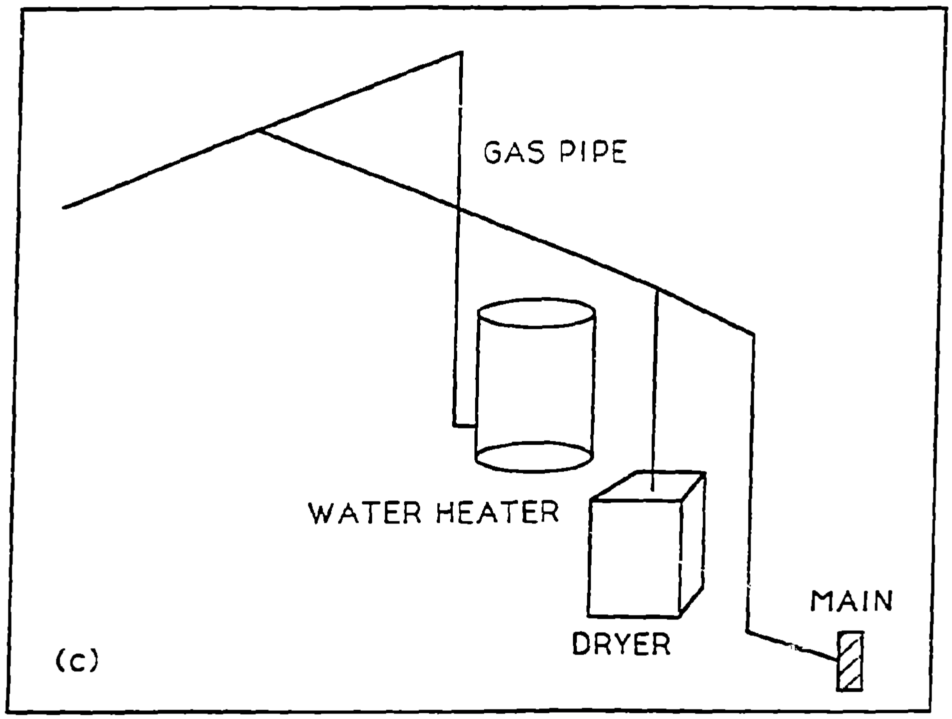


Figure 4.1. (Continued)

in the basements or garages where heaters are located in single family dwellings. In most cases, the piping system attachment to walls or structural elements is loose. Thus the piping system will experience the ground motion through the meter and gas main or through the basement retaining wall. This means that no appreciable dynamic interaction between the piping system and the structure will take place.

It is also noted that the probability estimates given in Table 4.1 are treated as "bench marks" representing risks in a normal condition. Since small earthquake intensity levels are not likely to dramatically change these probabilities, a lower bound intensity is used as a level below which these probabilities can be assumed unaffected. This lower bound earthquake level was determined to be V on the MMI scale and was decided upon by reviewing reports of earthquake damage evaluation for several past earthquakes.

At or below this level, the risk of gas leak development is practically unaffected by the earthquake and is the same as that summarized in Table 4.1.

The intensity V on the MMI scale translates into about 0.05g for most past California earthquakes. Figure 4.2 shows the variation of MMI versus ground acceleration levels. The ground motion attenuation equations reported by Donovan (1973) and Newmark and Rosenblueth (1971) were used to arrive at the MMI-acceleration variation depicted in Fig. 4.2.

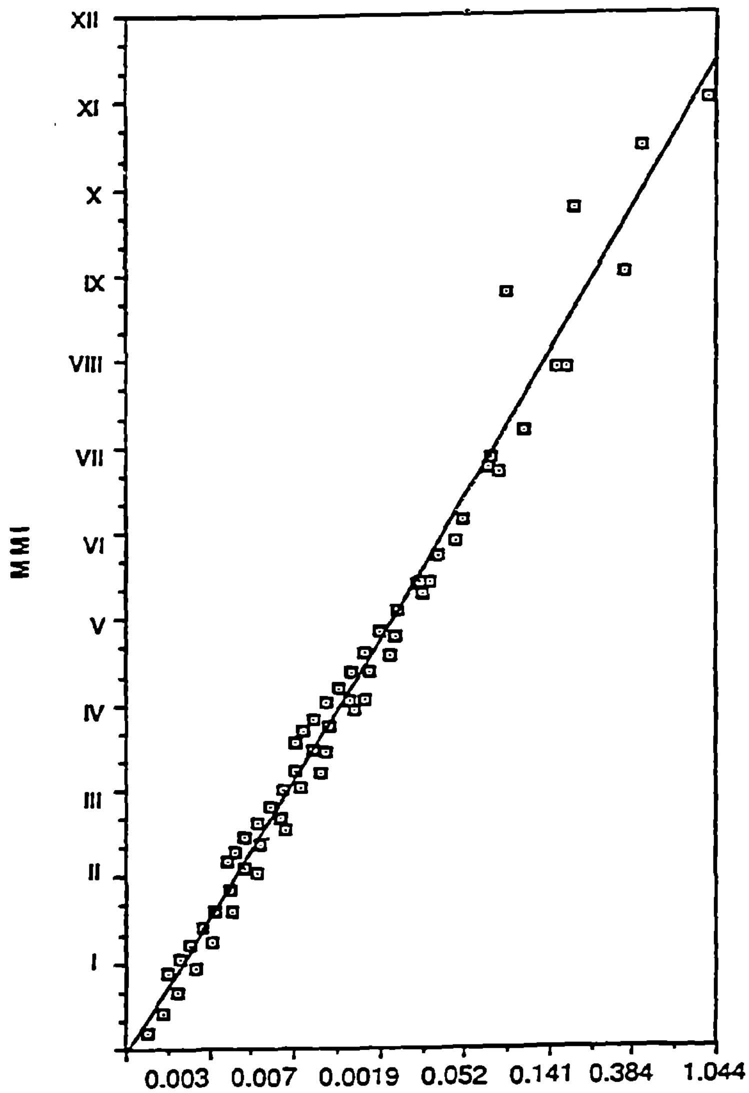


Figure 4.2. Modified Mercalli Intensity (MMI) vs. Ground acceleration in g's

4.1.1. Effect of Higher Acceleration on Risk of Leak in the Interior Gas Pipeline Systems

Table 4.2 summarizes the results of stresses developed at the most critical joint of systems in Fig. 4.1. The results are based on the Loma Prieta earthquake record adjusted for 1g acceleration. The record was applied in the longitudinal and transversal direction for each of the three structures in Fig.4.1 and the maximum stresses were then computed. Presented in Table 4.2 are also the maximum percentage of yield at the most critical joints. As seen in the table, under 1g application, the stresses are about 53% of yield. For the Loma Prieta record, this level is only exceeded for a few times. Thus it is concluded that the earthquake does not increase the risk of leak development in the gas piping system. The risk values presented in Table 4.1 are generally unaffected by the earthquake. An increase in the risk is however expected if a defect exists in the piping system especially at very high level accelerations that occur rarely.

4.2. Risk Associated with Appliance Failure

Failure in an appliance is defined, here, as overturning or sliding due to an earthquake. This means that once an appliance is dislodged or toppled, a leak will occur. The risk of failure for various types of appliances (water heaters) can then be obtained by modeling the movement of an appliance during an earthquake. Overturning will occur when

Table 4.2 Maximum Principle Stresses (psi) at Pipe Joints for 1g Normalized Record of the Loma Prieta Earthquake

System	σ_1	σ_2	Max % of Yield*
Fig 4.1 a	19180	2551	53
Fig 4.1 b	8801	1134	24
Fig 4.1 c	11300	1498	31

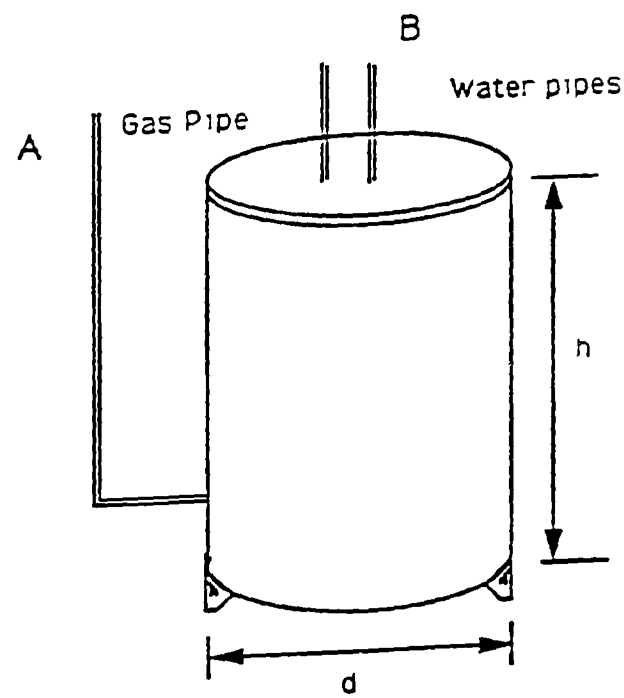
*Yield Stress=36000 psi
[Note] σ_1 and σ_2 are principal stresses for the most critical stress condition.

the appliance loses its stability. If the appliance is secured to the wall by means of metal straps, the probability of overturning greatly reduces. In this case, the possibility for overturning exists practically only when the straps are not adequately attached to studs in the wall. The metal straps may fail (separated from the wall) due to a weak or missing screw. The formulation of overturning for both cases of appliance with and without straps is explained next.

4.2.1 Appliance Without Straps

The possibility of overturning depends primarily on the geometry of the appliance, its connections to the gas and water lines and, of course, the ground motion acceleration experienced by the appliance. Figure 4.3 shows four types of water heaters which are widely used in apartments and single family dwellings. The information on these heaters was obtained through retailers distributing water heaters to consumers. Several other types are also available. However, the four types depicted in Fig. 4.3 (designated as Type A, B, C and D) were used in the analysis due to their popularity.

In a generic form, an appliance (water heater) is similar to that shown in Fig. 4.4a. As shown in Fig. 4.4a, the pipe gas connection is a short link attached to a vertical pipe (riser) which, in turn, is connected to the piping system overhead. Water lines are generally directly connected to the heater from the top. For the purpose of stability analysis, the appliance in Fig. 4.4a is modeled with the dynamic system



Heater Type	Capacity (GAL.)	Dimensions (in)	Net Wt. (lbs)
A	30	16*57.5	131
B	40	18*59.25	151
C	50	20*58.5	173
D	65	22*59.25	211

Figure 4.3. Four Typical Water Heaters Used in Single Family Dwellings

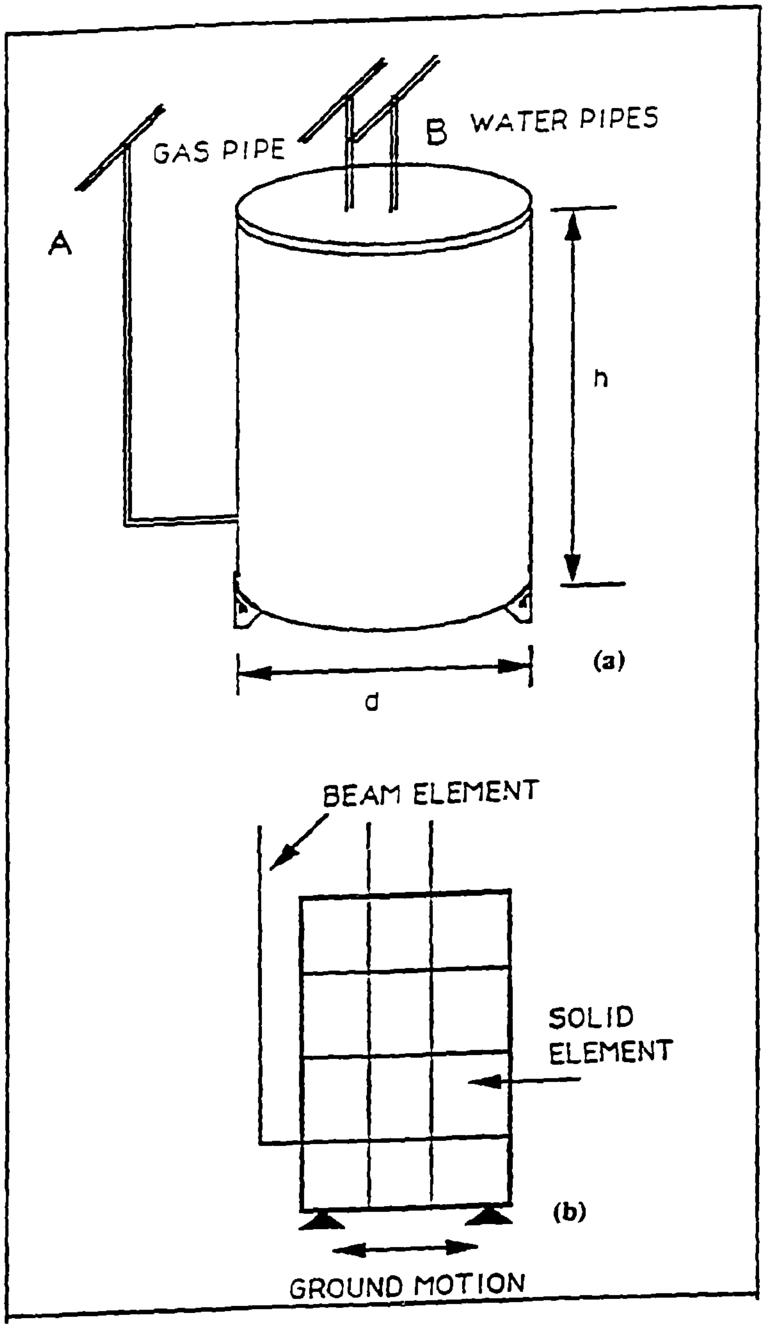


Figure 4.4. Unstrapped Water Heater, (a) Typical Water Heater, (b) Idealization for Dynamic Analysis, (c) Failure Paths

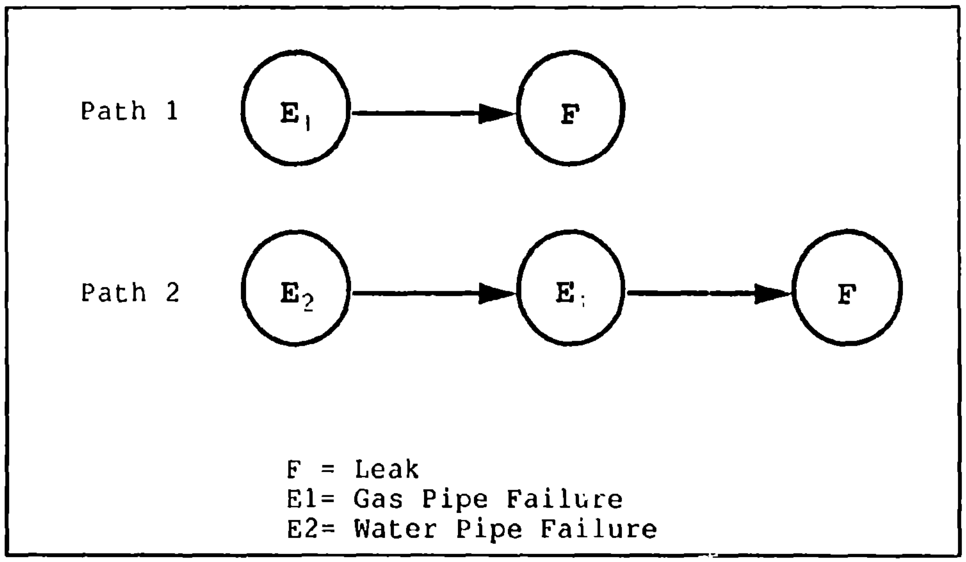


Figure 4.4 (continued)

depicted in Fig. 4.4b. The idealized model is made of solid elements (representing the appliance) and beam elements representing the pipes.

When an earthquake occurs, depending on the direction of the earthquake, severe bending and shear stresses can develop in gas and water pipes. In a worst case scenario, where the gas pipe is similar to that shown in Fig. 4.3, maximum stresses can develop at junction A of the gas pipe (see Fig 4.4a). Failure (gas leak) will occur when stresses exceed the joint resistance.

Maximum stresses develop at junctions A (of the gas pipe) and/or B (of the water pipes). The sequence of failure and the two possible failure paths are shown in Fig. 4.4c. If the probability of failure through paths 1 and 2 is represented by fp_1 and fp_2, one can respectively write:

$$fp_1=P(E_1) \tag{4.1a}$$

$$fp_2=P(E_1|E_2)P(E_2) \tag{4.1b}$$

in which E_1=event of overstress in the gas pipe, E_2=event of over stress in the water pipes and $E_1|E_2$= conditional event of E_1 given E_2. It is noted that once E_2 occurs, the distribution of stresses will change, and as a result, $P(E_1|E_2)$ may greatly increase. The computation of probabilities in Eq. 4.1 depends on the stresses developed in the pipes. Adapting the Tresca yield theory (Popov, 1968), if principal stresses at a critical location are σ_1 and σ_2, failure will occur according to the following criteria:

$$\sigma_1 - \sigma_2 = F_y \tag{4.2a}$$

$\sigma_1 = F_y$ (4.2b)

$\sigma_2 = F_y$ (4.2c)

in which F_y = yield strength of the material.

Based on the criteria in Eq. 4.2, $P(E_1)$ is:

$$P(E_1)=max[P(\sigma_1-\sigma_2>F_y);\ P(\sigma_1>F_y);\ P(\sigma_2>F_y)] \quad (4.3)$$

In deriving Eq. 4.3, it is assumed that the three events are highly correlated. This is a reasonable assumption in the sense that all three relations in Eq. 4.3 contain common parameters. Furthermore, σ_1 and σ_2 are affected by the same cause (i.e. ground acceleration) that make them highly correlated. Similar equations can also be written for $P(E_2)$ and $P(E_1|E_2)$.

In evaluating the probability terms in Eq. 4.3, principal stresses σ_1 and σ_2 and the yield strength F_y are treated as random variables. Randomness in the stresses is due to:

- Variation in workmanship and method of construction of the joint. This will be reflected in the stiffness of the piping system which in turn affects the stress results.
- Variation in pipe dimensions due to initial imperfection, corrosion, wear, etc.
- Variation in material properties.
- Variation in the method of stress analysis.

These variabilities result in uncertainty in the stress values obtained through analysis. If nominal stress values are denoted as $\sigma_1^{(n)}$ and $\sigma_2^{(n)}$, the random stresses σ_1 and σ_2 will then be written as:

$$\sigma_1=C_1\sigma_1^{(n)} \tag{4.4a}$$

$$\sigma_2=C_1\sigma_2^{(n)} \tag{4.4b}$$

in which C_1 (a random variable) is a correction factor that incorporates the aforementioned variations.

To precisely quantify the mean and standard deviation of C_1 is a challenging task. With the exception of variation in the material properties, the variability associated with the other factors has not been well studied. If there is no bias in C_1, its mean will be 1. The uncertainty in C_1 will then appear in the form of a coefficient of variation (COV) that includes all various levels of uncertainties resulting from the factors cited earlier (Ang and Cornell, 1974). Since the nominal stress values are deterministic, the COV of stress σ_1 and σ_2 is then equal to that in C_1.

The resistance of the joint(i.e., F_y) depends on the material yield strength, the threads resistance against overstress, the type of joint (elbow, tee, straight fitting), workmanship, etc. Specific data on the resistance of a joint with considerations for these factors is not available. Ideally, the joint resistance can be written as:

$$F_y=C_2F_y^{(n)} \tag{4.5}$$

in which $F_y^{(n)}$=nominal yield capacity of the pipe and C_2=a random variable that takes into account all possible factors that may influence the resistance of the joint. With proper workmanship and under idealized conditions, the mean value of C_2 is expected to be equal to 1 (i.e., $\bar{C}_2$=1). However, generally, $\bar{C}_2\leq1$ when a large variation in expected in C_2.

The probability terms in Eq. 4.3 can be formulated in terms of the mean and COV of the stresses and F_y. For example, for $P(\sigma_1-\sigma_2>F_y)$, the formulation is as follows:

Let $Z=F_y-(\sigma_1-\sigma_2)$, then $P(\sigma_1-\sigma_2>F_y)=P(Z\leq 0)$ and

$$\overline{Z}=\overline{F}_y-(\overline{\sigma}_1-\overline{\sigma}_2) \tag{4.6}$$

and

$$S_Z=[S^2_F+(S^2_1+S^2_2+2S_1S_2\rho)]^{1/2} \tag{4.7}$$

in which bar indicates the mean value, S_Z=standard deviation of Z, S_F=standard deviation of F_y and S_1 and S_2=standard deviation of σ_1 and σ_2, respectively (Ang and Tang, 1975). Parameter ρ is the correlation coefficient between σ_1 and σ_2 (ρ=1 is used here). Using a normal probability distribution for Z,

$$P(Z\leq 0)=1-\Phi(\overline{Z}/S_Z) \tag{4.8}$$

in which Φ is the normal probability distribution function (Ang and Tang, 1975).

Similar equations for $P(\sigma_1>F_y)$ and $P(\sigma_2>F_y)$ can also be obtained.

The four types of water heaters (see Fig. 4.3) were analyzed for the acceleration record of the 1989 Loma Prieta earthquake. The analysis was conducted for the following two cases:

- Gas pipe fails first (i.e., Event E_1 occurs)
- Water pipes fail first, then gas pipe fails (Events E_2 occurs followed by E_1)

Table 4.3 summarizes stress σ_1 for 0.1g amplitude ($\sigma_2\approx 0$). As seen in Table 4.3, for Types C and D heaters, failure of water

Table 4.3 Values of Stress σ_1 (psi) for 0.1g Amplitude

Heater	All Pipes intact	Water Pipes Failed
A	16,554	26,031
B	10,006	33,187
C	26,916	*
D	37,936	*

*Failure of water pipes will cause instability in heater and lead to failure of gas pipe also.

pipes causes instability in the heaters and thus leads to gas pipe failure. Using various amplitudes for the Loma Prieta record, the stresses σ_1 and σ_2 were obtained and used in Eqs. 4.3 and 4.8 to compute pf_1 and pf_2. In calculating the mean stresses, the COV in C_1 and C_2 were taken as 0.2 and 0.1, respectively. The probability results appear in Table 4.4. The probability of failure (P_F) of a heater (i.e., gas leak) is obtained based on the failure probabilities of the individual paths as follows (Ang and Tang, 1984):

$$max(pf_1, pf_2) \le P_F \le 1-(1-pf_1)(1-pf_2) \qquad (4.9)$$

We have selected the upper bound value in Eq. 4.9 as a conservative estimate for P_F. The results are summarized in Table 4.5 and graphed in Fig. 4.5.

4.2.2 Appliance with Straps

When the appliance is secured to a wall, the probability of failure reduces substantially. Figure 4.6 shows a typical scenario in which a metal strap is used to protect a heater. In this case the failure of the strap and its fasteners (screws or nails) are critical to the overall probability of overturning or sliding of the heater. Once the strap fails, the appliance behaves as the unprotected system explained in Section 4.2.1. Thus the failure probability f_p is:

$$f_p = P(F_A|F_S)P(F_S) \qquad (4.10)$$

in which F_A=event describing the failure of appliance without a strap (as described in Section 4.2.1) and F_S=event

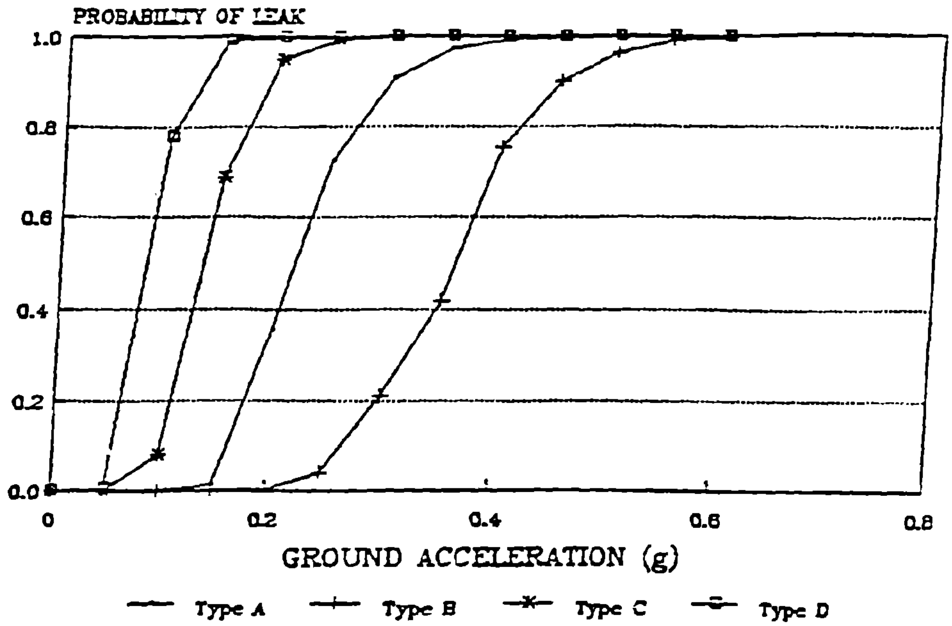


Figure 4.5. Leak Probabilities For Unstrapped Water Heaters

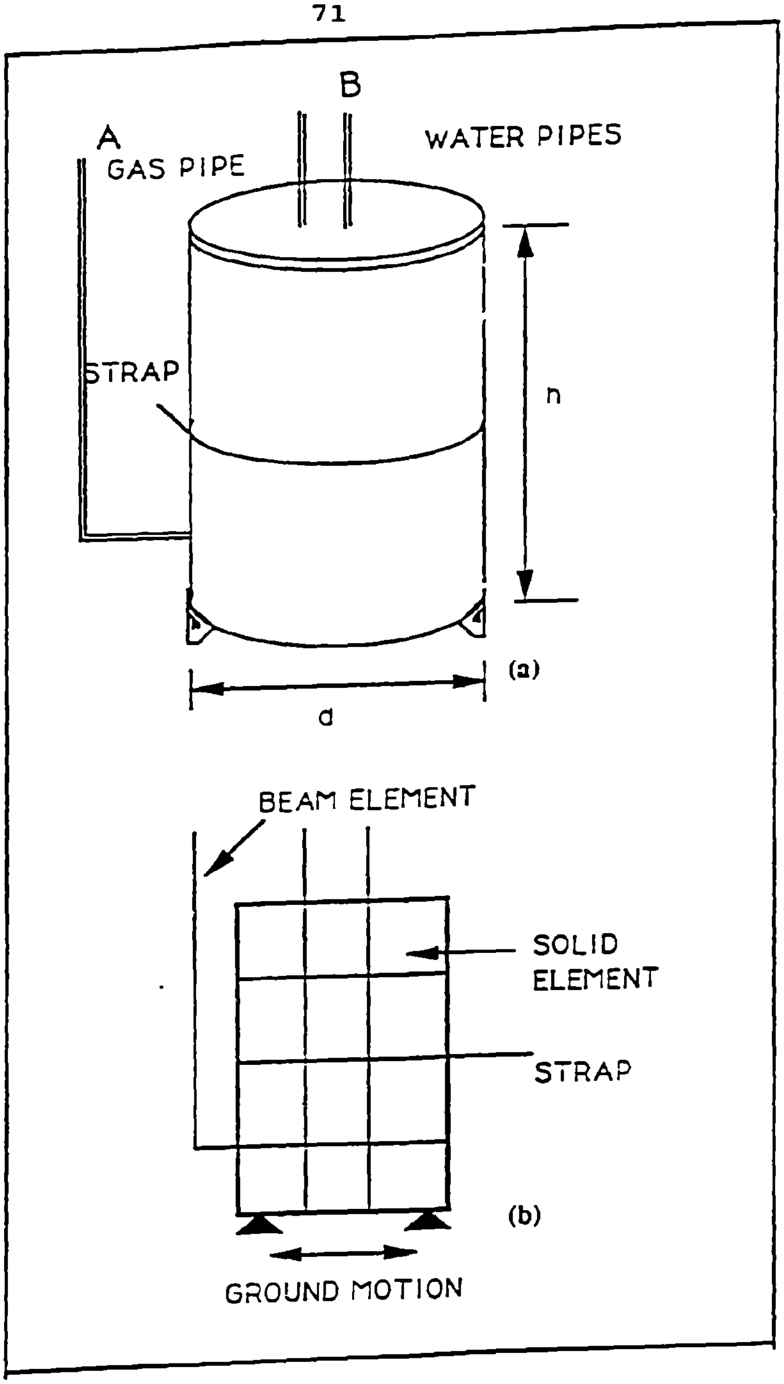


Figure 4.6. Strapped Water Heater, (a) Typical Water Heater, (b) Idealization for Dynamic Analysis

Table 4.4 Summary of Failure Probabilities pf_1 and pf_2

Peak Accel (g)	pf_1 A	pf_1 B	pf_1 C	pf_1 D	pf_2 A	pf_2 B	pf_2 C	pf_2 D
0.05	0	0	0	.001	0	0	0	0
0.10	0	0	.081	.591	0	0	0	.461
0.15	.012	0	.688	.942	0	0	.003	.903
0.20	.352	.002	.942	.995	0	0	.117	.986
0.25	.726	.038	.988	.999	.004	.001	.452	.997
0.30	.902	.198	.997	1	.049	.014	.745	1
0.35	.965	.363	1	1	.188	.084	.894	1
0.40	.986	.677	1	1	.405	.242	.955	1
0.45	.994	.824	1	1	1	.436	.981	1
0.50	.997	.907	1	1	1	.618	.991	1
0.55	1	.950	1	1	1	.758	.995	1
0.60	1	.973	1	1	1	.851	.997	1

Table 4.5 Summary of Leak Probabilities for Various Heaters

Peak Accel (g)	Leak Probability P_F A	B	C	D
0.05	0	0	0	.001
0.10	0	0	.081	.780
0.15	.012	0	.689	.994
0.20	.352	.002	.949	1
0.25	.726	.039	.993	1
0.30	.907	.209	.999	1
0.35	.972	.417	1	1
0.40	.992	.755	1	1
0.45	1	.901	1	1
0.50	1	.964	1	1
0.55	1	.989	1	1
0.60	1	.996	1	1

describing the failure of the strap. Simulation analyses are needed to quantify $P(F_S)$ as described below.

The event F_S is the key parameter in Eq. 4.10. Once the earthquake-generated force in the strap exceeds the resistance capacity of the strap, it will fail. Resistance capacity of the strap depends on:

- Fasteners holding force
- Strap metal yield capacity
- Strap metal tear capacity
- Fasteners shear or bearing capacity

Table 4.6 presents the capacity of a strap made of a 1x1/8 inch steel (A36) strap and 1/4-in. diameter screws. As seen in the table, the capacity is determined by the fastener pull-out force. This means that the strap size will not drastically affect the capacity. Furthermore, the various modes of failure summarized in Table 4.6 are expected to be highly correlated. Thus the smallest value (i.e., the pull-out capacity) will dominate any potential failure. The pull-out capacity is highly random and varies with the size and type of fastener, density and type of studs, workmanship, etc. The variation given in Table 4.6 is for specific gravity of stud material ranging between 33 to 44 PCF oven dry condition. Environmental conditions such as humidity and dampness can reduce the pull-out strength. On the other hand, the use of special cements and composites in drilled holes (which are made for fasteners) can increase the strength. The variability (coefficient of variation, COV) in the strength

Table 4.6 Capacity of the Strap

Mode of Failure	Capacity (lbs)
Fastener pull-out[1]	110-170
Metal yield[2]	2,700
Metal tear[2]	2,262
Fastener shear[2]	491
Metal Bearing[2] (at the fastener)	453

1 Information from Avalone and Baumeister (1978), Table 12.2.4.

2 Obtained based on strength formulas in Manual of Steel Construction, for gross and net areas of a bar subjected to tension (AISC-ASD, 1989).

due to material type is 0.58(167-110)/(167+110)=0.12 (based on a uniform distribution ranging between 110 to 167). Using a 0.25 COV for other uncertainties, the total COV (i.e., Ω_R) in pull-out strength is:

$\Omega_R=(0.12^2+0.25^2)^{1/2}=0.28$

The mean pull-out strength $\bar{R}=(167+110)/2=138.5$ lbs. If the force generated in the strap due to an earthquake of given acceleration is P, then

$$P(F_S)=P(R\leq P)=P(Z\leq 0)=1-\Phi(\bar{Z}/S_Z) \qquad (4.11)$$

in which R=random variable describing the resistance, Z=R-P, bar indicates mean, S=standard deviation, and Φ the normal probability distribution function.

$\bar{Z}=\bar{R}-\bar{P}$

$S_Z=(S_R{}^2+S_P{}^2)^{1/2}$

Furthermore,

$S_R=\Omega_R\bar{R}=0.28\bar{R}$ and $S_P=0.2\bar{P}$

in which 0.2 is the COV of the force in the strap. This is the same COV used in Section 4.2.1.

A series of simulation studies was conducted to determine the force P generated in the strap. The strap (see Fig. 4.6) was idealized as a loose link effective mainly to an axial load. Using the Loma Prieta earthquake record, the force in the strap and the corresponding probabilities of appliance failure are computed (from Eq. 4.10) and summarized in Tables 4.7 and 4.8. The failure probabilities are also graphically shown in Fig. 4.7.

Table 4.7 Probability of Failure of Strap

Acceleration (g)	Force in Strap (lbs)				$P(F_S)$			
	A	B	C	D	A	B	C	D
0.05	3.6	4.5	5.5	7.1	.0002	.0003	.0003	.0003
0.10	7.1	9.0	11.1	14.3	.0003	.0004	.0005	.0007
0.15	10.7	13.5	16.6	21.4	.0005	.0006	.0009	.0013
0.20	14.2	18.0	22.2	28.5	.0007	.0010	.0014	.0025
0.25	17.8	22.5	27.7	35.6	.0010	.0015	.0023	.0045
0.30	21.4	27.0	33.3	42.8	.0013	.0022	.0038	.0080
0.35	24.9	31.5	38.8	49.9	.0018	.0034	.0049	.0136
0.40	28.5	36.1	44.4	57.0	.0025	.0047	.0089	.0222
0.45	32.1	40.6	49.9	64.1	.0034	.0068	.0136	.0351
0.50	35.6	45.1	55.5	71.3	.0047	.0094	.0197	.0526
0.55	39.2	49.6	61.0	78.4	.0060	.0132	.0281	.0749
0.60	42.7	54.1	66.6	85.5	.0080	.0179	.0401	.1056
0.65	46.3	58.6	72.1	92.6	.0104	.0244	.0548	.1423
0.70	49.9	63.1	77.7	99.8	.0136	.0322	.0722	.1867
0.75	53.4	67.6	83.2	106.9	.0170	.0418	.0951	.2389
0.80	57.0	72.1	88.8	114.0	.0217	.0548	.1210	.2946
0.85	60.0	76.6	94.3	121.1	.0274	.0694	.1539	.3520
0.90	64.1	81.1	99.9	128.3	.0344	.0708	.1894	.4129
0.95	67.7	85.6	105.4	135.4	.0436	.1056	.2266	.5279
1.00	71.2	90.1	111.0	142.5	.0526	.1292	.2709	.5319

Table 4.8 Probability of Failure of Heater with Strap

Acceleration (g)	p_f			
	A	B	C	D
0.05	0	0	0	0
0.10	0	0	0	0.0005
0.15	0	0	0.0006	0.0013
0.20	0.0002	0	0.0013	0.0025
0.25	0.0007	0.0001	0.0022	0.0045
0.30	0.0012	0.0005	0.0038	0.0080
0.35	0.0017	0.0014	0.0049	0.0136
0.40	0.0025	0.0035	0.0089	0.0222
0.45	0.0340	0.0061	0.0136	0.0351
0.50	0.0047	0.0091	0.0197	0.0526
0.55	0.0060	0.0131	0.0281	0.0749
0.60	0.0080	0.0178	0.0401	0.1056
0.65	0.0104	0.0244	0.0548	0.1423
0.70	0.0136	0.0322	0.0722	0.1867
0.75	0.0170	0.0418	0.0951	0.2389
0.80	0.0217	0.0548	0.1210	0.2946
0.85	0.0274	0.0694	0.1539	0.3520
0.90	0.0344	0.0708	0.1894	0.4129
0.95	0.0436	0.1056	0.2266	0.5279
1.00	0.0526	0.1292	0.2709	0.5319

4.3 Risk of Fire in Electrical Distribution System

4.3.1 Estimated Risk in Routine (non-Earthquake) Condition

As described in chapter III, under normal conditions, non-earthquake conditions, electric fires are considered to be caused by NFPA(1986):

- Worn out or "retired" electrical equipment
- Improper use of approved equipment
- Accidental occurrences
- Defective installation

In a survey reported NFPA(1986), the number of electrical fires for 174 cities (surveyed in 1980) and 176 cities (surveyed in 1981 and 1982) was reported. Table 4.9 summarizes these statistics in terms of the average percentage of the total number of fires. As seen in the table, the electrical distribution system (which includes cables, cords, distribution panels, receptacles, lamps, fixtures, switches, termination and splices and wires) accounts for about 49.55% of all electrical fires. Wiring alone constitutes about 15.07% of all electrical (or 30% of the electrical distribution system) fires. An investigation into causes of electrical fires (Smith and McCoskrie, 1990) revealed that fires originated from electrical distribution systems in residential units account for about eight percent (8%) of all residential fires reported nationwide. In their investigation of 149 electrical fires, Smith and McCoskrie concluded that the percentage of electrical fires increased with the age of dwellings. Table 4.10 summarizes this finding. Although the

Table 4.9 Statistics of Electrical Fires (Data from NFPA 1986)

Equipment Involved	Average No. of Fires/yr.	% of Total
Air Conditioners	154	3.18
Appliance (Commercial/Industrial)	372	7.69
Appliance (Residential)	1428	29.54
Cables*	171	3.54
Cords*	290	6.00
Distribution Panels*	170	3.52
Fixtures-Lightings*	484	10.02
Lamps (Bulbs)*	75	1.54
Lighting Motors (not Integral with Appliance)	212	4.38
Receptacles*	135	2.78
Signs	63	1.29
Switches*	106	2.19
Termination and Splices*	97	2.08
Transformers*	136	2.81
Wires*	728	15.07
Pools	10	0.21
Miscellaneous equipment	13	0.27
Others	188	3.89
Total	4832	100.00

* Part of electrical distribution system

Total for electrical distribution system=49.55%

Table 4.10 Percentage of Electrical Distribution System Fires vs Age of Dwelling in 149 Fires (Smith and McCoskrie, 1990)

Age of Dwelling (Years)	% of Total Fires
≤10	6.4
11 to 20	8.5
21 to 40	29.1
Over 40	56.0
Total	100.0

results in Table 4.10 do not present a statistical sample, they, nevertheless, emphasize the importance of age on the risk of fires originating at electrical distribution systems in dwellings. More detailed investigation of the cause of these 149 fires, which occurred in 16 cities, revealed that the highest percentage of fires (34%) initiated at the branch circuit wiring. Table 4.11 presents the summary of these findings. It is observed that this percentage (34%) compares reasonably well with the 30% from the NFPA data (see Table 4.9). These results indicate the great potential of the electrical distribution system in promoting fire compared with other electrical components and equipment.

The risk of an electrical distribution fire in a residential dwelling can be estimated based on the statistics of past occurrence of such fires in a given area. These statistics are compiled by fire departments for their jurisdictions on a routine basis and they provide a valid sample for the estimation of the risk. However, the risk estimated would only represent the likelihood of fire from all causes (not necessarily earthquake related). The risk will however increase during an earthquake because of disturbances that occur in an electrical distribution system due to the building vibration. The effort in this section is focused on estimating the risk of electrical distribution fire and provide a basis for extrapolating this risk to arrive at estimates that would represent the effect of an earthquake of a given intensity.

Table 4.11 Failure Modes Involved in Residential Electrical Distribution System Fires Based on 149 Fires (Smith and McCoskrie, 1990)

Component	% of Total Fires
Service Equipment	14
Branch-Circuit Wiring	34
Receptacle Outlets & Switches	19
Cords and Plugs	19
Light Fixtures & Lamps	13
Transformers	<1

Table 4.12 San Francisco Fire Statistics (San Francisco Fire Department, 1991)

Years	84-85	85-86	86-87	87-88	88-89	89-90
Total Fires	7132	6709	6267	6212	5920	6210
Building Fires					2307	2297
1&2 Family Fires					514	484
Apartment Fires					1251	1287
Total Residential					1765	1771

Statistics of fires in San Francisco for six annual periods (1984-1990) are summarized in Table 4.12. Given in Table 4.12 are also the residential building fires and, more specifically, the fires in one- and two-story family dwellings and apartments. These statistics reveal that on the average, there are 6408 (Std. Dev.=436) fires in San Francisco each year. Based on the 1988-1990 data, residential fires constitute about 29% of total fires. With an estimated 8% of residential fires being attributed to electrical distribution systems, the total number of such fires is estimated at about 0.08x0.29x6408=149 (Std. Dev.=10) fires. According to Census Bureau's data (1990) as of 1990 there were 328,471 residential units (single family dwellings and apartments) in San Francisco. Thus the estimated risk of an electrical distribution system for any residential unit is 4.536×10^{-4} ($\pm3.044\times10^{-5}$). This risk is expected to be lower for units which are less than 10 years old. However, due to the lack of a valid statistical sample that can be used to describe the effect of age, the estimated risk will be used for all age groups.

4.3.2 Effect of Earthquake on the Risk of Fire

As described earlier, with a severe and persistent vibration of structural members, walls, floors and partitions, the risk of electric fires will increase. The risk estimated in the preceding section needs to be adjusted for various levels of seismic activities as prescribed by the ground accelerations. This can be achieved using one of the following two methods:

- Compile statistics of electric-related fires for past earthquakes and estimate to what extent the number of fires resulting from an earthquake increases. This method provides a data based approach for augmenting the risk of earthquake-related fires. However, the method is impaired by the fact that the data may be limited and biased (applied to certain unusual demographic conditions). Ideally to be useful in risk estimation, the data should clearly be descriptive of all causes and locations of fires and their severity in terms of casualty and property damage.
- Simulate the response of electric equipment and wires in an earthquake-induced vibration environment and estimate the increase in the level of activities that will trigger the risk of fire. The simulation will require that the mechanism via which an electric fire develops be known. This is generally difficult because of the variety of factors that are involved in the development of a fire.

Since data to establish the information on the effect of earthquakes on the development of electric fire is scarce, our effort is focused on simulation studies. For this purpose, the causes of electric fires, as described earlier, are evaluated to determine and select those that correlate directly with the vibration produced in various structural members. A factor that contributes to electric fire is the friction and wear of wires specially at joints and receptacles. The design of an electrical distribution system, the age of the system, and the load on the system can also drastically affect the risk of fire.

Our effort in this section is focused on the development of scenarios in which portions of an electric wiring system engage in vibration of a structure including its walls and other structural members. Figure 4.7 shows a masonry wall with a portion of an electric wiring system mounted on it.

It is emphasized that the system shown in Fig. 4.7 is only intended for the investigation of the effect of ground motion on deformation and vibration generated in the wire in a typical case where the wire is mounted on the wall. Many variations to this system exist that may change the outcome of the results of the simulation. Our primary purpose is to determine how severe the elongation in the wire becomes when the wall vibrates persistently over the duration of a given earthquake. The model will then be changed and the simulation will be repeated to investigate whether or not the design and layout of the wiring system and the wall configuration will have a major influence in the outcome of the analysis.

The maximum elongation generated in the wire will then be used as a basis to augment the risk of electrical distribution system fire so that the effect of various levels of ground shaking can be ascertained and quantified.

Records of six different earthquakes were obtained and used in the simulation analysis. Table 4.13 summarizes the

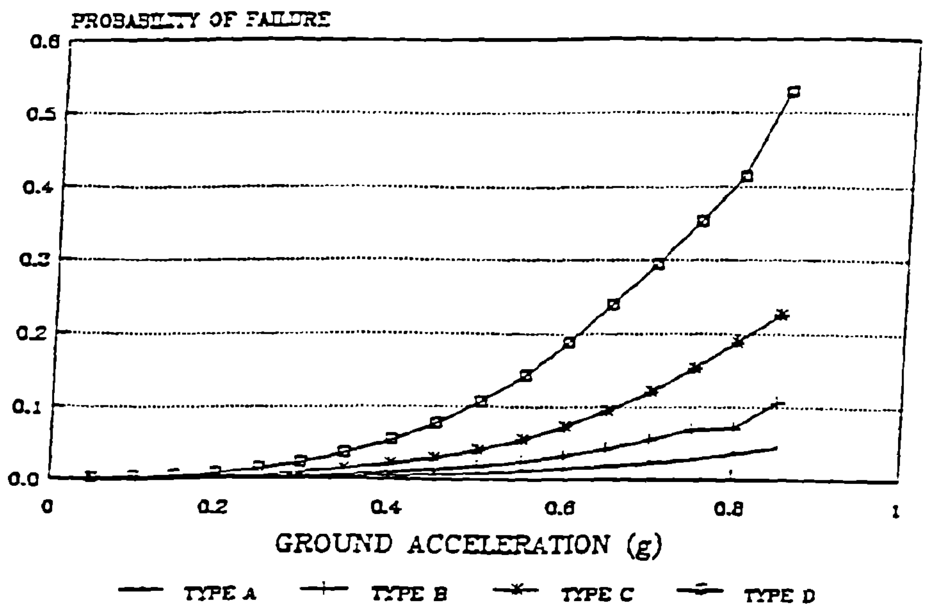


Figure 4.7. Failure Probabilities for Water Heaters with straps

Table 4.13 Acceleration and Duration of Various Earthquakes Used in Electric Distribution Simulations

Earthquake	Acceleration (g)	Duration (sec)	Max Wire Displacement(in)
Olympia 2	0.140	82.0	2.40E-03
Taft	0.180	54.0	9.70E-03
Olympia 1	0.280	89.1	7.40E-03
Elcentro	0.318	53.7	24.0E-03
Loma Prieta	0.330	40.0	18.0E-03
Cholame	0.430	44.0	24.0E-03

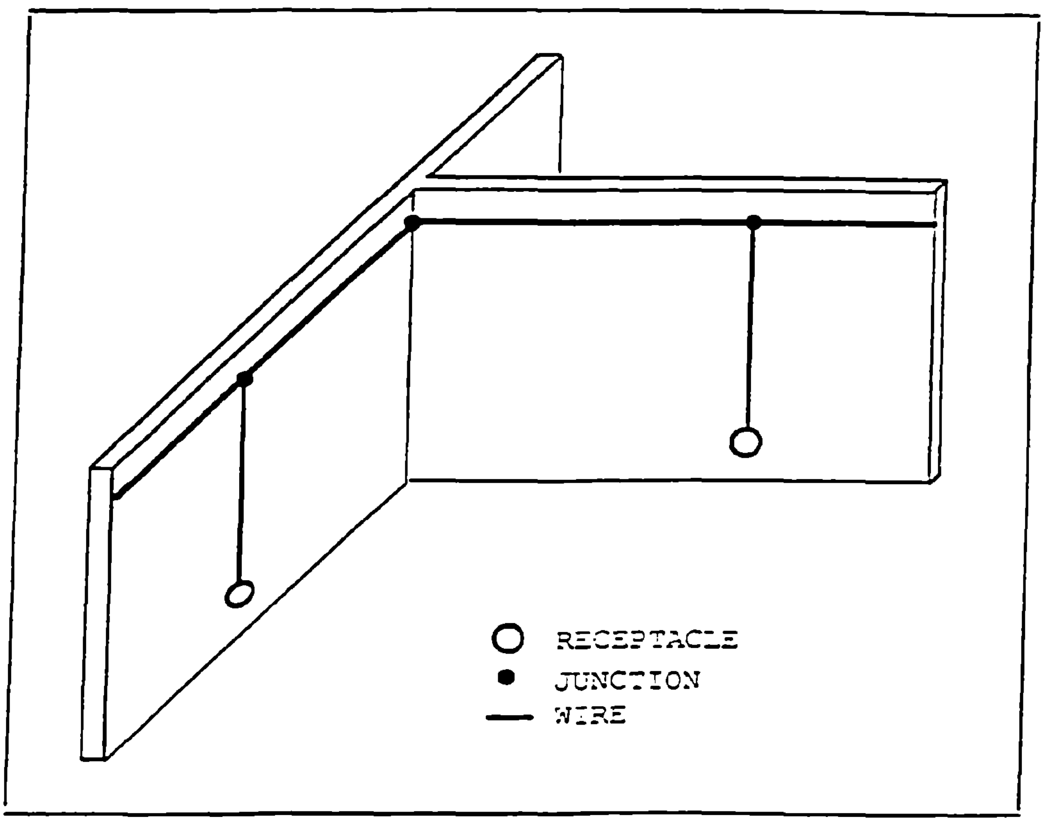


Figure 4.8. Wiring Configuration Used for Dynamic Analysis

maximum acceleration and duration for the six records.

The result of simulation showed a small deflection obtained in the wall at the location where electric wires are installed. (see Table 4.13) Furthermore, it was found that this deflection was neither affected by the wall configuration nor by the duration of the earthquake. Based on these results, it is found that the displacement will increase by 1.4 times as the acceleration will increment by 0.1g. This can be used as a basis for adjusting the risk of electrical fire as a result of earthquakes of various acceleration levels. Again, as discussed in section 4.2.1, at an acceleration below 0.05g, the risk is unaffected. However, at higher accelerations the risk obtained in Section 4.3.1 can be adjusted accordingly (see Table 4.14).

Table 4.14 Risk of Electric Fires for Various Accelerations

Acceleration (g)	Risk of Fire
0.05	0.454E-03
0.10	0.771E-03
0.15	1.311E-03
0.20	2.229E-03
0.25	3.789E-03
0.30	6.440E-03
0.35	10.950E-03
0.40	18.610E-03
0.45	31.640E-03
0.50	53.790E-03

Chapter V

ESTIMATION OF PROBABILITY OF POST-EARTHQUAKE FIRES

5.1 Introductory Remarks

In this chapter the estimates obtained for the risk of fire associated with electrical and gas distribution systems are used in the event trees of Chapter III to arrive at the estimated probability of post-earthquake fires. Specifically, the event trees are applied to San Francisco. For this purpose, the probabilities associated with various acceleration levels in San Francisco are obtained using the seismic risk analysis method developed by Mohammadi and Suen (1991). Furthermore, the events following a gas leak or a malfunction in an electrical distribution system are described and used in the estimation of the probability of fire.

5.2 Seismic Risk of San Francisco

As Described earlier, several methods are available that can be used for the estimation of probabilities that a given acceleration level will be exceeded in a given year. In this study, the model developed by Mohammadi and Suen (1991) is used. The model is essentially an extension of the seismic risk analysis method proposed by Derkiureghian and Ang (1977). In Mohammadi and Suen's model, the fault is modeled by a plane of rupture and the occurrence of future earthquakes is modeled using a generalized renewal process that accounts for a time-dependent seismic activity rate. The details of the model can be found in Mohammadi and Suen (1991). The formulation of the model will lead to the computation for P(Y>y) in which Y is a random variable describing the acceleration due to all potential earthquakes of various magnitudes that can occur in San Francisco and y is a specific desired acceleration level. The probability P(Y>y) is evaluated for a given year from the following equation:

$$P(Y>y) = \int P(Y>y|E_m) f_M(m)\,dm \qquad m_o \leq M \leq m_u \qquad (5.1)$$

in which E_m is the occurrence of an earthquake with a random magnitude M=m, f_M is the probability density function of M, and m_o and m_u are limits of the integral. The statistics of previous seismic activities in the area and the geometry of the existing major faults in Northern California are essential data used in solving Eq. 5.1 for P(Y>y). It is noted that the occurrence of future earthquakes and their magnitudes are treated as random. For magnitude, the probability density function f_M follows a truncated exponential and for the occurrence of future earthquakes, a time-dependent renewal Poissonian distribution is used.

Table 5.1 presents the estimation of P(Y>y), here referred to as the probability of exceedence. For San Francisco, this is obtained by using the model by Mohammadi and Suen (1991). The statistics presented in Table 5.1 were used in computing the probability of Event A in fault trees of Figs. 3.1 and 3.2.

Table 5.1 Estimation of Annual Probability of Acceleration Exceedence for San Francisco

Acceleration (g)	Probability of Exceedence
0.05	0.8110
0.10	0.2800
0.15	0.0850
0.20	0.0370
0.25	0.0180
0.30	0.0092
0.35	0.0053
0.40	0.0030
0.45	0.0016
0.50	0.0008

5.3 Events Following Gas Leaks

As seen in Fig. 3.1, following a gas leak, depending on the level of gas accumulation (about 4 to 14% volume of gas to volume of air must accumulate for gas to be ignitable, NFPA, 1986) and whether or not there exists an ignition source, a fire may or may not occur. The attempt in this section is focused on estimating the probabilities associated with these events.

The probability that a leak will be detected depends on many factors such as:

- The area where leaks occur
- Ventilation
- Occupants being at home at the time of the earthquake
- If at home, how sensitive occupants are to detect gas leaks

If a gas is detected, there may be many scenarios that can follow. An occupant may attempt to close the primary gas valve or may immediately call the gas company, police department or fire department. The amount of gas accumulated then depends on the response time by these authorities to close the area gas valves or to arrive at the site for appropriate actions.

If the gas leak is not detected, and no automatic shut-off valve is installed, then depending on the areas where the leak occurs, flammable level of accumulation can be reached at about 21 minutes. This is based on 4% gas accumulation (the minimum needed for ignition) in volume of air in a 3.5 ft.

diameter around an appliance and a partial pipe failure. At about 73 minutes after the start of the leak the gas will accumulate 14% of the air. This is the maximum level of accumulation that is needed for ignition to occur. At concentration above 14%, the accumulated gas will not ignite unless a dilution (due to opening windows, door, etc.) happens.

In the risk analysis conducted in this chapter, it is assumed that the gas will be detected by the occupants if they are at home at the time of the earthquake. However, it is assumed that there is a 50% chance that any occupant is at home at the time of the earthquake. If a leak occurs and it remains undetected, it is assumed, as the worst case scenario, that a combustible level will be reached in about 50% of the time. It is also assumed that there is a 50% chance that an effective igniting source is present (pilot burning, electrical wire malfunction occurs, etc.). If gas is not detected and it is accumulated to the combustible level, with an ignition source present, the occurrence of one of the four types of fire shown in Fig. 3.1 is unavoidable.

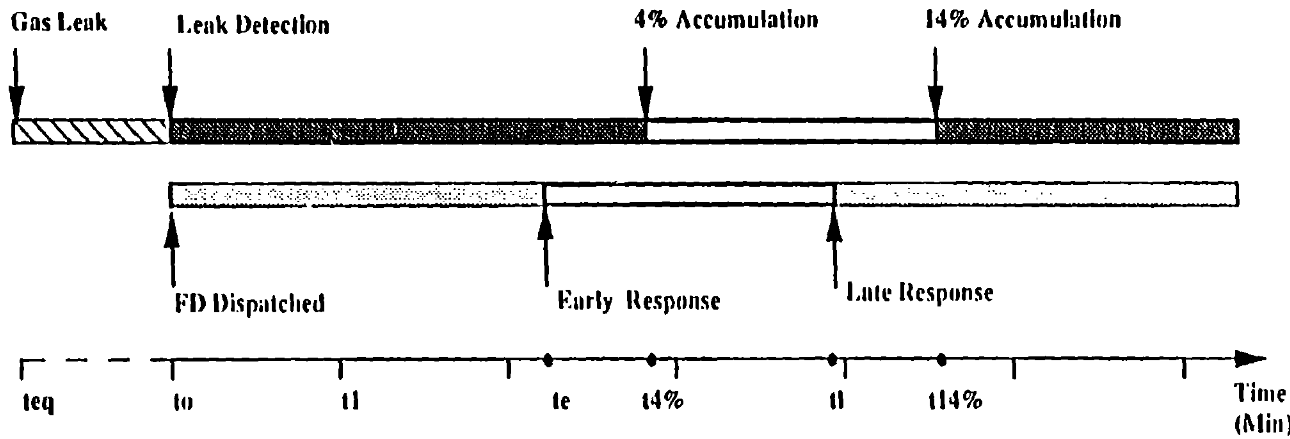
If, on the other hand, the leak is detected and an effective ignition source is present, then the probability that one of the four types of fire occurs depends on whether the gas concentration in the air can reach the 4% - 14% interval before there is an attempt by the fire department, gas company, etc. to shut off the gas. This probability can be estimated based on the average time needed for the authorities (say the fire department) to respond to the call received at the station and the time that is needed for the gas concentration to reach the 4% - 14% level. Figure 5.1 shows a graphical presentation of the time involved in gas accumulation and response by the authorities (e.g., the fire department). The early response time (t_e) represents average times in everyday operation (San Francisco Fire Department Data); whereas the late response time (t_l) is the representative of situations where there is a great demand on emergency response and rescue (e.g., during the Loma Prieta earthquake). Shown on the graphs are also times needed for the gas to reach the 4% ($t_{4\%}$) and 14% ($t_{14\%}$) levels. The estimated times $t_{4\%}$ and $t_{14\%}$ are based on partial failure of a gas pipe in which gas escapes at an opening as large as 50% of the perimeter of a 3/4 in. pipe. With $t_{4\%}$=21, $t_{14\%}$=73, t_e=3.5 and t_l=28.5 minutes, the overlapping times as shown in Fig. 5.1 are used as an estimation of the probability of fire development.

$$\text{Overlapping times} = \frac{t_l - t_{4\%}}{t_{14\%} - t_{4\%}} = \frac{28.5 - 21}{73 - 21} = 0.14$$

This estimate constitutes an average probability.

5.4 Events Following a Disturbance in the Electrical Distribution System

As seen in Fig. 3.2, a disturbance in the electrical distribution system can lead to one of four types of fires if the electricity is not cut off and the earthquake vibration persists over a sufficiently long period of time. Knowing



Estimated Times: t4%=21 min , t14%=73 min, te=3.5 min, tl=28.5min

Figure 5.1. Graphical Presentation of Events Following a Leak Detection

some data on the severeness of an electrical problem in the system and the length of time that the problem should persist so that a fire can occur, one can utilize a simulation model to estimate the probabilities of the events following the Event B in the tree of Fig. 3.2. However, due to lack of such data, our estimates of risk of electrical fires was directly obtained from available fire statistics (see Section 4.3) and adjusted for the earthquake effect. These estimates will be used for the calculation of the probability of post-earthquake fires for San Francisco.

5.5 Probability of Post-Earthquake fires for San Francisco

The probability of a post-earthquake fire is estimated using Eqs. 3.1 and 3.2. The estimates are for any type of fire. A discussion on the occurrence rates for a specific type of fire (of the four types) is explained later.

The probabilities obtained constitute the likelihood of occurrence of gas and electrical fires only. They do not include such isolated fire causes as overturning lamps and candles or spill of flammable materials.

(i) Gas-Related Fires -- The various events appearing in the tree of Fig. 3.1 and their respective probabilities are summarized below:

Event	Estimate of Probability
A	Use Table 5.1
B	Combine statistics in Table 4.1 (for piping system) and those in Tables 4.5 and 4.8 (for appliance without or with straps)
D	0.50
E	0.50
F	0.50
C (event of fire)	1.0 if leak not detected 0.14 if leak detected

Note that event A and B are acceleration-dependent and that B is estimated for two different cases, namely, appliances without and with straps for the four types of heaters described in section 4.2. It is also noted that the events given above are only considered when their corresponding preceding events occur. Thus, the probabilities for B, D, ... are basically probabilities $B|A$, $D|B$, ...

Event A represents the probability that an earthquake of a given acceleration (i.e., $Y=y$) occurs in San Francisco. Note that values given in Table 5.1 are exceedence probabilities, i.e.

$$P(Y>y) = 1 - \int_0^y f_Y(y)\,dy \tag{5.2}$$

in which f_Y= probability density function of ground acceleration Y. The probability of event A can be approximated as follows:

$$P(A) = P(Y=y) \approx P(y < Y \leq y+\Delta y) \tag{5.3}$$

$$\approx f_Y(y)\Delta y = P(Y \le y+\Delta y) - P(Y<y)$$
$$= P(Y>y) - P(Y > y+\Delta y)$$

By selecting a small acceleration interval (say, Δy=0.05g), P(A) can be obtained using the statistics of Table 5.1. For example P(Y = 0.20g) = P(Y > 0.20g) - P(Y > 0.20g + 0.05g) = 0.037 - 0.018 = 0.019.

It is also noted that the probability that exactly an acceleration y occurs is extremely rare. The estimates for P(A) are in fact P(Y=y) with Δy variation. Using estimates of P(A) along with probabilities for other events in the event tree of Fig. 3.1, the annual risk of post-earthquake fires for various intensities is then calculated (see Appendix B for typical computations) as reported in Tables 5.2 - 5.5 for the four types of water heaters (designated as Types A, B, C and D).

Since in any given year, theoretically, any acceleration level can occur, the probabilities for various accelerations can be combined to arrive at a gross estimate of the risk of fire. The following equation is used for this purpose:

$$P(C) = \Sigma P(C|A)P(A) = \Sigma_{\text{all } y} P(C|Y=y)P(Y=y) \qquad (5.4)$$

It is noted that $P(Y=y) \approx 0$ for y>0.50 thus not contributing to Eq. 5.4. The gross estimates based on Eq. 5.4 are also given in Tables 5.2 - 5.5.

(ii) <u>Electric Fires</u>

The probability of electric fires resulting from a given acceleration level was obtained in Chapter IV. These

Table 5.2 Estimated Probability of Post-Earthquake Fires for San Francisco (Based on Failure of Type A Gas Appliances and/or Gas Pipe)

Acceleration	No Straps Used		Straps Used	
(g)	P(C|A)*	P(C|A)P(A)**	P(C|A)	P(C|A)P(A)
0.05	0.00021	0.00011	0.00021	0.000110
0.10	0.00021	0.00004	0.00021	3.90E-05
0.15	0.00242	0.00012	0.00021	1.01E-05
0.20	0.05653	0.00107	0.00024	4.60E-06
0.25	0.11616	0.00102	0.00032	2.80E-06
0.30	0.14512	0.00056	0.00041	1.60E-06
0.35	0.15552	0.00036	0.00048	1.10E-06
0.40	0.15872	0.00022	0.00061	0.80E-06
0.45	0.16000	0.00013	0.00076	0.60E-06
0.50	0.16000	0.00009	0.00096	0.60E-06
Gross Estimate		0.00372		0.000170

*P(C|A) = Probability of fire given an acceleration level
**P(C|A)P(A) = Probability of fire considering a specific acceleration level

Table 5.3 Estimated Probability of Post-Earthquake Fires for San Francisco (Based on Failure of Type B Gas Appliances and/or Gas Pipe)

Acceleration	No Straps Used		Straps Used	
(g)	P(C|A)*	P(C|A)P(A)**	P(C|A)	P(C|A)P(A)
0.05	0.00021	0.0001100	0.00021	1.11E-04
0.10	0.00021	3.900E-05	0.00021	3.90E-05
0.15	0.00021	1.010E-05	0.00021	1.01E-05
0.20	0.00053	1.010E-05	0.00021	4.00E-06
0.25	0.00645	0.570E-04	0.00023	2.00E-06
0.30	0.03365	1.312E-04	0.00029	1.10E-06
0.35	0.06672	1.534E-04	0.00043	1.00E-06
0.40	0.12080	1.691E-04	0.00078	2.20E-06
0.45	0.14416	1.153E-04	0.00117	0.90E-06
0.50	0.15936	0.956E-04	0.00167	1.00E-06
Gross Estimate		0.00089		0.00017

*P(C|A) = Probability of fire given an acceleration level
**P(C|A)P(A) = Probability of fire considering a specific acceleration level

Table 5.4 Estimated Probability of Post-Earthquake Fires for San Francisco (Based on Failure of Type C Gas Appliances and/or Gas Pipe)

Acceleration	No Straps Used		Straps Used	
(g)	P(C|A)*	P(C|A)P(A)**	P(C|A)	P(C|A)P(A)
0.05	0.00021	0.000110	0.00021	0.000110
0.10	0.01317	0.002370	0.00021	3.90E-05
0.15	0.11023	0.005290	0.00022	1.10E-05
0.20	0.15183	0.002880	0.00042	0.80E-05
0.25	0.15888	0.001400	0.00056	4.90E-06
0.30	0.15984	0.000620	0.00082	3.20E-06
0.35	0.16000	3.70E-04	0.00094	2.20E-06
0.40	0.16000	2.20E-04	0.00163	2.30E-06
0.45	0.16000	1.28E-04	0.00023	1.90E-06
0.50	0.16000	0.94E-04	0.00336	2.00E-06
Gross Estimate		0.01348		0.000180

*P(C|A) = Probability of fire given an acceleration level
**P(C|A)P(A) = Probability of fire considering a specific acceleration level

Table 5.5 Estimated Probability of Post-Earthquake Fires for San Francisco (Based on Failure of Type D Gas Appliances and/or Gas Pipe)

Acceleration (g)	No Straps Used		Straps Used	
	P(C|A)*	P(C|A)P(A)**	P(C|A)	P(C|A)P(A)
0.05	0.00037	0.00020	0.00020	0.000110
0.10	0.12480	0.02246	0.00029	5.20E-05
0.15	0.15904	0.00763	0.00042	2.00E-05
0.20	0.16000	0.00303	0.00061	1.16E-05
0.25	0.16000	0.00141	0.00093	0.82E-05
0.30	0.16000	0.00062	0.00149	0.58E-05
0.35	0.16000	0.00034	0.00239	5.50E-06
0.40	0.16000	0.00022	0.00376	5.20E-06
0.45	0.16000	0.00013	0.00583	4.70E-06
0.50	0.16000	0.00009	0.00863	5.20E-06
Gross Estimate		0.03615		0.000230

*P(C|A) = Probability of fire given an acceleration level
**P(C|A)P(A) = Probability of fire considering a specific acceleration level

statistics are adjusted by the probability of occurrence of various levels of ground acceleration (see Table 5.1 and Eq. 5.3, Appendix B provides sample computation). The results are summarized in Table 5.6. Again a gross estimate is obtained and given in Table 5.6 based on Eq. 5.4.

5.6 Types of Fires

Occurrence of a specific type of fire (of the four types) depends on:

- Location in the house where the fire starts
- Availability and type of combustible materials in the room where fire spreads
- Response time by the fire department

Most earthquake-related fires initiated as isolated cases are either Type 1 or 2. Only a few fires can lead to Type 3 or 4 fires (see Chapter II for description of the types). These cases are severe if they spread to other houses. An attempt to develop specific probability values for various types of fire requires information on past post-earthquake fires and distribution of the number of fires in each type. Based on the data reported in Chapter II, the distribution among various types of fire is as follows:

Type 1:	7.3 %		
Type 2:	61.0 %	Type 1 + 2:	68.3 %
Type 3:	12.2 %	Type 3 + 4:	31.7 %
Type 4:	19.5 %		

This distribution, however, concerns a specific case and does

Table 5.6 Estimated Probability of Earthquake-Related Fires in San Francisco (Fires Caused by Electrical Problems)

Acceleration (g)	P(C|A)*	P(C|A)P(A)**
0.05	0.454E-03	0.241E-03
0.10	0.771E-03	1.388E-05
0.15	1.311E-03	6.293E-05
0.20	2.229E-03	4.235E-05
0.25	3.789E-03	3.334E-05
0.30	5.440E-03	2.512E-05
0.35	10.950E-03	2.519E-05
0.40	18.610E-03	2.605E-05
0.45	31.640E-03	2.531E-05
0.50	53.790E-03	3.227E-05
Gross Estimate		0.0005300

*P(C|A) = Probability of fire given an acceleration level
**P(C|A)P(A) = Probability of fire considering a specific acceleration level

not offer a statistically valid sample. Additional analysis of previous post-earthquake fire data (both in US and Japan) along with simulation studies will be needed to determine a valid distribution among the four types.

5.7 Fire Risk Contours for a Repeat of the Loma Prieta Earthquake

The probabilities of fire computed in Section 5.5 are used to obtain seismic-fire risk contours for San Francisco for a repeat of the Loma Prieta earthquake. The estimates are based on the acceleration levels recorded for the 1989 Loma Prieta earthquake (see Fig. 2.1) and probabilities reported in Tables 5.2 and 5.6. A Type A water heater is used as a basis for the probability of gas-related fire due to the popularity of Type A. Risk contours are given for (i) gas-related fires when straps for water heaters are not used, (ii) gas-related fires when straps for water heaters are used and (iii) electrical fires. The contours are provided only as a means to identify risk-prone areas and to compare the effectiveness of using straps to secure water heaters. The contours are shown graphically in Figs. 5.2 - 5.4. The risk values appearing on contour lines describe the annual probability of post-earthquake fire for any given residential unit for a repeat of the Loma Prita earthquake.

The maximum acceleration reported for the Loma Prieta earthquake was about 0.35g. The risk of fire for this acceleration (using the probability that acceleration = 0.35g)

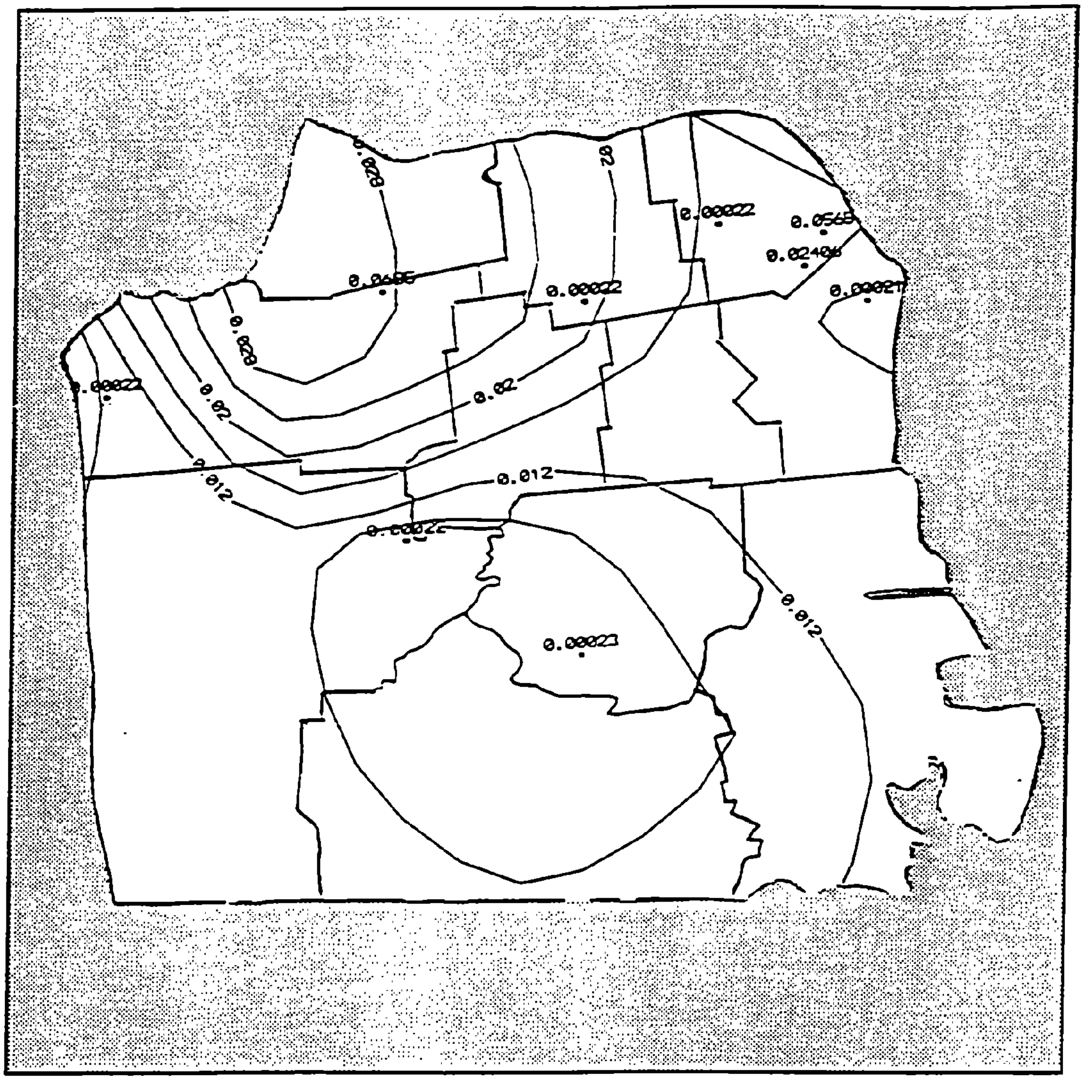


Figure 5.2. Risk Map for a Repeat of Loma Prieta for Unstrapped Water heater.

* The risk values appearing on the contour lines describe the annual probability of post-earthquake fire.

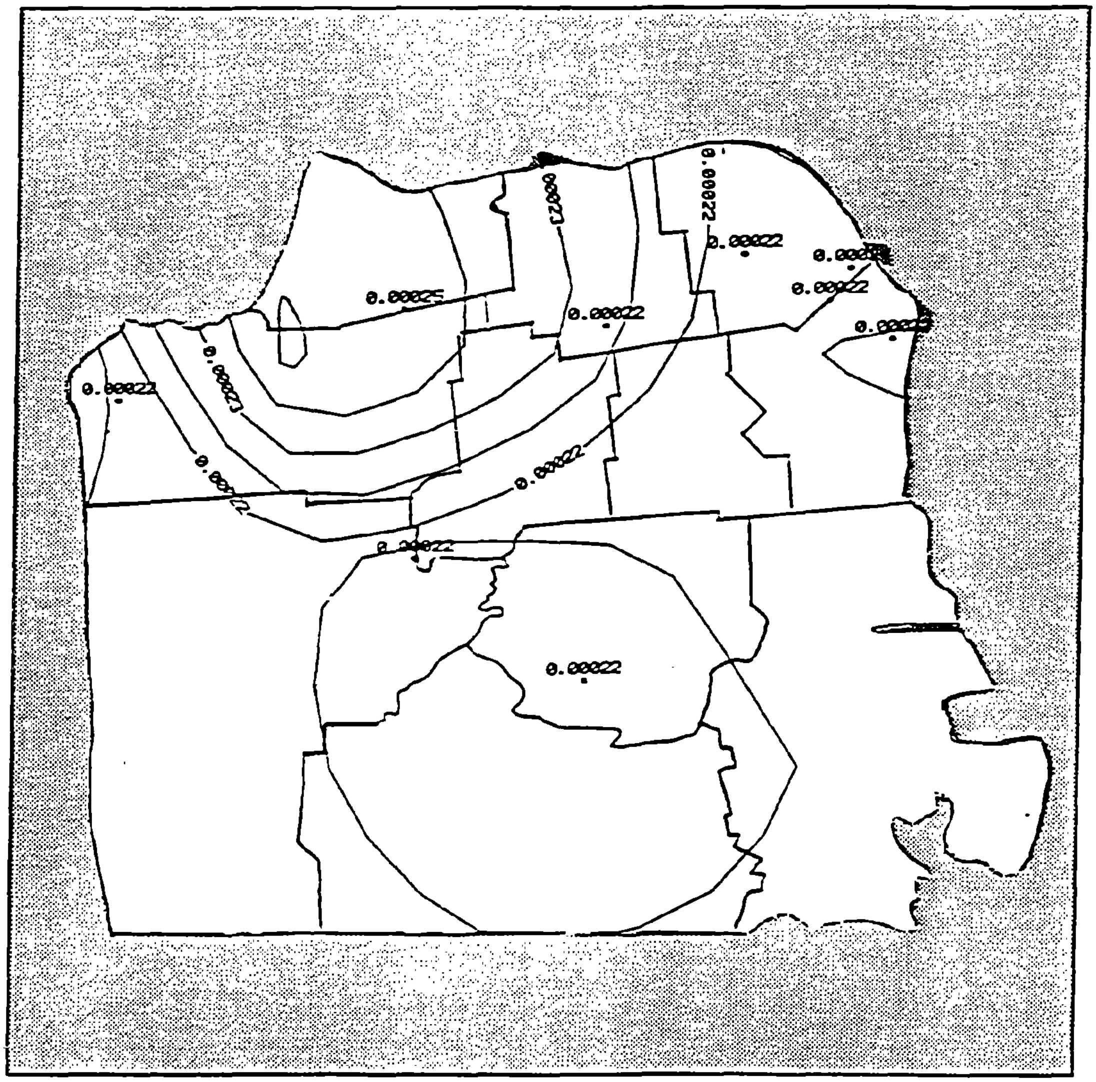


Figure 5.3. Risk Map for a Repeat of Loma Prieta for strapped Water heater.

* The risk values appearing on the contour lines describe the annual probability of post-earthquake fire.

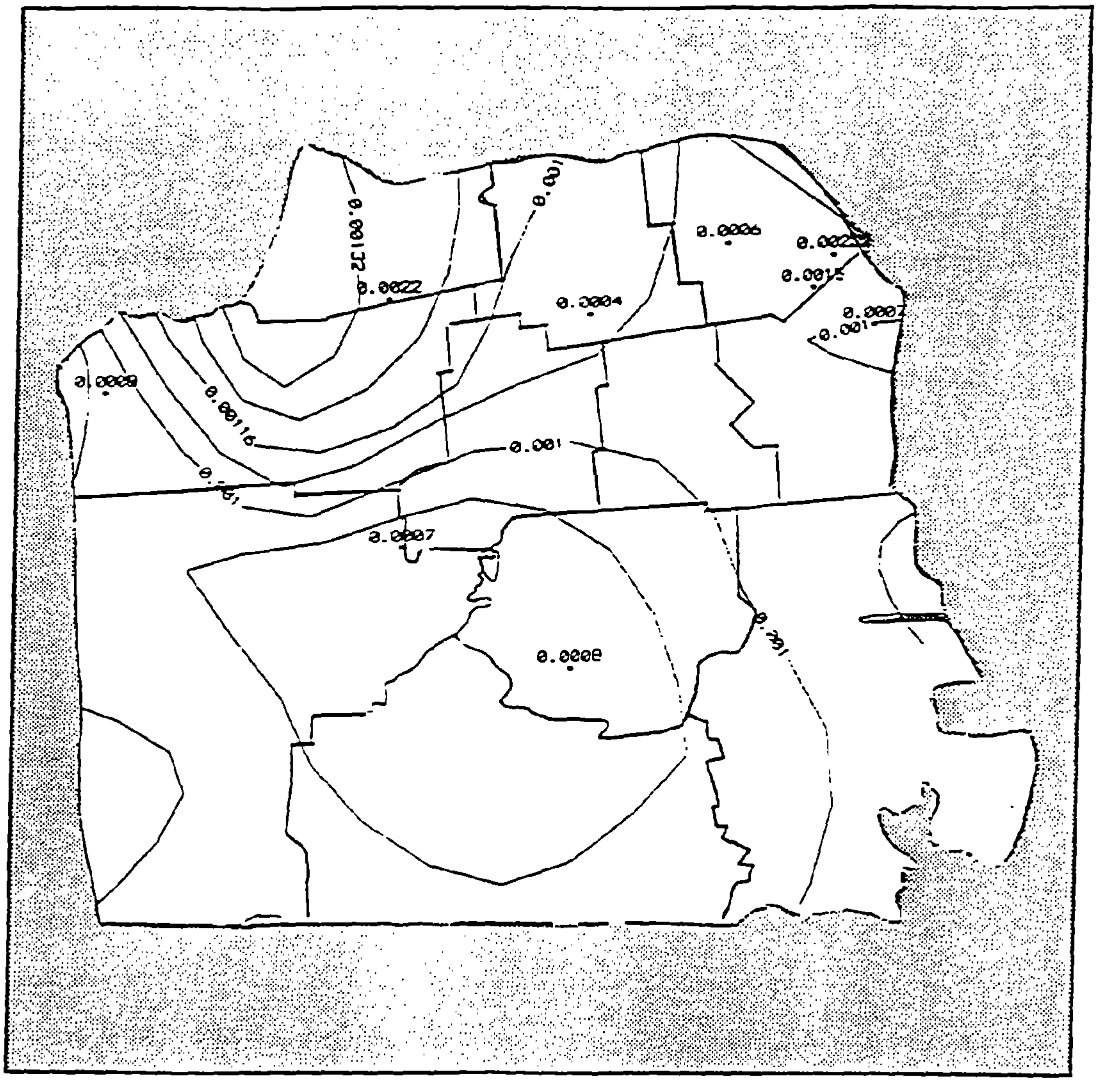


Figure 5.4. Risk Map for a Repeat of Loma Prieta for Electrical Distribution Systems.

* The risk values appearing on the contour lines describe the annual probability of post-earthquake fire.

per residential unit/year is:

0.00036 Gas related fires using Type A heater without straps

1.1E-06 Gas related fires using type A with straps

2.52E-05 Electric-related fires

Considering the fact that there are 328,471 residential units in San Francisco (see Sec. 4.3), the above risk levels translate into the following number of fires/year if acceleration is expected to be about 0.35g.

- about 118 fires if none of the residential units have secured heaters
- about 1 fire if all residential units have secured heaters; and
- about 8 fires due to potential electrical problems

These estimates are obtained by multiplying the risk for one unit by the total number of residential units. They emphasize the importance of having gas appliances secured to walls using straps. In the Loma Prieta earthquake, there were a total of 2 fires due to water heaters, 6 due to electrical wiring and 11 due to other appliances. It was not known what percentage of appliances during the earthquake in San Francisco had straps and were secured from movement.

It is emphasized that only a few areas experienced such high ground acceleration level (i.e., 0.35g). Thus the 118 fires estimated is an over-estimation. Considering the percentage of the population in District 4 (see Fig. 2.4) that experienced a high acceleration level, to the total population of San Francisco (approx. 10%), the estimate is 12 fires. This estimate is perhaps a better representative of the risk associated with potential areas that are more vulnerable to a high intensity ground motion.

CHAPTER VI

SUMMARY AND CONCLUSIONS

6.1 Summary and Conclusions

This study of post earthquake fire hazard reiterates the risks associated with residential fires following earthquakes and further emphasizes the need to plan for risk mitigation. The goal of constructing a risk model that dealt with residential units in particular introduced a new set of challenges which were very unique to this problem.

A thorough literature review was performed focussing specifically on :

- Fire investigation after the Loma Prieta earthquake of 1989.
- Fires following other past earthquakes.
- Causes of post-earthquake fires.
- Available models on fire hazard estimation and evaluation.

Such review provided the necessary data base for encompassing aspects such as types of fire, intensity of ground motion, soil type at the site of fires, and type and location of the effected structures. Moreover, examining previous models provided the frame work needed for the development of a model for simulating initiation of fires in residential units in urban areas following an earthquake event.

The methodology proposed provided more insight into the risk of post earthquake fire hazard as it concerned residential units. The methodology applied existing principles of probability as related to structural safety and seismic risk analysis.

A major effort in this research focused on the analysis of cause and effects of fires following the Loma Prieta earthquake of 1989. A summary of the findings is provided below:

The data on the number of fires by areas, cause and severeness of them was obtained from fire departments, reports on the events following the Loma Prieta earthquake and several communications with the San Francisco Fire Department.

The total number of fires was 67 of which 41 occurred in San Francisco. Although this seems to be many, yet it is a small number considering the intensity of the earthquake and affected areas which are densely populated. Twenty-seven fires occurred within seven hours after the earthquake. Beyond San Francisco, Santa Cruz County had 20 fires, Santa Clara and Berkeley each had 1 fire and Watsonville had 3 fires.

An investigation into the fires after the Loma Prieta earthquake indicated a variety of causes. Of 41 fires in San Francisco, 14 were due to electric wiring or electric equipment, 11 were caused by stoves (gas/electric), 2 due to water heaters and 2 other gas appliances. Several isolated causes such as overturning candles were also mentioned. The Marina City fires were initiated as a result of a fire in a four-story wood-frame building. The exact cause of this fire is unknown but it is believed to have originated at the rear of the building. This fire triggered 6 additional fires by the time the situation was under control. Santa Cruz had 20 fires of which only one residential building was destroyed by the fire. The cause of this was reported to be a gas main leak. Watsonville had 3 residential units destroyed by fires following the earthquake. The investigation of the fires following the Loma Prieta earthquake further emphasized the importance of such factors as intensity of the ground motion acceleration, the type of soil and its ground motion amplification characteristics, and the population density in the potential number of fires. In San Francisco, very densely populated areas (Marina City) are on mud and fill-type soil. The accelerations at some of these areas was reported to exceed 0.3g which caused more severe conditions in terms of building vibration and damage in the form of structural collapse and also fire.

Post-earthquake fires can occur as a result of a variety of causes. These include natural gas related incidents such as gas main ruptures, failures in the interior gas piping, and failure of gas appliances (i.e., water heaters). Post-earthquake fires of electric origin can be the result of failures in electric wiring, equipment and appliances. Overturning of lamps and burning candles and flammable material spills are also responsible for a portion of such fires, however; due to the unsystematic nature of this group of causes fires resulting from these were not modeled in this study.

Event trees were used in modeling the steps leading to gas and electrical fires following an earthquake. The trees proved to be very practical in demonstrating the sequence of events that follow after an earthquake and that can lead to a fire. The probability associated with individual events in the trees were quantified either using mathematical modeling or post performance data. When neither method could be used, subjective estimates were used on an over-estimated basis. However, these can easily be modified once more specific data for the occurrence of a given event is known. It is recommended that the trees be continuously reviewed and revised to incorporate any new data that could prove more specific information on the occurrence of those events for which subjective values were assigned. These events include gas leak detection, existence of an effective ignition source, and gas accumulation to a flammable level.

In case of gas leak detection, factors such as whether or not an occupant was present in the house at the time of the earthquake, location of the leak, and possible leak detection by smell are critical yet difficult to quantify.

Calculation of the probability of existence of an effective ignition source at the site of gas accumulation was also a perplexing task. The possibilities ranged from turning on the lights, or an electrical short to the introduction of a burning candle to the scene as a result of electrical power loss.

To quantify the time necessary for the gas to accumulate to a flammable level scenarios involving different size leaks in the gas piping system were considered. Using flow equations these times were calculated and compared to fire department's early and late response times thus arriving at the probability of reaching flammable levels of gas accumulation.

Generation of such an event tree yet introduced a new set of problems, namely the quantification of risk when mathematical modeling was not possible and no specific performance or subjective data was justified to be used. In such a case risk quantification was based on extrapolating the probabilities known to represent ordinary conditions. The result of the augmentation process in itself is dependent on the extent and variety of simulations and experiments performed to explicate the correlation between normal condition values and earthquake subjected results. For instance in case of electrical post-earthquake fires, listed failure probabilities for different components of a residential electrical system in normal conditions were augmented using the results of numerous computer simulations of a model depicting the electrical wiring of a residential unit under earthquake excitations.

Further investigation (including complete simulations where applicable) of such topics as dynamics of gas accumulation process in residential units, gas leak detection, in depth studies of possible sources of ignition in gas leak scenarios, and behavior of electrical distribution systems in an earthquake would be of enormous help to future attempts to refine risk models such as the one presented in this study.

An approach based on simulation via computer animation was tried in this study and showed some promises. However, the animation needs to be done on a case-by-case basis and requires an extensive computer modeling and analysis effort.

Employing our models for gas and electrical fire initiation in conjunction with the probabilities associated with various earthquake ground acceleration levels, probabilities of post-earthquake fires for a single family residential unit were computed considering gas and electrical fires. These probabilities were then calibrated for ground accelerations reported after the Loma Prieta earthquake. The result was estimated risk of fire in San Francisco for a repeat of the Loma Prieta event. Such information can provide basis for seismic preparedness planning and fire fighting effort during an earthquake emergency. Planners could use the information to provide alternative routes, shelters, and evacuation plans in case of conflagrations. Area hospitals could become prepared for a higher number of burn victims. Furthermore, the utility companies could introduce special seismic shut-off valves in the more vulnerable areas and dramatically reduce the risks.

The risk estimates for San Francisco were obtained for potential electric fires and gas-related fires for two possible scenarios, namely, water heaters unrestrained and restrained. The results indicated that using straps to secure heaters to walls can substantially mitigate the risk of fire. The result of analyses conducted in this study showed that any gas leak development (in the case of the survival of the building) is mainly because of water heaters being dislodged or overturned. Using straps to secure heaters is thus a very important mitigation effort that can be applied with almost no cost to the building owner.

6.2 Recommendations for Further Studies

As a result of our investigation into the fires following the Loma Prieta Earthquake, we recommend several additional studies that can be useful in risk analysis and risk mitigation for future earthquakes.

- Post-earthquake fire risk data (in the form of risk maps) need to be developed to describe potentials for fire in residential buildings. A limited study to estimate the risk for San Francisco is completed and included in this report. However, this needs to be further evaluated and refined.
- Alternative sources for fire fighting activities need to be studied and optimized for various localities. Alternative routes and water sources for a timely response to a fire in the area are to be fully investigated and identified. This is especially critical for densely populated areas and areas which are prone to amplified ground motion due to their soil types.

- Possible measures to reduce risk of fire in residential buildings need to be quantified in terms of their effectiveness in reducing the probability of fire. Using straps to secure water heaters, installing automatic gas shut-off valves and automatic electrical distribution system circuit breakers are some examples of such fire-risk mitigation measures. The effectiveness of straps in mitigating fire risk was investigated in this study. Other measures need to be evaluated also.
- The reliability of sprinkler systems in an earthquake and their effectiveness to reduce the risk of intense fires needs to be estimated and quantified. Since such information cannot easily be established from past performances, analytical methods needs to be developed and tested for this purpose.
- With the advents in computer animation technology many possibilities for post-earthquake fire simulation and investigation have become available. Computer animation techniques could be employed for both investigative and educational ventures into the problem of post-earthquake fire hazard.

BIBLIOGRAPHY

American Institute of Steel Construction (1989). Manual of Steel Construction, Allowable Stress Design. 9th ed. AISC, Chicago.

Ang, A. H.-S., and C. A. Cornell (1974). "Reliability Basis of Structural Safety and Design". Journal of Structural Division, ASCE, ST9, Vol. 100, Sept., Pages 1755-1769.

Ang, A. H.-S., and W.H. Tang (1975). Probability Concepts in Engineering Planning and Design. Vol. I. John Wiley and Sons, New York.

Ang, A. H.-S., and W.H. Tang (1984). Probability Concepts in Engineering Planning and Design. Vol. II. John Wiley and Sons, New York.

Avallone, E.A., and T. Baumeister III (1978). Marks' Standard Handbook for Mechanical Engineers. 9th ed. McGraw-Hill, Inc., New York.

Cornell, C. A. (1968) "Engineering Seismic Risk Analysis," Bulletin of Seismological Society of America, Vol. 58, No. 5, pages 1583-1606.

Der-kiureghian, A., and A. H.-S. Ang (1977). "A Fault-Rupture Model for Seismic Risk Analysis." Bulletin of Seismological Society of America. Vol. 67, No. 4, August.

Donovan, N.C. (1973). A Statistical Evaluation of Strong Motion Data Including the Feburary 9, 1971 San Fernando Earthquake. Proc. of Fifth World Conference on Earthquake Engineering. EERI, Rome, Italy.

Federal Emergency Management Agency, United States Fire Administration (1991). The Loma Prieta (San Francisco /Monterey Bay) Earthquake. Report Prepared by the National Fire Protection Association, Fire Investigations Department, Grant EMW-90-G-3440, September.

Itoigawa, E., and I. Tsukagoshi (1988). Stochastic Model for Fire Spread in Urban Areas Based on Fire Brands Effect. Proc. of 2nd Japan-U.S. Workshop on Urban Earthquake Hazard Reduction. Institute of Social Safety, Japan, and Earthquake Eng. Research Institute, USA. 223-233.

Longinow, A., J. Mohammadi, and T. A. Williams (1989). "Analysis of Risk Associated with Interior Gas Distribution Systems." Topical Report. Gas Research Institute, Chicago.

Longinow, A. et al (1990). "Load and Environmental Effects on Interior Gas Piping Systems." Final Technical Report #GRI-90/0132: 4.1-1.4. Prepared for Gas Research Institute, by Wiss, Janney, Elstner Associates, Northbrook, Illinois.

Mizuno, H. (1987). "On Outbreak of Fires in Earthquakes." Dissertation, Dept. of Architecture. Kyoto University, Kyoto.

Mohammadi, J. (1990). "Earthquakes and Earthquake-Resistant Design. Cost Engineering 32: 12-17.

Mohammadi, J., A. Longinow, and T. A. Williams (1991). "System Reliability Using Expert Opinions." Structural Safety.

Mohammadi, J., and S.-J. Suen (1991). "Effect of Source Parameters in Seismic Hazard Analysis." European Earthquake Engineering.

National Fire Protection Agency (1986). Fire Protection Handbook. 16th ed. NFPA.

Newmark, N. M., and E. Rosenblueth (1971). Fundamentals of Earthquake Engineering. Prentice-Hall, Inc. Englewood Cliffs, N.J.

Popov, E. P. (1968). Introduction to Mechanics of Solids. Prentice Hall, Englewood Cliffs, NJ, Page 319.

San Francisco Fire Department (1990-1992). Various Personal, Correspondence, and Communications.

Scawthorn, C. G., and Y. Yamada (1981). Lifeline Effects on Post-Earthquake Fire Risk. Lifeline Earthquake Engineering: The Current State of Knowledge. Proc. of the 2nd Specialty Conference of the Technical Council on Lifeline Earthquake Engineering. Ed. D.J. Smith, Jr. American Society of Civil Engineers, New York.

Scawthorn, C. G. (1985). "Post-Earthquake Fire", Proceedings- U.S.- Japan Workshop on Urban Earthquake Hazard Reduction. Publication No. 85-03, EERI, Berkeley, CA, Pages 237-243.

Scawthorn, C.G. (1986). Simulation Modeling of Fire Following Earthquake. Proc. of 3rd U.S. National Conf. on Earthquake Engineering. Vol. III.

Scawthorn, C.G. (1987). Fires Following Earthquakes. Proc. of 1st International Symp. on Fire Safety Science. Hemisphere, New York.

Scawthorn, C.G. (1988). Fire and Hazardous Materials Following Earthquake: U.S. Perspectives. Proc. of 2nd Japan-United States Workshop on Urban Earthquake Hazard Reduction. Inst. of Social Safety, Japan, and Earthquake Eng. Res. Inst., USA. 234-243.

Schiff, A.J. (1985). "Life Lines", Proceedings- U.S.- Japan Workshop on Urban Earthquake Hazard Reduction. Publication No. 85-03, EERI, Berkeley, CA, Pages 243-249.

Schiff, A.J. (1988). "The Whittier-Narrows, California Earthquake of October 1, 1987." Earthquake Spectra 4.

Shakal A., et al. (1989). "CSMIP Strong-Motion Records from the Santa Cruz Mountains(Loma Prieta), California Earthquake of 17 October 1989," Report No. OSMS 89-06, California Strong Motion Instrumentation Program,California Department of Conservation, Sacramento, CA.

Smith, L.E., and D. McCoskrie (1990). "What Causes Wiring Fires in Residences." Fire Journal. Jan./Feb. 19-24.

Steinbrugge, K. V., R. Bush, and E. Zacher (1973). "San Fernando Earthquake February 9, 1971." Pacific Fire Rating Bureau, San Francisco.

Stussman, H. B., and J. J. Kosowatz (1989). "Utility Lines Stood Up Quite Well." Engineering News Record. 26 Oct.

URS Corporation (1988). "Risk of Earthquake-Induced Gas Fires in Residential Housing." Report Prepared for Southern California Gas Company. URS Corporation, San Francisco.

APPENDIX A

THE MODIFIED MERCALLI INTENSITY SCALE

THE MODIFIED MERCALLI INTENSITY SCALE
(Excerpted from Suen 1988)

Mercalli's improved intensity scale served as a basis for the scale advanced by Wood and Neumann, known as the modified Mercalli scale and commonly abbreviated MM. The modified version is described below with some improvements (Newmark and Rosenblueth, 1971).

To eliminate many verbal repetitions in the original scale, the following convention has been adopted. Each effect is named at the level of intensity at which it first appears frequently and characteristically. Each effect may be found less strongly, or in fewer instances, at the next lower grade of intensity; more strongly or more often at the next higher grade. A few effects are named at two successive levels to indicate a more gradual increase.

Masonry A, B, C, D. To avoid ambiguity of language, the quality of masonry, brick or otherwise, is specified by the following lettering (which has no connection with the conventional Class A, B, C construction).

Masonry A. Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B. Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C. Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D. Weak materials, such as adobe; poor mortar;

low standards of workmanship; weak horizontally.

Modified Mercalli Intensity Scale of 1931 (Abridged and Rewritten by C. F. Richter.)

1. Not felt. Marginal and long-period of large earthquakes.
2. Felt by persons at rest, on upper floors, or favorably placed.
3. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
4. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of 4, wooden walls and frames crack.
5. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
6. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, and so on, off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken visibly, or heard to rustle.
7. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D including cracks. Weak chimneys broken at roof

line. Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets, and architectural ornaments. Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged

8. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and walls. Cracks in wet ground and on steep slopes.

9. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. General damage to foundations . Frame structures, if not bolted, shifted off foundations. Frames racked. Conspicuous cracks in ground. In alleviated areas sand and mud ejected, earthquake fountains, sand craters.

10. Most masonry and frame structures destroyed with their foundations. Some well-build wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted

horizontally on beaches and flat land. Rails bent slightly.

11. Rails bent greatly. Underground pipelines completely out of service.
12. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

APPENDIX B

SAMPLE COMPUTATIONS FOR PROBABILITY OF FIRE

SAMPLE COMPUTATIONS FOR PROBABILITY OF FIRE

B.1 Gas Related Fires

The following computation is done for an acceleration level equal to 0.20g and Type A heater as an example. Equations 3.1 are used for calculating P(C).

$P(C|E) = 1.0$ if leak is not detected

$P(C|E) = 0.14$ if leak is detected

$P(E|D) = 0.5$

$P(D|B) = 0.5$

$P(E|F) = 0.50$

$P(F|\bar{D}) = 0.50$

$P(\bar{D}|B) = 0.50$

$P(B|A) = 0.352$ (For 0.2g acceleration, Type A heater without straps, see Table 4.5).

$P(B|A) = 0.00132$ (For the gas piping system for a typical Single Family dwelling, see Section 4.1).

Thus, the heater failure dominates. Probability of fire from Eqs. 3.1 given 0.20g acceleration is:

$$P(C|A)=[0.14 \times 0.5 \times 0.50 + 1.0 \times 0.50 \times 0.5 \times 0.5] \times 0.352=0.0563$$

Considering the probability for the event A, i.e.

$P(A) = 0.037 - 0.018 = 0.019$ (From Table 5.1), then:

$P(C|A)P(A) = 0.0563 \times 0.019 = 0.00107$

These are given in Table 5.2 for 0.20g, and the case where no straps are used. Similar calculations are done for other accelerations, heater types with or without straps.

B.2 Electric Fires

The following computation is done for an acceleration level equal to 0.20g. The risk value computed in Chapter IV and reported in Table 4.14 for 0.20g is 2.229E-03.

Thus, $P(C|A) = 2.229E-03$

Considering the probability of having the acceleration 0.20g, i.e.

$P(A) = 0.019$, then:

$P(C|A)P(A) = 2.229E-03 \times 0.019 = 4.235E-05$

These estimates are reported in Table 5.6.

Similar calculations can be done for other acceleration levels. Note that the above simple procedure was used instead of Eqs. 3.2 because of the fact that the estimates for the risk of electric fires given an acceleration level was calculated without any specific reference to the intermediate events depicted in Fig. 3.2. This was done due to the fact that no information was available to quantify the intermediate events in the tree of Fig. 3.2.

APPENDIX C

FIRE INCIDENT REPORTS FOR THE CITY OF SAN FRANCISCO

(OCT. 17-20)

SAN FRANCISCO FIRE DEPARTMENT

FIRE INCIDENT REPORT

San Francisco FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

8079

Date 10/17/89 Time 21:30

( ) Box / No. 8422 (X) Unit Disp. / Co. No. E-33

1. K. DINTCEO
2. 150 Pont Blvd. — 1F — San Francisco — 9,4,1,3,2
3. Same — Same
4. Parkmerced Apts.

A. INFORMATION (PAGE 17)

1. 3,8,0,0,5 | 0,0,8,6 | | 2,1:3,0,1,0,1,7,8,9,5,5,0,9

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1,1 | Building Fire
2. 4,2 | Apartment Complex
3. 4,2,4 | Apartments

C. PROPERTY TYPE (PAGE 41)

2 | Building Type 1 — 0,3

D. EXTENT OF DAMAGE (PAGE 45)

1. 2 | Confined to area of origin.
2. 2 | " " " " "
3. 2 | " " " " "
4. 2,1,0,0,0 | 1,1,0,0,0

E. LOCATION & CAUSE (PAGE 49)

1,0,2 | Second Floor
4,6 | Lamp
5,4 | Electric Lamp
8,2 | Earthquake

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1. 1,4 | Living Room
2. 6,9 | Paper
3. 2,1 | Chair
4. 0,1 | Ceiling

G. SPREAD OF FIRE (PAGE 77)

0,1 | Ceiling
6,8 | Cardboard
2,0 | Furniture
8,2 | Earthquake

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

MAIN FIRE BLDG.

FIRE INCIDENT REPORT

San Francisco Fire Department

State of California, Office of the State Fire Marshal

Date 10/17/89 Time 1710

Incident No. 0,3,0,2,7

(X) Box / No. E-19 ( ) Unit Disp. / Co. No.

1	Ramone Lang	Renter	
2	354 Byxbee	S.F.	334-1872
3	Ted McCann	?	Belmont, CA
4			

A. INFORMATION (PAGE 17)

1	3 8 0 0 5			1,5	1,0 1,7 8,9 3	0,9

B. PROPERTY CLASSIFICATION (PAGE 19)

1	1,1 Bldg. Fire
2	
3	4,1,1 Dwelling, Sin. Fam.

C. PROPERTY TYPE (PAGE 41)

1	XX
2	1 Building Type 5 — 2
3	

D. EXTENT OF DAMAGE (PAGE 45)

1	5 Spread Beyond Bldg.
2	5 " " "
3	5 " " "
4	1,5,010,0,0 — 5,010,0,0

E. LOCATION & CAUSE (PAGE 49)

1	1,0,1 Ground Floor
2	4,1 Fixed Wiring
3	2,5 Short Circuit Arc, Unspec.
4	5,5 Electrical Failure

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1	2,1 Bedroom
2	6,3 Wood, Sawn
3	1,7 Structural Member or Framing
4	12 Exterior of Bldg.

G. SPREAD OF FIRE (PAGE 77)

1	0,2 Exterior of Bldg.
2	6,3 Wood, Sawn
3	1,2 Exterior Sidewall Covering
4	6,5 Prop. Too Close, Exposure

H. PROTECTION FACILITIES (PAGE 91)

1	
2	
3	
4	
5	
6	

I. PROTECTION FACILITIES (PAGE 91)

1	
2	
3	
4	
5	
6	
7	
8	

J. MISCELLANEOUS (PAGE 109)

1	
2	

FIRE INCIDENT REPORT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

San Francisco FIRE DEPARTMENT

Date 10-17-89 Time 17:33

Incident No. 3,0,4,7

( ) Box / No.________ (X) Unit Disp. / Co. No.______

1	Occupant name: Unknown	Relationship: Unknown
2	Address: 3723-25 Divisadero St.	City: San Francisco; Zip: 9,4,1,2,3; Telephone no.: Unknown
3	Owner name: Unknown	
4		

A. INFORMATION

Fire Dept. ID	Incident No.	Exposure No.	Time	Month	Day	Year	Day
3,8,0,0,5	3,5,5,5	4	1,7,2,4	1,0	1,7	8,9	3

B. PROPERTY CLASSIFICATION

1. 1,1 Building fire.
2.
3. 4,2,1 Two flats.

C. PROPERTY TYPE

2. 1 Building Type 5 — 3

D. EXTENT OF DAMAGE

1. 5 Spread beyound building of exposure.
2. 5
3. 5
4. Estimated loss – property: 1,8,0,0,0,0,0; Estimated loss – contents: 1,5,0,0,0,0

E. LOCATION & CAUSE

1. Refer to B.F.I.

F. AREA, MATERIALS & SMOKE SPREAD

1. Refer to B.F.I.

G. SPREAD OF FIRE

1. Refer to B.F.I.

H. PROTECTION FACILITIES

I. PROTECTION FACILITIES

J. MISCELLANEOUS

8838

FIRE INCIDENT REPORT — San Francisco Fire Department

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/17/89 Time 2000

Incident No. 0 0 0 3 3

(x) Box / No. 6374 ( ) Unit Disp. / Co. No. E's 32&

Batt. 9 10 Div 3

1	GOODMAN LUMBER COMPANY	N.A.
2	445 BAYSHORE BLVD.	SAN FRANCISCO 9,41,2,4 415 334-9014
3	UNKNOWN	
4	NOT AVAILABLE	

#8038

A. INFORMATION (PAGE 17)

1 3,8,0,0,5 | 0 0 0 3 3 | 2,0,0, 10 17 18,0 3 | 5 | 1 0

B. PROPERTY CLASSIFICATION (PAGE 19)

1	1, 1 BUILDING FIRE
2	5, 8 SHOPPING COMPLE.
3	5, 5, 5 BUILDING SUPPLY STORER

C. PROPERTY TYPE (PAGE 41)

1	
2	3 Building Type 10,0,1
3	

D. EXTENT OF DAMAGE (PAGE 45)

1	2 CONFINED TO AREA OF ORGIN
2	4 CONFINED TO BUILDING OF ORGIN
3	2 CONFINED TO AREA OF ORGIN
4	1,0,0,0,0 — 5,0,00

E. LOCATION & CAUSE (PAGE 49)

1	1, 0,1 GROUND FLOOR
2	5, 5 GENERATOR (PROPANE FUELED)
3	1, 2 HEAT FROM GAS FUELED EQUIPMENT
4	5, PART FAILURE (BREAK IN PIPE EARTHQUAKE)

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1	7, 6 EXTERIOR WALL SURFACE
2	1, 4 L. P. GAS
3	1 2 EXTERIOR SIDEWALL FINISH
4	0, 2 EXTERIOR OF BUILDING

G. SPREAD OF FIRE (PAGE 77)

1	0,2 EXTERIOR OF BUILDING
2	1,4 L. P. GAS
3	1,2 EXTERIOR SIDEWALL
4	5,1 PART FAILURE (BREAK IN PIPE EARTHQUAKE)

H. PROTECTION FACILITIES (PAGE 91)

1	1 WET PIPE
2	1 NOT A FACTOR
3	1 WET
4	1 NOT A FACTOR
5	5 A. B. C.
6	1 NOT A FACTOR

I. PROTECTION FACILITIES (PAGE 97)

1	
2	
3	
4	
5	
6	
7	
8	

J. MISCELLANEOUS (PAGE 100)

1	
2	

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-17-89 Time 1733

Incident No. 3 0 4 7

( ) Box / No. E16, RS11, B4 (X) Unit Disp. / Co. No.

1	Unknown	Renters	X
2	2130 Beach St.	San Francisco 9 4 1 2 3	Unknown
3	Unknown		
4	Unknown		

A. INFORMATION (PAGE 17)

1	3 8 0 0 5	3 5 5 5	1	1 7 2 4	1 0	1 7	8 9	3		0 4

B. PROPERTY CLASSIFICATION (PAGE 19)

	Code	
1	1 1	Building fire. [X]
2		
3	4 2 3	Apartments 7-20 units.

C. PROPERTY TYPE (PAGE 41)

1	[X]	
2	1	Building Type 5 — 3
3		

D. EXTENT OF DAMAGE (PAGE 45)

	Code	
1	9	Spread from exposure.
2	5	Spread beyound building of exposure.
3	5	
4	1 5 0 0 0 0 0 0	1 2 5 0 0 0

E. LOCATION & CAUSE (PAGE 49)

	Code	
1		Refer to B.F.I.
2		
3		
4		

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

	Code	
1		Refer to B.F.I.
2		
3		
4		

G. SPREAD OF FIRE (PAGE 77)

	Code	
1		Refer to B.F.I.
2		
3		
4		

H. PROTECTION FACILITIES (PAGE 91)

	Code	
1		
2		
3	0	Unknown
4	0	Unknown
5	0	Unknown
6	0	Unknown

I. PROTECTION FACILITIES (PAGE 97)

	Code	
1		
2		
3		
4		
5	0	Unknown — 0 Unknown
6	0	Unknown
7	0	Unknown
8		

J. MISCELLANEOUS (PAGE 103)

1		
2		

FIRE INCIDENT REPORT

San Francisco FIRE DEPARTMENT
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-17-89 Time 15:23

Incident No. 2,9,9,4

( ) Box / No.________ (x) Unit Disp. / Co. No. E3/B4

1. N/A | N/A | X
2. Intersection Octavia & California St. | San Francisco | 9,4,1,1,5 | N/A
3. P. G. & E. | 245 Market St. San Francisco Ca. 94105

A. INFORMATION (PAGE 17)

1. 3,8,0,0,5 | 2,9,9,4 | 1,5 2,3 | 1,0 | 1,7 | 8,9 | 3 | 0,4

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1,9 Under ground P.G.& E. Vault [X]
3. 6,4,2 Electrical vault.

C. PROPERTY TYPE (PAGE 41)

1. [X]
2. 7 Building Type 2 | 2,0,1

D. EXTENT OF DAMAGE (PAGE 45)

1. 2 Confined to area of origin.
2. 9 Not a factor.
3. 9 Not a factor.
4. None | 2,0,0,0,0

E. LOCATION & CAUSE (PAGE 49)

1. 2,0,1 One floor below ground.
2. 4,2 Transformer.
3. 2,4 Short circuit arc, unspecified.
4. 5,4 Short circuit or ground fault.

F. AREA MATERIALS & SMOKE SPREAD (PAGE 53)

1. 9,2 Public street.
2. 0,0 Insulating oil for switches.
3. 6,2 Transformer.
4. 3,2 Exterior / ground level.

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 100)

FIRE INCIDENT REPORT — STATE OF CALIFORNIA, OFFICE OF THE STATE FIRE MARSHAL — San Francisco Fire Department

8049

Date 10/17/89 Time 21:30

( ) Box / No. 8422 (X) Unit Disp. / Co. No. E-33

1	Occupant name: K. DINTCEO	
2	Address: 150 Font Blvd. Room/Apt. No.: 1F	City: San Francisco Zip: 94132
3	Owner name: Same	Address: Same
4	Business name: ParkMerced Apts.	

A. INFORMATION (PAGE 17)

1	Fire Dept. ID: 3 8 0 0 5	Incident No.: 0 0 8 6	Time: 2 1:3 0	Date: 1 0 1 7 8 9

B. PROPERTY CLASSIFICATION (PAGE 19)

	Code	Description
1	1 1	Building Fire
2	4 2	Apartment Complex
3	4 2 4	Apartments

C. PROPERTY TYPE (PAGE 41)

	Code	Description
2	2	Building Type 1 — Stories: 3

D. EXTENT OF DAMAGE (PAGE 45)

	Code	Description
1	2	Confined to area of origin.
2	2	" " " " "
3	2	" " " " "
4	Estimated loss – property: 2,000	Estimated loss – contents: 1,000

E. LOCATION & CAUSE (PAGE 49)

	Code	Description
1	1 0 2	Second Floor
2	4 6	Lamp
3	5 4	Electric Lamp
4	8 2	Earthquake

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

	Code	Description
1	1 4	Living Room
2	6 9	Paper
3	2 1	Chair
4	0 1	Ceiling

G. SPREAD OF FIRE (PAGE 77)

	Code	Description
1	0 1	Ceiling
2	6 8	Cardboard
3	2 0	Furniture
4	8 2	Earthquake

H. PROTECTION FACILITIES (PAGE 91)

	Code	Description
1		Sprinklers – Type
2		Sprinklers – Effectiveness
3		Standpipes – Type
4		Standpipes – Effectiveness
5		Portable extinguishers – Type
6		Portable extinguishers – Effectiveness

I. PROTECTION FACILITIES (PAGE 97)

Code	
	Private brigade – Type
	Private brigade – Effectiveness
	Special hazard protection – Type
	Special hazard protection – Effectiveness
	Signal or warning system – Type
	Signal warning system – Means of activation
	Signal warning system – Type detectors
	Watchman effectiveness / Other facilities effectiveness

J. MISCELLANEOUS (PAGE 109)

1	Firefighters: No. injured / No. of deaths	Civilians: No. injured / No. of deaths
2	SFM form 3011 submitted for each death — check box if yes ☐	

SFM Form 40-66 (7-73)

MAIN FIRE BLDG.

FIRE INCIDENT REPORT San Francisco Fire Department

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/17/89 Time 1710 Incident No. 0,3,0,2,7

(X) Box / No. E-19 ( ) Unit Disp. / Co. No.

Occupant name	Ramona Lang
Relationship	Renter
Alarm source	Tel. XX
Address	354 Byxbee
City	S.F.
Telephone no.	334-1872
Owner name	Ted McCann
Owner address	?
Owner city	Belmont, CA

A. INFORMATION (PAGE 17)

Fire Dept. ID	Incident No.	Exposure No.	Time	Month Day Year	Day	Census Tract	Dist.	Out of Jurisdiction
3 8 0 0 5			1 5	1 0 1 7 8 9	3		0 9	

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1,1 Bldg. Fire
2.
3. 4,1,1 Dwelling, Sin. Fam.

C. PROPERTY TYPE (PAGE 41)

1. XX
2. 1 Building Type 5 — 2
3.

D. EXTENT OF DAMAGE (PAGE 45)

1. 5 Spread Beyond Bldg.
2. 5 " " "
3. 5 " " "
4. Estimated Loss - Property: 1,5,0,0,0,0,0 — Estimated Loss - Contents: 5,0,0,0,0

E. LOCATION & CAUSE (PAGE 48)

1. 1,0,1 Ground Floor
2. 4,1 Fixed Wiring
3. 2,5 Short Circuit Arc, Unspec.
4. 5,5 Electrical Failure

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1. 2,1 Bedroom
2. 6,3 Wood, Sawn
3. 1,7 Structural Member or Framing
4. 12 Exterior of Bldg.

G. SPREAD OF FIRE (PAGE 77)

1. 0,2 Exterior of Bldg.
2. 6,3 Wood, Sawn
3. 1,2 Exterior Sidewall Covering
4. 6,5 Prop. Too Close, Exposure

H. PROTECTION FACILITIES (PAGE 81)

I. PROTECTION FACILITIES (PAGE 87)

J. MISCELLANEOUS (PAGE 109)

39

FIRE INCIDENT REPORT — San Francisco Fire Department

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-17-89 Time 17:33

Incident No. 3.0.4.7

( ) Box / No.______ (X) Unit Disp. / Co. No.______

Occupant name: Unknown	Relationship: Unknown	
Address: 3735-37 Divisadero St.	City: San Francisco	Zip: 9,4,1,2,3 — Telephone: Unknown
Owner name: Unknown	Address:	
Manager name:	Address:	

A. INFORMATION (PAGE 17)

Fire Dept. No.	Incident No.	Exposure No.	Time	Month	Day	Year	Day	District
3 8 0 0 5	3 5 5 5	6	1 7 2 4	1 0	1 7	8 9	3	0 4

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1,1 Building fire.
2.
3. 4,2,1 Two flats

C. PROPERTY TYPE (PAGE 41)

1 Building Type 5 — 3

D. EXTENT OF DAMAGE (PAGE 45)

1. 3 Confined to floor of exposure.
2. 3
3. 4 Confined to building of exposure.
4. Estimated loss – property: 1,0,0,0,0,0 — Estimated loss – contents: 2,5,0,0,0

E. LOCATION & CAUSE (PAGE 49)

1. Refer to B.F.I.

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1. Refer to B.F.I.

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT — SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-17-89 Time 17:33

( ) Box / No.________ (X) Unit Disp. / Co. No.______

1	Unknown	Unknown	
2	2136-38 Beach St.	San Francisco 94123	Unknown
3	Unknown		
4			

A. INFORMATION (PAGE 17)

1 | 3 8 0 0 5 | 3 5 5 5 | 2 | 1 7 2 4 | 1 0 1 7 8 9 | 3 |

B. PROPERTY CLASSIFICATION (PAGE 19)

1 | 1 1 | Building fire.
2 |
3 | 4 2 1 | Two flats.

C. PROPERTY TYPE (PAGE 41)

1 | X |
2 | 1 | Building Type 5 | 3
3 |

D. EXTENT OF DAMAGE (PAGE 45)

1 | 4 | Confined to building of exposure.
2 | 4 |
3 | 4 |
4 | Estimated loss - property: 1,000,000 | Estimated loss - contents: 25,000

E. LOCATION & CAUSE (PAGE 49)

1 | Refer to B.F.I.
2 |
3 |
4 |

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1 | Refer to B.F.I.
2 |
3 |
4 |

G. SPREAD OF FIRE (PAGE 77)

1 |
2 |
3 |
4 |

H. PROTECTION FACILITIES (PAGE 91)

1 |
2 |
3 |
4 |
5 |
6 |

I. PROTECTION FACILITIES (PAGE 97)

1 |
2 |
3 |
4 |
5 |
6 |
7 |
8 |

J. MISCELLANEOUS (PAGE 105)

1 |
2 |

FIRE INCIDENT REPORT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

San Francisco Fire Department

Date 10-17-89 Time 17:33

Incident No. 3,0,4,7

( ) Box / No.________ (X) Unit Disp. / Co. No. E16

1	Occupant name: Unknown	Renters
2	Address: 3701 Divisadero St.	San Francisco 9 4 1 2 3 Unknown
3	Owner name: Unknown	
4	Manager name: Unknown	

A. INFORMATION (PAGE 17)

1	3 8 0 0 5	3 5 5 5	1 7 2 4 1 0 1 7 8 9

B. PROPERTY CLASSIFICATION (PAGE 19)

	Code	
1	1 1	Building fire.
2		
3	4 2 4	Apartments over 20-units.

C. PROPERTY TYPE (PAGE 41)

	Code	
2	1	Building Type 5

D. EXTENT OF DAMAGE (PAGE 45)

	Code	
1	5	Spread beyound building of origin.
2	5	-
3	5	-
4	2 5 0 0 0 0 0	4 0 0 0 0 0

E. LOCATION & CAUSE (PAGE 49)

	Code	
1		Refer to B.F.I.
2		
3		
4		

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

	Code	
1		Refer to B.F.I.
2		
3		
4		

G. SPREAD OF FIRE (PAGE 77)

	Code	
1		Refer to B.F.I.
2		
3		
4		

H. PROTECTION FACILITIES (PAGE 97)

	Code	
1	0	Unknown
2	0	-
3	0	-
4	0	-
5	0	-
6	0	-

I. PROTECTION FACILITIES (PAGE 97)

Code	
0	Unknown / 0 Unknown
0	Unknown

J. MISCELLANEOUS (PAGE 100)

1					
2					☐

#0133

FIRE INCIDENT REPORT San Francisco Fire Department

State of California, Office of the State Fire Marshal

#8003

Date 10/17/89 Time 1(0013)

(X) Box / No. 8175 ( ) Unit Disp. / Co. No.

1	Rose Adams	tennant		
2	965 Chennery	S F	9.4.1.3.1	585 1711
3				
4				

#8003

A. INFORMATION (PAGE 17)

3 8 0 0 5 | 0.0.1.3 | 10 1 1 7 8 9 | 3 | 6

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1, 1 Building Fire
2.
3. 4.1 ,1 single family

C. PROPERTY TYPE (PAGE 41)

Building Type 5 — 2

D. EXTENT OF DAMAGE (PAGE 45)

1. 2 confined to area
2. 2 " "
3. 2 " "
4. Estimated loss - property: 1 0,0,0 — Estimated loss - contents: 5,0,0

E. LOCATION & CAUSE (PAGE 49)

1. 0.2 second floor
2. 9, 8 no Equipment
3. 4.4 candle
4. 7, 1 overturned

F. AREA MATERIALS & SMOKE SPREAD (PAGE 53)

1. 2. 1 bedroom
2. 7, 2 cotton
3. 3.1 Mattress
4. 0, 1 ceilings

G. SPREAD OF FIRE (PAGE 77)

1. 0. 9 not a factor

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 105)

EXPOSURE # 1

FIRE INCIDENT REPORT — San Francisco Fire Department
State of California
Office of the State Fire Marshal

Date 10/17/89 Time 1710 — Incident No. 0 3 0 2 7

(X) Box / No. E-19 ( ) Unit Disp. / Co. No.

Occupant Name: Mable Hayter	Relationship: Owner	
Address: 350 Byxbee St.	City: S.F.	Telephone No.: 584-1026
Owner Name: Same	Address	
Name	Address	Telephone No.

A. INFORMATION (PAGE 17)

Fire Dept. ID	Incident No.	Exposure No.	Time	Month/Day/Year	Day	
3 8 0 0 5	0 3 0 2 7	0 0 1	1 7 1 0	10 / 17 / 89	3	0 0

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 1 Bldg. Fire
2.
3. 4 1 1 Dwelling, Sin. Fam.

C. PROPERTY TYPE (PAGE 41)

1. X
2. 1 Building Type 5 — 2
3.

D. EXTENT OF DAMAGE (PAGE 43)

1. 4 Bldg. of Orig.
2. 4 " " "
3. 4 " " "
4. Estimated Loss – Property: 1 0 0 0 0 0 — Estimated Loss – Contents: 1 5 0 0 0 0

E. LOCATION & CAUSE (PAGE 49)

1. 1 0 1 Ground Floor
2. 9 3 Separate Adjoining Object
3. 8 1 Direct Flame
4. 6 5 Prop. Too Close, Exposure Fire

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1. 7 6 Exterior Wall Surface
2. 6 3 Wood, Sawn
3. 1 2 Exterior Sidewall Covering
4. 0 2 Exterior of Bldg.

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT — San Francisco Fire Department
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-17-89 Time 17:33

( ) Box / No.________ (X) Unit Disp. / Co. No.______

1	Unknown	Unknown	
2	3729-31 Divisadero St.	San Francisco 9,4,1,2,3	Unknown
3	Unknown		
4			

A. INFORMATION (PAGE 17)

3,8,0,0,5 | 3,5,5,5 | 5 | 1,7,2,4 | 1,0 | 1,7 | 8,9 | 3 | 02

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1,1 Building fire. [X]
2.
3. 4,2,1 Two flats.

C. PROPERTY TYPE (PAGE 41)

[X]
1 Building Type 5 — 3

D. EXTENT OF DAMAGE (PAGE 45)

1. 5 Spread beyound building of exposure.
2. 5
3. 5
4. 8,0,0,0,0,0 | 5,0,0,0,0

E. LOCATION & CAUSE (PAGE 49)

1. Refer to B.F.I.

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1. Refer to B.F.I.

G. SPREAD OF FIRE (PAGE 77)

1. Refer to B.F.I.

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 105)

Computer 8020

FIRE INCIDENT REPORT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

SAN FRANCISCO FIRE DEPARTMENT

Date 10/17/89 Time 17:15

Incident No. 85001

( ) Box / No. 4522 E21, 65 (X) Unit Disp. / Co. No. ____

1 Occupant name: MR. McARTHY	Relationship: TENANT	
2 Address: 3739 LOYOLA TERRACE	City: SAN FRANCISCO	Zip: 94117
3 Owner name: MR. HOWARD JUNKER (UNKNOWN)		
4		

A. INFORMATION (PAGE 17)

Fire Dept. ID	Incident No.	Exposure No.	Time / Month / Day / Year
38005			1715 10 17 89 E3 E7 E5

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 71 BUILDING FIRE
2.
3. 421 FLATS 2 UNITS

C. PROPERTY TYPE (PAGE 41)

1 Building Type 5 — 003

D. EXTENT OF DAMAGE (PAGE 45)

1. 3 CONFINED TO FLOOR OF ORIGIN
2. 4 CONFINED TO BUILDING
3. 4 CONFINED TO BUILDING
4. Estimated loss – property: 1,000.00; Estimated loss – contents: 500.00

E. LOCATION & CAUSE (PAGE 49)

1. 102 SECOND LEVEL
2. 21 STOVE
3. 12 GAS FUELED
4. 72 ACCIDENTALLY NOT TURNED OFF

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1. 24 KITCHEN
2. 57 FOOD
3. 76 COOKING MATERIAL
4. 07 HORIZONTAL

G. SPREAD OF FIRE (PAGE 77)

1. 09 NOT A FACTOR
2.
3.
4.

H. PROTECTION FACILITIES (PAGE 91)

1. Sprinklers – type
2. Sprinklers – effectiveness
3. Standpipes – type
4. Standpipes – effectiveness
5. Portable extinguishers – type
6. Portable extinguishers – effectiveness

I. PROTECTION FACILITIES (PAGE 97)

Private brigade – type
Private brigade – effectiveness
Special hazard protection – type
Special hazard protection – effectiveness
Signal warning system – type – effectiveness
Signal warning system – means of activation
Signal warning system – type detectors
Watchman effectiveness – Other facilities effectiveness

J. MISCELLANEOUS (PAGE 109)

1. Fire fighters: no. injured, no. of deaths; Civilians: no. injured, no. of deaths
2. Std form 801-1 submitted for each death ☐

SFM Form 60-AC (7-73)

Ring the Co → won't take without consent 8875

FIRE INCIDENT REPORT — San Francisco Fire Department
State of California, Office of the State Fire Marshal

Date 10-17-89 Time 2:16 Incident No. 8875

(X) Box / No. 8631 ( ) Unit Disp. / Co. No.

Occupant name	Mrs Diamond
Address	69 Castenada Av.
City	S.F.
Zip	94131
Owner name	Mrs Diamond
Owner address	69 Castenada Av. S.F. 94131

A. INFORMATION (PAGE 17)

Fire Dept. ID	Incident No.	Month	Day	Year	Day	Census	Tract
38005	00013	10	17	89	3	SF	08

B. PROPERTY CLASSIFICATION (PAGE 19)

	Code	
1	11	Building Fire
2		
3	411	Dwelling 1-family

C. PROPERTY TYPE (PAGE 41)

Code	Description
1	Building Type Single Occup. 002

D. EXTENT OF DAMAGE (PAGE 45)

	Code	
1	2	Confined to area of origin
2	2	" " " " "
3	2	" " " " "

E. LOCATION & CAUSE (PAGE 49)

	Code	
1	101	Ground Floor
2	00	Unknown
3	00	Undetermined
4	82	Earthquake

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

	Code	
1	43	Storage room
2	11	Natural gas
3	14	Flooring
4	04	Other vertical openings

G. SPREAD OF FIRE (PAGE 77)

	Code	
1	00	Not a factor
2	11	Natural Gas
3	17	Wood framing
4	82	Earthquake

H. PROTECTION FACILITIES (PAGE 97)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/17/89 Time 1549

Incident No. 0 3 0 0 5

(X) Box / No. 6141 ( ) Unit Disp. / Co. No.

1 Occupant name: Eleina Rivera	Relationship: Owner	
2 Address: 718 Brazil Ave.	City: S.F.	Telephone no.: 587-9697
3 Owner name: Same	Address:	City:
4 Manager name:	Address:	City:

A. INFORMATION (PAGE 17)

Fire dept. ID	Incident no.	Exposure no.	Time	Month	Day	Year
3 8 0 0 5	0 3 0 0 5		1 5 4 9	1 0	1 7	8 9

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 1 Bldg. Fire
2.
3. 4 1 1 Dwelling, Sin. Fam.

C. PROPERTY TYPE (PAGE 41)

1. [X]
2. 1 Building Type 5 — No. stories 2
3.

D. EXTENT OF DAMAGE (PAGE 45)

1. Extent of damage – fire: 2 Area of Orig.
2. Extent of damage – smoke: 2 " " "
3. Extent of damage – water:
4. Estimated loss – property: 0 Estimated loss – contents: 1, 0

E. LOCATION & CAUSE (PAGE 49)

1. Level of origin: 1 0 2 Second Floor
2. Source of heat causing ignition: 2 1 Stove
3. Form of heat causing ignition: 1 2 Gas Fueled Equipt.
4. Act or omission causing ignition: 5 1 Leak

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1. Area of origin: 2 4 Kitchen
2. Type of material first ignited: 1 1 Nat'l. Gas
3. Form of material first ignited: 6 5 Fuel
4.

G. SPREAD OF FIRE (PAGE 77)

1.
2.
3.
4.

H. PROTECTION FACILITIES (PAGE 91)

1. Sprinklers – type
2. Sprinklers – effectiveness
3. Standpipes – type
4. Standpipes – effectiveness
5. Portable extinguishers – type
6. Portable extinguishers – effectiveness

I. PROTECTION FACILITIES (PAGE 97)

1. Private hydrants – type
2. Private hydrants – effectiveness
3. Special hazard protection – type
4. Special hazard protection – effectiveness
5. Type / Code / Effectiveness
6. Signal warning system – means of activation
7. Alarm warning system – type detectors
8. Watchman effectiveness / Other protection type

J. MISCELLANEOUS (PAGE 109)

1. Firefighters: no. injured, no. of deaths | Civilians: no. injured, no. of deaths
2. Check box if yes [ ]

SFM Form (1-60 7-73)

FIRE INCIDENT REPORT San Francisco FIRE DEPARTMENT
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-17-89 Time 08:15 Incident No. 2,9,1,0

(X) Box / No. 1543 ( ) Unit Disp. / Co. No.

Occupant name: Miss Carpender	Relationship: Renter		
Address: 830 Post St. Rm. 17	City: San Francisco	Zip: 9,4,1,0,9	Telephone: Unknown
Owner name: Unknown	Address:		
Name: Miss Reinesch	Address: 830 Post. S.F. Ca. 94109 Rm. 14		Telephone: 928 - 4467

A. INFORMATION (PAGE 17)

Fire dept. ID	Incident No.	Exposure No.	Time	Month Day Year		
3,8,0,0,5	2,9,1,0		0,8,1,5	1,0 1,7 8,9		0,4

B. PROPERTY CLASSIFICATION (PAGE 18)

Code	
1. 1	Building fire.
4. 2. 3	Apartments 7-20 units.

C. PROPERTY TYPE (PAGE 41)

Code	
1	Building Type 3 (5)

D. EXTENT OF DAMAGE (PAGE 43)

Code	
1	Confined to materials first ignited.
1	" " " "
1	" " " "
Estimated loss - property: None	Estimated loss - contents: 1,0

E. LOCATION & CAUSE (PAGE 49)

Code	
1,0,4	Fourth floor.
2,1	Stove.
8,1	Direct flame.
7,3	Unattended.

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
2,4	Kitchen.
7,6	Cooking materials.
5,7	Food.
0,4	Verticle openings.

G. SPREAD OF FIRE (PAGE 77)

Code	

H. PROTECTION FACILITIES (PAGE 91)

Code	
	Sprinklers - type
	Sprinklers - effectiveness
4	Dry without permanent water supply.
1	Not a factor in oputcome.
5	For classes A, B & C type fires.
1	Not a factor in outcome.

I. PROTECTION FACILITIES (PAGE 97)

Code	
1	Local — 3 Satisfactory
2	Automatic detectors & pull stations.
2	Smoke.

J. MISCELLANEOUS (PAGE 100)

Firefighter No. injured	No. of deaths	Civilians No. injured	No. of deaths

FIRE INCIDENT REPORT — San Francisco Fire Department

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-17-89 Time 17:3?

Incident No. 13047

( ) Box / No.________ (X) Unit Disp. / Co. No._____

Occupant name: Unknown	Telephone: Unknown	
Address: 3717-19 Divisadero St.	City: San Francisco	Zip: 94123 · Telephone: Unknown
Owner name: Unknown		
Manager name:		

A. INFORMATION (PAGE 17)

Fire dept. ID	Incident no.	Exposure no.	Time	Month	Day	Year	Day
38005	3555	3	1724	10	17	89	3

B. PROPERTY CLASSIFICATION

Code	
11	Building fire.
421	Two flats.

C. PROPERTY TYPE

Code	
1	Building Type 5 · 3

D. EXTENT OF DAMAGE

Code	
5	Spread beyond exposure building.
5	
5	

Estimated loss - property: 180,000 · Estimated loss - contents: 50,000

E. LOCATION & CAUSE

Refer to ~~XXX~~ B.F.I.

F. AREA, MATERIALS & SMOKE SPREAD

Refer to B.F.I.

G. SPREAD OF FIRE

Refer to B.F.I.

H. PROTECTION FACILITIES

I. PROTECTION FACILITIES

J. MISCELLANEOUS

8062

FIRE INCIDENT REPORT — SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/17/89 Time 23:31

(X) Box / No. 4532 ( ) Unit Disp. / Co. No. ____

Address: 630 & 632 Cole Street	City: S.F.	Zip: 94117	
Owner Name: Dorris Kashavaroff	Address: 145 Merced Ave. S.F.	Zip: 94127	

A. INFORMATION (PAGE 17)

Fire Dept. ID	Incident No.	Month Day Year
38005	00009	10 17 89

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1.1	Building Fire
4.2.1	Flats (2 Units)

C. PROPERTY TYPE (PAGE 41)

1 Building Type 5

D. EXTENT OF DAMAGE (PAGE 45)

Code	
4	Confined To Building
4	Confined To Building
4	Confined To Building
Estimated Loss – Property: 2500.00	Estimated Loss – Contents: 500.00

E. LOCATION & CAUSE (PAGE 49)

Code	
1.0.1	Ground Floor
4.1	Electrical ~~etc.~~ Wiring
2.2	Short Circuit (Mechanical Dmg)
8.2	Earthquake

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
4.2	Closet
6.3	Wood
1.9	Lathe
C.7	Horizontal Openings

G. SPREAD OF FIRE (PAGE 77)

Code	
C.9	Not A Factor

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT — San Francisco FIRE DEPARTMENT

STATE OF CALIFORNIA

OFFICE OF THE STATE FIRE MARSHAL

Date [illegible] Oct 1[illegible] Time [illegible]

(x) Box / [illegible] 4443 ( ) Unit Disp. / Co. No.____

Incident No. 0, 3, 7, 5, 6

1 [illegible] Phein

2 3[illegible]7 Jackson St — San Francisco CA — 9 4 1 1 8

A. INFORMATION (PAGE 17)

1 | 3, 8, 0, 0, 5 | 0, 3, 7, 5, 6 | | 1, 0, 1, 6, 1, 0, 1, 6, 8, 9 | | 0, 7 |

B. PROPERTY CLASSIFICATION (PAGE 19)

1 1, 1 | [illegible] fire

2 |

3 4, 1, 1 | dwelling

C. PROPERTY TYPE (PAGE 41)

1 [illegible]

2 1 | Building Type 5

3 [illegible]

D. EXTENT OF DAMAGE (PAGE 43)

1 2 | confined to area first ign[illegible]

2 2 | area

3 2 | area

4 Estimated loss – property: 1,000.00 — Estimated loss – contents: 500

E. LOCATION & CAUSE (PAGE 49)

1 1, 0, 2 | 2nd floor

2 4, 8 | lamp

3 5, 6 | lamp bulb

4 8, 2 | earthquake

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1 1, 4 | sitting room

2 6, 7 | [illegible]

3 4, 3 | books

4 [illegible], 1 | ceiling

G. SPREAD OF FIRE (PAGE 77)

1 |

2 |

3 |

4 |

H. PROTECTION FACILITIES (PAGE 97)

1 |

2 |

3 |

4 |

5 |

6 |

I. PROTECTION FACILITIES (PAGE 97)

1 |

2 |

3 |

4 |

5 |

6 |

7 |

8 |

J. MISCELLANEOUS (PAGE 109)

1 |

2 [illegible] ☐

SFM Form [illegible]

FIRE INCIDENT REPORT — San Francisco Fire Department

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/16/89 Time 2048 — Incident No. 0,4,1,4,7

( ) Box / No. 1641 (x) Unit Disp. / Co. No. E 3

1	Occupant name: Cal Dreucher	Occupation: Tenant/manager
2	Address: 1020 Larkin Street # 106	City: San Francisco — Zip: 9,4,1,0,9
3	Owner name:	Address:
4		Address:

A. INFORMATION (PAGE 17)

Fire Dept. ID	Incident No.	Exposure No.	Time	Month	Day	Year
3 8 0 0 5	0 4 1 4 7		2 0 4 8	1 0	1 8	8 9

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1,1 | Building fire
2. ,|
3. 4,2,2 | Flats

C. PROPERTY TYPE (PAGE 41)

2 | Building Type 5 — 0 0 3

D. EXTENT OF DAMAGE (PAGE 45)

1. 1 | Confined to material first ignited
2. 2 | Confined to area of origin
3. |
4. Estimated loss – property: 5,0 — Estimated loss – contents: 0

E. LOCATION & CAUSE (PAGE 49)

1. 1,0,2 | second floor
2. 2 6 | Barbeque
3. 4 7 | open fire
4. 4 9 | misuse of [illegible]

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1. 2.4 | Kitchen
2. 5 6 | briquettes
3. 7 6 | charcoal
4. |

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

San Francisco Fire Department
State of California
Office of the State Fire Marshal

Date 10/18/89 Time 2054 Incident No. 0 4 1 5 1

( ) Box / No. ______ (X) Unit Disp. / Co. No. E 3

1	Occupant name: Yvonne Smers	Relationship: Lessee	
2	Address: 1308 Larkin Street	City: San Francisco	Zip: 94109
3	Owner name:	Address:	
4		Address:	

A. INFORMATION (PAGE 17)

Fire dept ID	Incident no.	Exposure no.	Time	Month	Day	Year	Day	Census tract	Dist.
38005	04151		2054	10	17	89	2		04

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	Building fire
4 2 4	Flats

C. PROPERTY TYPE (PAGE 41)

Code	
2	Building Type 5

D. EXTENT OF DAMAGE (PAGE 45)

Code	
2	Confined to area of origin
2	Confined to area of origin
2	Confined to area of origin

Estimated loss - property: 1200; Estimated loss - contents: 1300

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0 2	Second floor
9 8	No equipment involved
4 4	Candle
4 6	Combustible to close to wall

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
2 5	Bathroom
5 9	Candle
5 9	Candle

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/18/89 Time 1637

Incident No. 0,3,9,8,9

( ) Box / No. 3365 ( ) Unit Disp. / Co. No.____

Ms Morgan	Tenant	
5 Galilee	S F	

A. INFORMATION (PAGE 17)

3,8,0,0,5	0,3,9,8,9		1,6,3,7	1,0	1,8	8,9

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 . 1 | Building Fire
2. |
3. 4 . 2 . 3 | Apartments 12 Units

C. PROPERTY TYPE (PAGE 41)

1.
2. 1 | Building Type 5 — 1 . 0 . 2
3.

D. EXTENT OF DAMAGE (PAGE 45)

1. 1 | Confined to material first ignited
2. 1 | " " " " "
3. 1 | " " " " "
4. 0 | 0

E. LOCATION & CAUSE (PAGE 49)

1. 1 0 2 | Second Floor
2. 2 1 | Stove
3. 1 . 2 | Gas Fueled
4. 7 . 3 | Unattended

F. AREA MATERIALS & SMOKE SPREAD (PAGE 53)

1. 2 4 | Kitchen
2. 5 . 7 | Food
3. 7 . 6 | Cooking Materials
4. 0 . 7 | Horizontal

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

San Francisco FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 18 Oct 89 Time 17:01

Incident No. 0 4 0 0 2

(X) Box / No. 1313 ( ) Unit Disp. / Co. No.

1	Rosita Young	Tenant	
2	754 Grant	San Francisco 94108	349-4281
3			
4			

A. INFORMATION (PAGE 17)

Fire Dept ID	Incident No	Exposure No	Time	Month	Day	Year	Day Code	Census	Dist
3 8 0 0 5	0 4 0 0 2		1 7 0 1	1 0	1 8	8 9	4	5	0 3

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	building fire
5 4 4	jewelry shop

C. PROPERTY TYPE (PAGE 41)

Code	
1	Building Type 5 — 3

D. EXTENT OF DAMAGE (PAGE 45)

Code	
1	confined to material first ignited
1	- - - - -
1	- - - - -
Estimated loss - property: 0 0	Estimated loss - contents: 0 0

E. LOCATION & CAUSE (PAGE 49)

Code	
2 0 1	basement one floor
9 8	no equipment
4 4	candle
7 3	unattended

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
2 7	office
7 2	cotton
3 4	wearing not on person
0 4	other verticle openings

G. SPREAD OF FIRE (PAGE 77)

Code	
0 9	not a factor

H. PROTECTION FACILITIES (PAGE 91)

Code	
	Sprinklers - type
	Sprinklers - effectiveness
	Standpipes - type
	Standpipes - effectiveness
5	for classes A,B,C
1	not a factor in outcome

I. PROTECTION FACILITIES (PAGE 97)

Code	
	Private brigade - type
	Private brigade - effectiveness
	Special hazard protection - type
	Special hazard protection - effectiveness
	Signal or warning system

J. MISCELLANEOUS (PAGE 109)

Firefighters: No. Injured	No. of Deaths	Civilians: No. Injured	No. of Deaths

SFM Form 50-60 (7 73)

FIRE INCIDENT REPORT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

SAN FRANCISCO FIRE DEPARTMENT

Date 10/18/89 Time 17:57

Incident No. 0 4 0 2 7

[X] Box / No. 7242 ( ) Unit Disp. / Co. No.

1	Occupant name: Marcella Harvey	Relationship:	Alarm source:
2	Address: 818-A 30th Ave., Room/Apt. no.: A	City: San Francisco, Zip: 19 4 1 2 1	Telephone no.: 221-1684
3	Owner name:	Address: City: Zip:	Census/Parcel no.:
4	Manager name:	Address: City: Zip:	Telephone no.:

A. INFORMATION (PAGE 17)

Fire Dept. No.	Incident No.	Exposure No.	Time	Month	Day	Year	Day	County	Dist	Out of jurisdiction
3 8 0 0 5	0 4 0 2 7		1 7 5 7	1 0	1 8	8 9		0 8	9	

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	Type of incident: Building fire
4 2	Property classification (general): Apartment house
4 2 2	Property classification (individual): Apartment house 4-units

C. PROPERTY TYPE (PAGE 41)

Code	
2	Building structure: Building Type 5

D. EXTENT OF DAMAGE (PAGE 45)

Code	
1	Extent of damage – fire: Confined to material first ignited
1	Extent of damage – smoke: Confined to material first ignited
1	Extent of damage – water: Confined to material first ignited
	Estimated loss – property: 0
	Estimated loss – contents: 0

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0 2	Level of origin: Second floor
2 1	Source of heat causing ignition: Stove
5 9	Form of heat causing ignition: Heat from hot object
7 3	Act or omission causing ignition: Unattended

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
2 4	Area of origin: Kitchen
5 7	Type of material first ignited: Food
7 6	Form of material first ignited: Cooking materials
0 9	Main avenue of smoke spread: Not a factor

G. SPREAD OF FIRE (PAGE 77)

Code	
0 9	Main avenue of fire spread: Not a factor
	Type material causing spread:
	Form material causing spread:
	Act or omission causing spread:

H. PROTECTION FACILITIES (PAGE 91)

Code	
	Sprinklers – type
	Sprinklers – effectiveness
	Standpipes – type
	Standpipes – effectiveness
	Portable extinguishers – type
	Portable extinguishers – effectiveness

I. PROTECTION FACILITIES (PAGE 97)

Code	
	Private systems – type
	Private systems – effectiveness
	Special hazard protection – type
	Special hazard protection – effectiveness
	Warning system – type / effectiveness
	Signal warning system – means of activation
	Signal warning system – type detectors
	Watchman effectiveness / Other fire lines effectiveness

J. MISCELLANEOUS (PAGE 109)

Firefighter no. injured	Firefighter no. of deaths	Civilian no. injured	Civilian no. of deaths

Separate form submitted for each death (check box if yes) [ ]

STM Form 63-60 (7 73)

FIRE INCIDENT REPORT

San Francisco FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/18/89 Time 0943

Incident No. 0 3 7 3 7

( ) Box / No. 4362 ( ) Unit Disp. / Co. No.

Occupant name	Gretha Evans
Relationship	Tenant
Address	1954 MC Allister
City	S F
Owner name	Bill Sfakiotokis
Address	11 Sagebush San Rafael

A. INFORMATION (PAGE 17)

3 8 0 0 5 | 0 3 7 3 7 | 0 9 4 3 | 1 0 1 8 8 9 | 5 | S F

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 1 Building fire
2.
3. 4 2 2 Flats

C. PROPERTY TYPE (PAGE 41)

Building Type 5

D. EXTENT OF DAMAGE (PAGE 45)

1. 1 Confined to material first ignited
2. 1
3. 1
4. Estimated loss – property: 0; Estimated loss – contents: 0

E. LOCATION & CAUSE (PAGE 49)

1. 1 0 3 Third Floor
2. 2 1 Stove
3. 1 2 Gas Fueled
4. 7 2 Unattended

F. AREA MATERIALS & SMOKE SPREAD (PAGE 53)

1. 2 4 Kitchen
2. 5 7 Food
3. 7 6 Cooking Materials
4. 0 7 Horizontal Openings

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 97)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT STATE OF CALIFORNIA, OFFICE OF THE STATE FIRE MARSHAL — San Francisco FIRE DEPARTMENT

Date 10/18/89 Time 20:22 — 0.4.1.3.0

(X) Box / No. 1542 ( ) Unit Disp. / Co. No.____

Occupant name: SALLY LACEY	Relationship: TENANT	
Address: 1040 BUSH ST #303	City: SAN FRANCISCO 94108	Telephone no.:
Owner name:	Address:	City / Zip / Telephone no.:
Manager name: MILDRED BRUCON	Address:	Telephone no.: 673-6768

A. INFORMATION (PAGE 17)

Fire dept ID: 3 8 0 0 5

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1.1	Building
4.2	APTS

C. PROPERTY TYPE (PAGE 41)

2 Building Type 3 — 4

D. EXTENT OF DAMAGE (PAGE 45)

Code	
2	CONFINED to AREA
1	CONFINED to material
1	CONFINED to material
Estimated loss - property: 100	Estimated loss - contents: 100

E. LOCATION & CAUSE (PAGE 49)

Code	
1.0.3	THIRD
9.8	No equipment involved
4.4	CANDLE
7.3	UNATTENDED

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 53)

Code	
2.1	Sleeping Room
6.5	Wood
2.5	CHEST OF DRAWERS

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

Code	
4	Dry
1	Not a Factor
5	ABC
4	Extinguished Fire

I. PROTECTION FACILITIES (PAGE 97)

Code	
1	Local — 3 Satisfactory
2	Auto & Manual
7	Smoke

J. MISCELLANEOUS (PAGE 100)

FIRE INCIDENT REPORT San Francisco Fire Department
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 18 Oct 89 Time 18:35 | Incident No. 0 4 0 4 6

(x) Box / No. 1557 ( ) Unit Disp. / Co. No.

Occupant name	Greg Higgs
Relationship	tenant
Address	1030 Larkin, Room/Apt No. 10, San Francisco 94109
Owner name	
Involved name	Arnie Gottlibb, see above

A. INFORMATION (PAGE 17)

Fire Dept ID 3 8 0 0 5 | Incident No. 0 4 0 4 6 | Time 1 8 3 5 | 1 0 | 1 8 | 8 9 | 5 | 0 3

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 1 building fire
2.
3. 4 2 4 apartment over 20 units

C. PROPERTY TYPE (PAGE 41)

1 Building Type 5 — 4

D. EXTENT OF DAMAGE (PAGE 45)

1. 2 confined to area of origin
2. 2 — smoke
3. 2 — water
4. Estimated loss – property 1,200.00; Estimated loss – contents 300.00

E. LOCATION & CAUSE (PAGE 49)

1. 1 0 2 second floor
2. 9 8 no equipment
3. 3 1 cigarette
4. 3 1 unattended

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1. 2 1 bedroom
2. 6 7 paper
3. 7 5 rubbish
4. 0 9 not a factor

G. SPREAD OF FIRE (PAGE 77)

1. 0 0 not a factor

H. PROTECTION FACILITIES (PAGE 91)

1. Sprinklers – type
2. Sprinklers – effectiveness
3. 4 dry (standpipes – type)
4. 1 not a factor (standpipes – effectiveness)
5. 5 for classes A B C (portable extinguishers – type)
6. 1 not a factor (portable extinguishers – effectiveness)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT — STATE OF CALIFORNIA, OFFICE OF THE STATE FIRE MARSHAL — San Francisco FIRE DEPARTMENT

Date 10/18/89 Time 13:06 Incident No. 0 3 8 6 2

( ) Box / No. ____ (X) Unit Disp. / Co. No. E 34

1	Occupant name: Curtis Huth	Relationship: Tenant
2	Address: 300 16TH Ave Apt. 402	City: San Francisco; Telephone: 387-5853
3	Owner name: Mr. Woo	
4	Manager name: Mrs. Wilson	Address: Same Apt. 102

A. INFORMATION (PAGE 17)

3 8 0 0 5 | 0 3 8 6 2 | | 1 3 0 6 | 1 0 | 1 8 | 8 9 | 2 | 0 7

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 1 Building Fires
2. 1
3. 4 2 3 Apartments

C. PROPERTY TYPE (PAGE 41)

2. 2 Building Type 5 — 0 0 0

D. EXTENT OF DAMAGE (PAGE 45)

1. 1 Confined to material first ignited
2. 1 "
3. 1 "
4. Estimated loss – property: 0 0; Estimated loss – contents: 50

E. LOCATION & CAUSE (PAGE 49)

1. 1 0 4 Fourth floor
2. 2 1 Stove
3. 5 7 Improperly opr. elec. heat equip.
4. 4 6 Combustible to close

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1. 2 4 Kitchen
2. 2 9 Wine vinegar
3. 9 9 Not Classified
4. 0 9 Not a factor

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

1. 5 Combination
2. 1 Not a factor
3. 4 Dry
4. 1 Not a factor
5. 2 B & C
6. 4 Ext. fire

I. PROTECTION FACILITIES (PAGE 97)

5. 1 Local — Not installed
6. 2 Auto & Manual
7. 2 Smoke

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT — San Francisco Fire Department
State of California, Office of the State Fire Marshal

Date 10/18/89 Time app. 11:30 — Incident No. 0.0.0.0.2

(X) Box / No 7332 — ( ) Unit Disp. / Co. No. ____

Occupant name	Relationship
Mrs. Harris	Tenant

Address	City	Zip
1256-6th Ave.	San Francisco	19.4. 1 22

A. Information (Page 17)

Fire Dept No.	Incident No.	Exposure No.	Time	Month	Day	Year	Day
3 8 0 0 5	0 0 0 0 0		1 1 3 0	1 0	1 8	8 9	

B. Property Classification (Page 19)

Code	Description
1 .1	Building fire
4 .2	Apartment house
4 .1 .4 .2	unit apartment house

C. Property Type (Page 41)

Code	Description
2	Building Type 5

D. Extent of Damage (Page 45)

Code	Description
1	confined to material first ignited
1	Confined to material first ignited
	Confined to material first ignited

Estimated loss – property: .0 — Estimated loss – contents: .0

E. Location & Cause (Page 49)

Code	Description
1 0 2	Second floor
2 1	Stove
5 9	Heat from hot object
7. 3	Unattended

F. Area, Materials & Smoke Spread (Page 63)

Code	Description
2 4	Kitchen
6 7	Paper
7 5	Trash
0 9	Not a factor

G. Spread of Fire (Page 77)

H. Protection Facilities (Page 91)

I. Protection Facilities (Page 97)

J. Miscellaneous (Page 109)

SFM Form 60-80 (7 73)

FIRE INCIDENT REPORT — STATE OF CALIFORNIA, OFFICE OF THE STATE FIRE MARSHAL — San Francisco Fire Department

Date 10/18/89 Time 0917 Incident No. 3,6,7,3

( ) Box / No. ________ (X) Unit Disp. / Co. No. E21/T5

Occupant name: Sacred Grounds Restaurant	Relationship: n/a			
Address: 2095 Hayes St.	City: San Francisco	Zip: 9,4,1,1,7		
Owner name: Valerie Hararah	Address: 2095 Hayes St.	City: S.F.	Zip: 94117	

A INFORMATION (PAGE 17)

3 8 0 0 5	3.6.7.3	0.8.1.7 10 1.8 8.9 0	S T 0 5

B PROPERTY CLASSIFICATION (PAGE 19)

1	1. 1 building fire
2	4. 0 restaurant
3	1. 6. 1 restaurant

C PROPERTY TYPE (PAGE 41)

1	[X]
2	1 Building Type ... 1 0 0 2

D EXTENT OF DAMAGE (PAGE 45)

1	2 CTACO
2	2 CTACO
3	2 CTACO
4	Estimated loss – property: 1 . 1 . 0; Estimated loss – contents: 2 . 5

E LOCATION & CAUSE (PAGE 49)

1	1. 0 1 ground floor
2	2 1 hot plate
3	5 1 hot object
4	4 . 6 combustible too close

F AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1	2. 4 cooking area
2	6. 3 wood shelf
3	7. 6 cooking mtrls.
4	0. 9 not a factor

G SPREAD OF FIRE (PAGE 77)

1	0 0 not a factor
2	0 8 not applicable
3	2 3 cabinet
4	7. 3 unattended

H PROTECTION FACILITIES (PAGE 91)

1	
2	
3	
4	
5	
6	4 extinguished fire

I PROTECTION FACILITIES (PAGE 91)

1	
2	
3	
4	
5	
6	
7	
8	

J MISCELLANEOUS (PAGE 101)

1	
2	

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/18/89 Time 0130 Incident No. 0,0,0,6,9

(X) Box / No. 5512 ( ) Unit Disp. / Co. No.

1	Occupant name: Floria Roldan	Relationship: tennant	Alarm source: [X]	
2	Address: 1138 Valencia	City: S F	Zip: 9,4,1,1,0	Telephone: 282 0537
3	Owner name: Hogan & Vest Reality	Address: 949 Stockton ST SF		
4				Telephone: 421 5117

A. INFORMATION (PAGE 17)

1	Fire Dept ID: 3 8 0 0 5	Incident No.: 0 0 0 6 9		Time / Month / Day / Year: 0 1 3 0, 1 0, 18, 8 9		Dist: 6

B. PROPERTY CLASSIFICATION (PAGE 19)

	Code	
1	1 1	Building Fire
2		
3	4 2 3	12 Units

C. PROPERTY TYPE (PAGE 41)

	Code	
1		X
2	1	Building Type 5 — Stories: 3
3		

D. EXTENT OF DAMAGE (PAGE 45)

	Code	
1	4	Confined to building
2	4	" "
3	4	" "
4	Estimated loss - property: 2,5 0,0,0	Estimated loss - contents: 7 0,0,0

E. LOCATION & CAUSE (PAGE 49)

	Code	
1	1 0 2	second floor
2	2 3	Coffee pot (elect)
3	5 6	properly operating electrical
4	7 3	Unattended

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

	Code	
1	2 3	Dining room
2	5 1	Rubber insulation
3	6 1	electrical insulation
4	0 4	vertical openings

G. SPREAD OF FIRE (PAGE 77)

	Code	
1	0 4	vertical openings
2	6 3	finished lumber
3	1 5	interior wall covering
4	7 3	unattended

H. PROTECTION FACILITIES (PAGE 91)

	Code	
1		Sprinklers - type
2		Sprinklers - effectiveness
3		Standpipes - type
4		Standpipes - effectiveness
5		Portable extinguishers - type
6		Portable extinguishers - effectiveness

I. PROTECTION FACILITIES (PAGE 97)

Code	
	Private brigade - type
	Private brigade - effectiveness
	Special hazard protection - type
	Special hazard protection - effectiveness
	Signal or warning system type / effectiveness
	Signal warning system - means of activation
	Signal warning system - type detectors
	Watchman effectiveness / Other facilities effectiveness

J. MISCELLANEOUS (PAGE 109)

1	Firefighters - no. injured	no. of deaths	Civilians - no. injured	no. of deaths
2				Check box if yes: ☐

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/19/89 Time 0442

Incident No. I 4 2 6 9

( ) Box / No. ____ (X) Unit Disp. / Co. No. E11

Occupant name	Address	City
Salvation Army	1500 Valencia	S.F.

A. INFORMATION (PAGE 17)

3 8 0 0 5 | I 4 2 6 9 | 0 4 4 2 | 1 0 | 1 9 | 8 9 | 5 | S F | 0 6

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	Building fire
4	
5 3 7	Furniture repair

C. PROPERTY TYPE (PAGE 41)

Code	
1	Building Type 3

D. EXTENT OF DAMAGE (PAGE 45)

Code	
2	Confined to area
3	Confined to floor
4	Confined to building
Estimated loss - contents	5 0 0 0

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0 2	Second floor
9 8	No equip involved
7 2	Spontaneous ignition
4 7	Improper storage

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
6 5	Shop area
8 5	Oily rags
5 8	Cleaning cloths
0 9	Not a factor

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 97)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

San Francisco Fire Department

State of California
Office of the State Fire Marshal

Date 10/19/89 Time 1313

( ) Box / No. 1243 ( ) Unit Disp. / Co. No.

Occupant name: Burger King(Resturant) — Tenant

Address: 346 Kearny St — San Francisco — 94115

Manager: Tom Gin — S.F. — 94115 — 346-1888

A. Information (Page 17)

Fire Dept. No.: 3 8 0 0 5 — Incident No.: I 4 4 8 3 — 1 3 1 3 / 1 0 1 9 8 9 — 5 — 0 1

B. Property Classification (Page 19)

Code	Description
1 1	Building fire
1 6 1	Resturant

C. Property Type (Page 41)

7 — Building Type 7

D. Extent of Damage (Page 45)

Code	Description
1	Confined to material
1	Confined to material
1	Confined to material

Estimated loss - property: 0 — Estimated loss - contents: 0

E. Location & Cause (Page 49)

Code	Description
1 0 1	Ground floor
2 4	Fryer
1 2	Fryer
9 0	Overheated

F. Area, Materials & Smoke Spread (Page 63)

Code	Description
2 4	Kitchen
3 1	Grease
7 6	Cooking material

G. Spread of Fire (Page 77)

H. Protection Facilities (Page 91)

I. Protection Facilities (Page 97)

J. Miscellaneous (Page 109)

FIRE INCIDENT REPORT

San Francisco FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/19/89 Time 0719

Incident No. I.4.3.0.5

( ) Box / No. 1336 ( ) Unit Disp. / Co. No.

1950 Stockton St San Francisco

Al Tirquerim 1956 Stockton St San Francisco

A. INFORMATION (PAGE 17)

3 8 0 0 5 | I.4.3.0.5 | | 0.7 1.9 1 1 0 1 9 1 8 9 5 | 0 1

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 . 1 Building fire
2.
3. 4 . 2 . 2 Flats

C. PROPERTY TYPE (PAGE 41)

[X]

2 Building Type 5 — 3

D. EXTENT OF DAMAGE (PAGE 45)

1. 4 Confined to building
2. 4 Confined to building
3. 4 Confined to building
4. 3,510,0.0.0 | 510.0.0

E. LOCATION & CAUSE (PAGE 49)

1. 1 . 0 . 1 Basement
2. 1 . 2 Water heater
3. 5 . 9 Water heater
4. 4 . 6 Combustibles too close

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1. 9 . 8 Basement
2. 6 . 7 Paper
3. 7 . 5 Trash
4.

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

San Francisco FIRE DEPARTMENT

Date 19 Oct 89 Time 00:33

Incident No. 0. 4. 2. 2. 1

(x) Box / No. 2158 ( ) Unit Disp. / Co. No.

Occupant name: Copy Rite	Relationship: tenant		Yes [X]
Address: 74 New Montgomery St	City: San Francisco	Zip: 94105	
Owner name:	Address:		
Manager name:	Address:		

A. INFORMATION (PAGE 17)

Fire Dept No.	Incident No.	Exposure No.	Time	Month	Day	Year	Day
3 8 0 0 5	0 4 2 2 1		0 0 3 3	1 0	1 9	8 9	5

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	building fire
5 9 5	photocopy firm

C. PROPERTY TYPE (PAGE 41)

Code	
1	Building Type 1

D. EXTENT OF DAMAGE (PAGE 45)

Code	
3	confined to floor of origin
3	- - - - -
3	- - - - -
Estimated loss - property: 115,010,00	Estimated loss - contents: 5,010,00

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0 1	ground floor
4 1	fixed wiring
2 2	short circuit
8 2	earthquake

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
4 1	storage area
6 7	paper
5 1	stock boxes
0 7	horizontal

G. SPREAD OF FIRE (PAGE 77)

Code	
0 9	not a factor

H. PROTECTION FACILITIES (PAGE 91)

Code	
1	dry
1	not a factor
5	for classes A,B,C
1	not a factor

I. PROTECTION FACILITIES (PAGE 97)

Code	
1	local — Code 1: satisfactory
2	auto/manual
2	smoke

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 19 Oct 89 Time 12:02

Incident No. 0 4 4 3 8

(X) Box / No. 2252 ( ) Unit Disp. / Co. No.

Occupant name: Anglo Hotel			
Address: 241 6th.	Room/Apt No.: #231	City: San Francisco	
Owner name: Nick Patel	Address: 241 6th. Street	City: S.F.	

A. INFORMATION (PAGE 17)

Fire Dept ID	Incident No	Exposure No	Time	Month	Day	Year	Day		
3 8 0 0 5	0 4 4 3 8		1 2 0 2	1 0	1 9	8 9	04		0 3

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	Building Fire
1	
4 4 1	Hotel, year round

C. PROPERTY TYPE (PAGE 41)

Code	
XX	
1 1	Building Type 3 — 10 0 8

D. EXTENT OF DAMAGE (PAGE 45)

Code	
1	Confined to material first ignited
1	
1	

Estimated loss – property: 0 Estimated loss – contents: 5 0

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0 2	2nd floor Rm # 231
4 6	light fixture, electric lamp
2 3	Short circuit, defective
3 1	Abandoned

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
2 1	Sleeping area
7 2	Mattress
3 1	Mattress
0 4	Vertical Opening

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 87)

Code	
	Sprinklers – type
	Sprinklers – effectiveness
	Standpipes – type
	Standpipes – effectiveness
5	For Classes A,B,C fires
1	Not a factor

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/19/89 Time 1416

Incident No. 0 4 5 0 8

( ) Box / No. 1216 (X) Unit Disp. / Co. No. 13

Americen Express Travel Agency

257 Post st. — SF — 94108

Wells Fargo Bank

A. INFORMATION (PAGE 17)

3 8 0 0 5 | 0 4 5 0 8

B. PROPERTY CLASSIFICATION (PAGE 19)

1 1 | Building fire

5 9 1 | Business office

C. PROPERTY TYPE (PAGE 41)

1 | Building Type Single

D. EXTENT OF DAMAGE (PAGE 45)

2 | Confined to area of origin

2 | " " " " "

2 | " " " " "

Estimated loss - contents: 150.0

E. LOCATION & CAUSE (PAGE 49)

1 0 7 | Second floor

4 1 | Fixed wiring

2 4 | Short circuit arc, unspecified

5 0 | Mechanical failure

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

5 2 | Conduit

5 2 | "

5 2 | "

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

5 | Ext. fires

1 | not a factor

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

San Francisco FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/19/69 Time 1530

Incident No. 0 4 5 4 4

(x) Box / No. 1641 (x) Unit Disp. / Co. No. ____

Occupant name	Sa[illegible]rs Dry Cleaners
Address	98[illegible] [illegible] St.
City	SF
Zip	94109
Owner name	[illegible]
Managing name	

A. INFORMATION (PAGE 17)

Fire Dept. No.	Incident No.	Exposure No.	Time	Month	Day	Year	Day
3 8 0 0 5	0 4 5 4 4		15 30	10	19	69	[illegible]

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	Type of incident: Building fire
	Property classification (complex):
5 6 6	Property classification (individual): Dry Cleaning shop

C. PROPERTY TYPE (PAGE 41)

Code	
1	Structure type: Building Type Single

D. EXTENT OF DAMAGE (PAGE 45)

Code	
1	Extent of damage – fire: confined to material 1st ignited
1	Extent of damage – smoke: " " " " "
1	Extent of damage – water: " " " " "
	Estimated loss – property:
	Estimated loss – contents: 130.0

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0	Level of origin: Ground floor
5 5	Source of heat causing ignition: Generator
2 2	Form of heat causing ignition: Short circuit arc, [illegible]
5 4	Act or omission causing ignition: short circuit

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
6 1	Area of origin: Machinery room
5 1	Type of material first ignited: rubber
6 1	Form of material first ignited: Electrical insulation
[illegible]	Item mostly involved smoke spread: [illegible]

G. SPREAD OF FIRE (PAGE 77)

Code	
	Item mostly involved fire spread
	Type material causing spread
	Form material causing spread
	Act or omission causing spread

H. PROTECTION FACILITIES (PAGE 89)

Code	
	Sprinklers – type
	Sprinklers – effectiveness
	Standpipes – type
	Standpipes – effectiveness
5	Portable extinguishers – type: 1.3.40 fires
2	Portable extinguishers – effectiveness: Extinguished fire

I. PROTECTION FACILITIES (PAGE 97)

Code	
	Private brigade – type
	Private brigade – effectiveness
	Special hazard protection – type
	Special hazard protection – effectiveness
	Signal or warning system – type / effectiveness
	Signal warning system – means of activation
	Signal warning system – type detectors
	Watchman effectiveness / Other facilities effectiveness

J. MISCELLANEOUS (PAGE 109)

Firefighters – No. injured	Firefighters – No. of deaths	Civilians – No. injured	Civilians – No. of deaths

SFM form submitted for each death / Check box if yes ☐

SFM FORM 6000 (7-73)

FIRE INCIDENT REPORT

San Francisco FIRE DEPARTMENT
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 19 Oct 89 Time 19:34

Incident No. 0:4:6:3:8

(X) Box / No. 2252 ( ) Unit Disp. / Co. No.

Occupant name: M. Martinez	Relationship: Tenant	
Address: 172 6th. Avenue # 401	City: San Francisco	

A. INFORMATION (PAGE 17)

3 8 0 0 5 | 0.4.6.3.8 | 1 | 9.3.4 | 10 | 1.9 | 8.9 | 4 | 0.3

B. PROPERTY CLASSIFICATION (PAGE 19)

1.1 | Building fire

4.4.1 | Hotel year round

C. PROPERTY TYPE (PAGE 41)

1 | Building Type 3 | 1000 6

D. EXTENT OF DAMAGE (PAGE 45)

1 | Confined to material first ignited

1

1

Estimated loss - property: 0 | Estimated loss - contents: 0

E. LOCATION & CAUSE (PAGE 49)

1.0.24 | fourth floor # 401

2 1 | Stove

4.9 | Heat from spark

7.3 | Unattended

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

2.4 | Kitchen

5.7 | Food

7.6 | Cooking material

0.4 | Vertical openings

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 97)

1 | Wet pipe

1 | Not a factor

4 | Dry

1 | Not a factor

5 | For Classes A,B,C fires

1 | Not a factor

I. PROTECTION FACILITIES (PAGE 97)

1 | Local | 1 | Satisfactory

3 | Manual sending station only

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT — San Francisco Fire Department
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-20-89 Time 12:08

Incident No. 0 4 8 4 0

( ) Box / No. ________ (X) Unit Disp. / Co. No E-39

1	Occupant name: Miles Blagen		Alarm source: XX
2	Address: 400 Portola Dr.(Small Park area)	City: San Francisco.Ca	Zip: 9 4 1 3 1
3	Owner name: S.F. City and Cty.		
4			

A. INFORMATION (PAGE 17)

	Fire Dept	Incident No	Exposure No	Time / Month / Day / Year / Day	County	Dist
1	3 8 0 0 5	0 4 8 4 0		1 2 0 8 1 0 2 0 8 9 6		0 9

B. PROPERTY CLASSIFICATION (PAGE 18)

	Code	
1	1 2	Brush
2		
3	9 3 1	Brush outdoors

C. PROPERTY TYPE (PAGE 41)

1	X
2	9 Building Type
3	

D. EXTENT OF DAMAGE (PAGE 43)

	Code	
1	2	Confined to area of origin
2	1	Confined to material
3		
4	Estimated loss - property: 0 0	Estimated loss - contents: 0 0

E. LOCATION & CAUSE (PAGE 48)

1	
2	
3	
4	Refer to B.F.I

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1	
2	
3	
4	Refer to B.F.I

G. SPREAD OF FIRE (PAGE 77)

1	
2	
3	
4	Refer to B.F.I

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 8?)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT San Francisco Fire Department
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/20/89 Time 0213 Incident No. 4 7 2 1

(x) Box / No. 4143 ( ) Unit Disp. / Co. No.

1	VICTOR ROWLEY	OWNER
2	848 WALLER STREET	SAN FRANCISCO 552-6247
3	SEE ABOVE	
4		

A. INFORMATION (PAGE 17)

1 3 8 0 0 5 | 4 7 2 1 | | 0 2 1 3 | 1 0 2 0 8 9 | 6 | | 0 5

B. PROPERTY CLASSIFICATION (PAGE 19)

1	11 1 BUILDING FIRE
2	
3	4 1 1 DWELLING

C. PROPERTY TYPE (PAGE 41)

1	X
2	1 Building Type 5 — 0 0 3
3	

D. EXTENT OF DAMAGE (PAGE 45)

1	2 CTAOO
2	4 CTBOO
3	2 CTAOO
4	1500 — 0.0

E. LOCATION & CAUSE (PAGE 49)

1	1 0 4 ATTIC SPACES
2	1 6 WATER HEATER VENT FLUE
3	1 2 HEAT FROM GAS FUELED EQUIPMENT
4	7 9 USE OD UNINSULATED FLUE PIPE

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1	4 3 ATTIC
2	6 3 WOOD SAWN
3	1 1 EXTERIOR ROOF COVERING
4	0 7 HORIZONTAL OPENINGS

G. SPREAD OF FIRE (PAGE 77)

1	
2	
3	
4	

H. PROTECTION FACILITIES (PAGE 91)

1	
2	
3	
4	
5	5 ABC
6	2 HELPED TO CONTROL FIRE

I. PROTECTION FACILITIES (PAGE 97)

1	
2	
3	
4	
5	
6	
7	
8	

J. MISCELLANEOUS (PAGE 109)

1	
2	

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10/20/88 Time 02:21

Incident No. 0 4 7 2 4

(x) Box / No. 5554 ( ) Unit Disp. / Co. No. E-7

Address	City	Zip
Folsom St. and Bernal Heights	San Francisco	94110

A. INFORMATION (PAGE 17)

Fire Dept. ID	Incident No.	Time	Month	Day	Year	County Code	Dist.
38005	04724	0221	10	20	88	5 5	06

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 3 | Vehicle Motorcycle
2. |
3. 0 1 1 | Motorcycle

C. PROPERTY TYPE (PAGE 41)

1. Property Management: X
2. 6 | Building Type
3.

D. EXTENT OF DAMAGE (PAGE 45)

1. Extent of Damage – Fire: 2 | Confined to area of origin
2. Extent of Damage – Smoke: 2 |
3. Extent of Damage – Water: 2 |
4. Estimated Loss – Property: 1500; Estimated Loss – Contents:

E. LOCATION & CAUSE (PAGE 49)

1. Level of Origin: 1 0 1 | Ground
2. Source of Heat Causing Ignition: 9 6 | Vehicle
3. Form of Heat Causing Ignition: 0 0 | Undetermined
4. Act or Omission Causing Ignition: 2 7 | Suspicious Act Unknown

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

1. Area of Origin: 8 4 | Fuel Tank
2. Type of Material First Ignited: 2 3 | Gasoline
3. Form of Material First Ignited: 6 5 | Fuel
4. Avenue of Smoke Spread: 0 9 | Not A Factor

G. SPREAD OF FIRE (PAGE 77)

1. Avenue Fire Spread: 0 9 | Not A Factor
2. Type Material Causing Spread: 2 3 | Gasoline
3. Form Material Causing Spread: 6 5 | Fuel
4. Act or Omission Causing Spread: 2 7 | Suspicious Act Unknown

H. PROTECTION FACILITIES (PAGE)

1. Extinguishing Type
2. Sprinklers Effectiveness
3. Standpipes – Type
4. Standpipes – Effectiveness
5. Portable Extinguishers – Type
6. Portable Extinguishers – Effectiveness

I. PROTECTION FACILITIES (PAGE 97)

1. Private Service – Type
2. Private Service – Effectiveness
3. Special Hazard Protection – Type
4. Special Hazard Protection – Effectiveness
5. Type / Code / Effectiveness
6. Signal Warning System – Means of Activation
7. Signal Warning System – Type Detectors
8. Effectiveness / Code / Other Facilities Effectiveness

J. MISCELLANEOUS (PAGE 109)

1. Firefighter / Civilian
2. (Check if yes) ☐

FIRE INCIDENT REPORT San Francisco Fire Department
STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-20-89 Time 06:57

( ) Box / No. ______ (x) Unit Disp. / Co. No. Eng 57

Occupant name: Muni Driver # 2952 — Relationship: Driver

A. INFORMATION (PAGE 17)

Fire Dept. No.	Incident No.	Exposure No.	Time	Month	Day	Year	Day	Census	Dist.	Out of Jurisdiction
3 8 0 0 5	0 4 7 4 5		0 6 5 7	1 0	2 0	8 9	2	S.F.	1 0	

B. PROPERTY CLASSIFICATION (PAGE 19)

1. 1 3 | Vehicle Fire
2. |
3. 0 1 2 | Muni Bus

C. PROPERTY TYPE (PAGE 41)

2. 6 | Building Type

D. EXTENT OF DAMAGE (PAGE 43)

1. Extent of damage – fire: 2 | Confined to area of origin
2. Extent of damage – smoke: 2 | " " " " "
3. Extent of damage – water: 2 | " " " " "
4. Estimated loss – property: 5,000 — Estimated loss – contents: 0

E. LOCATION & CAUSE (PAGE 49)

1. Level of origin: |
2. Source of heat causing ignition: 0 6 | Vehicle
3. Form of heat causing ignition: 2 6 | Arc or spark
4. Act or omission causing ignition: 5 1 | Part failure

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

1. Area of origin: 8 3 | Engine Area
2. Type of material first ignited: 1 0 | Diesel Fuel
3. Form of material first ignited: 6 5 | Fuel
4. Main avenue of smoke spread: |

G. SPREAD OF FIRE (PAGE 77)

1. Main avenue of fire spread: |
2. Type material causing spread: |
3. Form material causing spread: |
4. Act or omission causing spread: |

H. PROTECTION FACILITIES (PAGE 91)

1. Sprinklers – type: |
2. Sprinklers – effectiveness: |
3. Standpipes – type: |
4. Standpipes – effectiveness: |
5. Portable extinguishers – type: |
6. Portable extinguishers – effectiveness: |

I. PROTECTION FACILITIES (PAGE 97)

1. Private brigade – type: |
2. Private brigade – effectiveness: |
3. Special hazard protection – type: |
4. Special hazard protection – effectiveness: |
5. Signal or warning system type: | effectiveness: |
6. Signal warning system – means of activation: |
7. Signal warning system – type detectors: |
8. Watchman effectiveness: | Other facilities effectiveness: |

J. MISCELLANEOUS (PAGE 105)

Firefighter no. injured	no. of deaths	Civilians no. injured	no. of deaths

SFM Form 00 ? submitted for each death — check box if yes ☐

SFM Form 604A (7-73)

FIRE INCIDENT REPORT — STATE OF CALIFORNIA, OFFICE OF THE STATE FIRE MARSHAL — SAN FRANCISCO FIRE DEPARTMENT

Date 10/20/89 Time 1708 Incident No. 4 18 14 10

( ) Box / No. 5353 ( ) Unit Disp. / Co. No. E-39

Occupant name	N/A
Address	IFO 400 Portola Dr.
City	S.F.
Owner name	n/a
Name	n/a

A. INFORMATION (PAGE 17)

Fire Dept. ID
3 8 0 0 5

B. PROPERTY CLASSIFICATION (PAGE 19)

C. PROPERTY TYPE (PAGE 41)

Building Type

D. EXTENT OF DAMAGE (PAGE 45)

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0 1	Ground level
9 8	No equipment involved
4 9	Spark or open flame
1 7	Incendiary

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
9 4	open park area
5 4	Grass, leaves, twigs, ect.
7 4	Natural form, brush
0 9	Not a factor

G. SPREAD OF FIRE (PAGE 77)

Code	
0 9	Not a factor
9 8	N/A
7 4	Natural form, brush
1 7	Incendiary

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 97)

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

SAN FRANCISCO FIRE DEPARTMENT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

Date 10-20-89 Time 07:51

Incident No. 0.4.7.5.2

(X) Box / No. 6243 ( ) Unit Disp. / Co. No.

1	Occupant name: Ms. Mable McDonald	Relationship: Renter	
2	Address: 83 Brookdale Ave.	City: San Francisco, Ca 9 4 1 3 4	Telephone no. 415
3	Owner name: S.F. Housing Auth.	Address: 440 Turk St., S.F.	
4	Manager name: Mr. Freeman	Address:	

A. INFORMATION (PAGE 17)

Type report	Incident no.	Exposure no.	Time	Month Day Year	Day	Dist.
3 8 0 0 5	0.4.7.5.2		0.7.5.1	1 0 2 0 8 9	6	0 9

B. PROPERTY CLASSIFICATION (PAGE 19)

Code	
1 1	Building Fire
4 2 3	Apts. under 20 units

C. PROPERTY TYPE (PAGE 41)

Code	
1	Building Type 3 — 0 0 2

D. EXTENT OF DAMAGE (PAGE 43)

Code	
2	Confined to area of origin
3	Confined to floor of origin
3	Confined to floor of origin

Estimated loss – property: 2000 Estimated loss – contents: 100

E. LOCATION & CAUSE (PAGE 49)

Code	
1 0 2	Second Floor
9 8	No equipment involved
4 5	Match
3 6	Child playing with

F. AREA, MATERIALS & SMOKE SPREAD (PAGE 63)

Code	
2 1	Bedroom
7 2	Cotton
3 1	Mattress
0 4	Vertical openings

G. SPREAD OF FIRE (PAGE 77)

H. PROTECTION FACILITIES (PAGE 91)

I. PROTECTION FACILITIES (PAGE 91)

Code	
6	Household — Satisfactory
1	Automatic detector
2	Smoke detector

J. MISCELLANEOUS (PAGE 109)

FIRE INCIDENT REPORT

STATE OF CALIFORNIA
OFFICE OF THE STATE FIRE MARSHAL

San Francisco Fire Department

Date 10/20/89 Time 18:52

Incident No. 0.4.9.5.3

(X) Box / No. 1565 ( ) Unit Disp. / Co. No. ____

Occupant name: Richard Leone	Relationship: tenant		
Address: 1424 Pacific Ave	City: San Francisco	Zip: 9.4.1.3.3	

A. INFORMATION (PAGE 17)

3 8 0 0 5 | 0.4.9.5.3 | | 1.8.5.2 | 1.0 | 2.0 | 8.9 | 6 | S.F | 0.1

B. PROPERTY CLASSIFICATION (PAGE 19)	C. PROPERTY TYPE (PAGE 41)
1.1 Building Fire	X
	2 Building Type 5 — 10 0.4
4.2.3 Apartment 7-20 units	

D. EXTENT OF DAMAGE (PAGE 45)	E. LOCATION & CAUSE (PAGE 49)
1 Confined to material first ignited	2.0.1 Basement
2 Confined to area first ignited	9 8 No equipment involved
1 Confined to material first ignited	3 1 Cigarette
Estimated loss - property: 10 05.0 / Estimated loss - contents: 0.0.0	3.1 Discarded material

F. AREA MATERIALS & SMOKE SPREAD (PAGE 63)	G. SPREAD OF FIRE (PAGE 77)
4.7 Garage	N/A
6.7 Paper	
7.5 Rubbish	

H. PROTECTION FACILITIES (PAGE 91)	I. PROTECTION FACILITIES (PAGE 97)
1 For classes A B C fires	
1 Not a factor	

J. MISCELLANEOUS (PAGE 100)