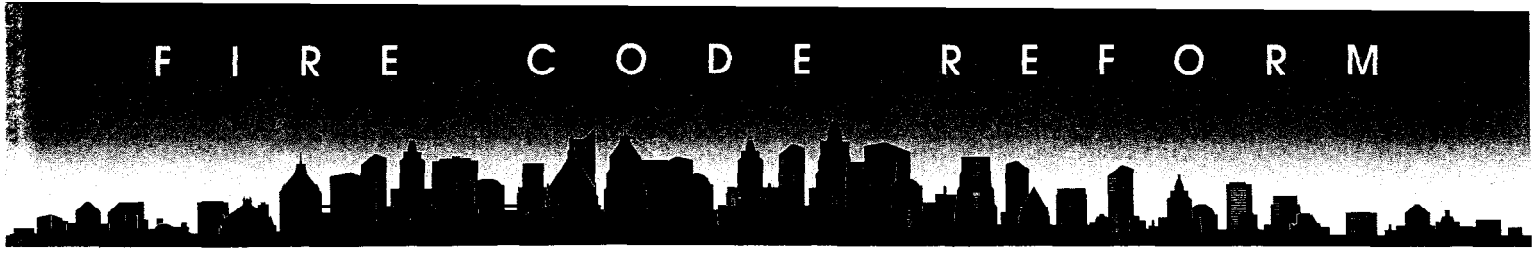

Technical Report
FCRC-TR 97- 02

Analysis of USA Retail Fires

FCRC Project 6
Fire Safety Systems for
Low-Rise, Sprinklered Shopping Centres

Fire Code Reform Research Program
February I997

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Background

The Fire Code Reform Research Program is funded by voluntary contributions from regulatory authorities, research organisations and industry participants.

Project 6 of the Program involved specific studies into different aspects of fire-safety in low-rise, sprinklered shopping centres. One of the major tasks was detailed analysis of Statistics relating to retail fires.

Dr Ian Thomas of BHP Research, Melbourne Laboratories whilst located at 245 Wellington Road, Mulgrave, Victoria 3170 carried these analyses and this Report summarises his work in respect of USA retail fires.

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Comments

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PROJECT 6

ANALYSIS OF USA RETAIL FIRES

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The Broken Hill Proprietary Company Limited
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EXECUTIVE SUMMARY

The purpose of this report is to present and interpret data available on actual fires in retail premises. It is based on almost seventy-eight thousand fires in USA retail premises between 1983 and 1993 that resulted in 87 civilian and 14 fire fighter fatalities, 2118 civilian and 4580 fire tighter injuries and estimated property losses of US$2 billion. In these fires the average **rates** of casualties per 1000 fires are: 1.12 civilian fatalities, 0.18 fire fighter fatalities, 27.2 civilian injuries and 58.7 fire fighter injuries and the average estimated loss per fire is US$28,100. The civilian casualty rates are low compared with Australian and USA residential fires.

Only 22% of the fires with known extent of flame damage have flame damage not confined within the room of origin. Casualty and property loss rates increase substantially with increasing extent of flame damage - factors of 5.9 and 12 for fire fighter fatalities and injuries respectively, 10 and 2.0 for civilian fatalities and injuries respectively and 12 for property losses between fires with extent of flame damage not confined and those confined within the room of origin. Overall, 42% of fires with known extent of smoke damage cause smoke damage **not** confined within the room of origin. Factors similar to those for flame damage reflect increased casualty and property loss rates for fires with extent of smoke damage not confined within the room of origin.

The peak number of fires per hour is nearly three times the minimum, some of this variation reflecting changes in the areas of fire origin with time of alarm. The extent of flame damage varies substantially with alarm time with the greatest variation being in fires with flame spread confined to the object of origin - these increase greatly during the day resulting in the percentage of fires with extent of flame damage **not** confined within the room of origin increasing greatly during the night to 43% from the daytime minimum of 12%. The fire fighter injury and civilian fatality rates are consistently higher during the night than during the day but the civilian injury rate is consistently lower during the night than during the day.

Sprinklers do not operate in 69% of fires where they are present, however in 94% of these cases the fire is judged too small to require operation. With sprinklers present about 6% of fires have flame damage **not** confined to the room of fire origin compared with about 25% for fires with sprinklers not present. Similarly, with sprinklers present about 34% of fires have smoke damage **not** confined to the room of fire origin compared with about 45% for fires with sprinklers not present. The fire fighter fatality and injury rates, civilian fatality rate and estimated property loss per fire are lower for fires with sprinklers present than for fires with sprinklers not present but the civilian injury rate is higher for fires with sprinklers present.

The fire brigade arrival time is between 0 and 9 minutes for 90% of fires. Between 21% and 22% of fires have extent of flame damage not confined to the room of origin for fire brigade arrival times between 0 and 9 minutes but this rises to between 35% and 45% for fire brigade arrival times between 10 and 19 minutes.

Detectors do not operate in more than 50% of fires where they are known to have been present (in many cases because the fires are too small). Detectors do not seem to improve the civilian and fire fighter injury rates but may improve the civilian and fire fighter fatality rates.

The civilian fatality and injury rates are high for fires in motor vehicle or boat sales or services with many of these high rates linked also to the involvement of flammable liquids and gases.

The equipment involved in ignition in 39% (of known) fires is electrical distribution equipment and in 17% appliances, equipment. The form of heat of ignition for 36% of fires is attributed to heat from electrical equipment arcing, overload and 20% to heat from open flame, spark.

The extent of damage resulting from the ignition of a fire in retail premises appears to be primarily dependent on the presence of people:

- particularly during the day and evening when awake, able and alert people are in these buildings in considerable numbers the extent of damage and casualties is likely to be much less than at other times presumably because they deal with many of the fires quickly and effectively
- presumably the presence of detectors can help by warning the occupants and fire department earlier than would otherwise occur in cases where there are no people in the immediate vicinity of the fire, but before sprinklers are activated
- if present and the fire is not dealt with beforehand, sprinklers are likely to extinguish or limit the growth of a fire
- finally, when they arrive and if the fire has not already been dealt with, fire fighters influence the final extent of destruction resulting from a fire

It is quite clear from these summaries that design and management of retail buildings to minimise the number of fire starts and to minimise the extent of smoke and fire spread is likely to reduce the human casualties and property losses due to such fires. The use of alert people, detectors, and particularly automatic sprinklers appear the most effective means of achieving such reductions.

CONTENTS

1 INTRODUCTION

The purpose of this report is to present and interpret data available on actual fires in retail premises. This report analyses records of 77,996 fires in retail premises in the USA taken from the NFIRS' database for the years 1983 to 1993 but excluding 1986. All *are* for *Type of Situation* Found = 11, that is, a *structure fire*.

In these fires a total of *87 civilian* and 14 *fire fighter fatalities, 2118 civilian* and 4580 *fire fighter injuries* and estimated *property losses* of US$2,193,000,000 are recorded.

Thus, the average **rates** of casualties and losses are:

- 1.12 *civilian fatalities* per 1000 fires (or one for every 897 fires)
- 0.18 *fire fighter fatalities* per 1000 fires (or one for every 5571 fires)
- *27.2 civilian injuries* per 1000 fires (or one for every 37 fires)
- *58.7 fire fighter injuries* per 1000 fires (or one for every 14 fires)
- US$28,100 average *estimated* loss per fire

There *are* a total of *73* fires with *civilian fatalities (0.09%* of all fires or one *fire* with a *civilian fatality* in every 1068 fires). There are three, four and five *civilian fatalities,* each in one tire; two *civilian fatalities* in five fires and one *civilian fatality* in each of sixty-five fires. Each of *the* fourteen *fire fighter fatalities* are in separate fires.

The *civilian injuries* occur in 1461 fires (1.9% of all fires or one fire with a *civilian injury* in every *53* fires), a single *civilian injury* in 1172 fires and the maximum of 119 *civilian injuries* in a single fire. The number of fires with the various numbers of *civilian injuries* are tabulated in Appendix A.

Similarly, *fire fighter injuries* occur in 2481 fires (3.2% of all fires or one fire with a *fire fighter injury* in every 3 1 fires), a single *fire fighter injury* in 1619 fires and the maximum of *30 fire fighter injuries* in a single fire. The number of fires with the various numbers of *fire fighter injuries* are tabulated in Appendix A.

In reviewing the data presented below *the overall average fatality* ***rates*** mentioned above **(1.12 for *civilians*** and **0.18 for *fire fighters)*** will be used as a basis for comparison of various cases.

The fires with several *civilian casualties* may distort the significance of *casualty* ***rates*** if they occur in categories with very small numbers of fires. Consequently, throughout this report the categories that include these fires are noted following the definitions of the categories.

One focus of this review is the occurrence of *fatalities* and *injuries* in fires. An attempt is made to identify factors that might lead to *fatalities or injuries* by looking at the absolute number *offatalities and injuries* that occur for the various values of the available factors and also under combinations of factors. To do this the available fields in the NFIRS database are assessed as being *input variables*

(or factors), *output variables* or matters of record unlikely to have a direct influence on the occurrence or outcome of a tire.

The fields identified *as output variables* (that is, those that tend to measure the effect of a fire) are civilian and firefighter fatalities and injuries, extent of flame damage, extent of smoke damage, estimated dollar loss and property damage classification.

The fields identified as useful *input variables* include sprinkler and detector presence and performance, construction type, time from alarm to fire brigade arrival, fixed property use, area of fire origin, equipment involved in ignition, form of heat of ignition, type and form of material ignited and ignition factor.

The fields identified primarily as record fields include dates, day of week, alarm time, fire department ID, exposure number, etc.

However, an important factor in -determining the number of injuries (and deaths, but less clearly) that should not be overlooked is simply *the number of fires that occur* in a particular category. As a general rule (provided there is a reasonably large number of fires in a category) the more fires, the more deaths, injuries and property losses. Clearly, a most beneficial means of reducing the casualties and losses associated with fires is simply to minimise (or reduce) the number of fire starts. Thus, reduction in ignition sources, flammable and combustible contents and building elements is a factor that should always be considered in building design and management.

In the next section the variation of various factors and rates with *extent of flame damage* is examined in some detail, however, it is worthwhile providing here some information to put the following sections into context.

It can be seen in Table 1 that although fires where the *extent of flame damage* is *confined to the room of jire origin* are significantly more numerous than fires where *tie extent of flame damage* extended *beyond the room of fire origin,* they generally result in fewer casualties and, consequently, in far fewer casualties and losses per fire.

TABLE 1 EFFECT OF FLAME DAMAGE EXTENDING BEYOND ROOM OF FIRE ORIGIN

Extent of Flame Damage	*Fires (% of known)*	*Fire Fighter Injuries* (rate *)	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate*)*	*US$ Losses (loss per fire)*
Confined to Room of Fire Origin	54,719	992	1315	5	22	4.7389e8
	(78%)	(18.1)	(24.0)	(0.09)	(0.40)	(8660)
of Fire Origin	15,232	3418	722	8	61	1.6388e9
	(22%)	(224)	(47.4)	(0.53)	(4.0)	(107,589)
Unknown, etc	8045	170	81	1	4	8.0394e7
	(12%)	(21.1)	(10.1)	(0.12)	(0.50)	(9993)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

Table 1 shows that for fires in which flame damage *extends beyond the room of fire origin* compared with those where it is *confined to the room of fire origin:*

- *the civilian fatality rate* is ten times higher
- the *fire fighter fatality* rate is nearly six times higher
- *the civilian injury rate* is nearly twice as high
- the *firefighter injury rate* is over twelve times higher
- the *estimatedproperty loss rate* is twelve times higher

Thus it is obvious that fires with *extent of flame damage* that *extends beyond the room of fire origin* are, on average, very much more dangerous and damaging than fires where the *extent of flame damage* is *confined to the room of origin.*

The data presented in this report represent fires- that are notified to the fire brigades. An unknown number of fires are not notified to the fire brigades and are therefore not included in the data. It is to be expected that a large proportion of *fire starts* fail to grow significantly or are extinguished while still very small by the building occupants. Information obtained from a Swiss insurance company indicates that in the Canton of Berne (Switzerland) while the fire brigade are called to about 1500 fires each year, over 5000 claims are made for fire damage to buildings. Thus, in that case, the number of fire *starts* is at least three times the number notified to the fire departments. It is reasonable to assume that the actual number of *fire starts* is significantly larger again, because a further group of fires will do no damage or sufficiently little damage that placing an insurance claim is unwarranted or embarrassing.

Note that in many of the tables below the number of fires in some categories is relatively low and, as a consequence, the calculated *fatality and injury rates are* subject to significant uncertainty. In many cases the number of fires is so low that, even if the average rates mentioned above are applicable, no fatalities or injuries is expected. Consequently, a calculated rate of zero may be quite misleading. In such cases, rather than placing (0.0) in the tables, the entry (#) has been used. Such entries should be read as: *the calculated rate is 0.0, but the number of fires is so low that this may be misleading and should be viewed with great caution.*

Note also that in many tables the percentage of fires in various categories is calculated as the percentage of the *known* fires, and that the total percentage adds to over 100% because a percentage is also included for *the unknown, etc* category. If the percentage for the *unknown, etc* category is high, caution should be exercised in interpreting the significance of the % of *known* figures for the other categories.

In the following section the rate figures mentioned above are compared with similar data from other studies. This is followed by sections in which the data is examined in some detail for many of the individual fields (particularly *input variables)* under which the data is classified.

Appendix A contains the tables mentioned above along with tables and figures for some fields (principally record *variables).*

2 COMPARISON WITH OTHER STUDIES

It is useful to compare the overall casualty rates presented above with similar rates obtained in other studies[2,3,4,5].

In Australian there are 35,303 reported *residential* structure fires from 1989 to 1993 that result in 250 *civilian* and four *fire fighter fatalities,* 2192 *civilian* and 382 *fire fighter injuries* and A$ 4.8 billion *estimated property* loss. The resulting casualty *rates* for Australian *residential are:*

- 7.1 civilian fatalities per 1000 fires
- 0.11 fire fighter fatalities per 1000 fires
- 62.1 civilian injuries per 1000 fires
- 10.8 fire fighter injuries per 1000 fires
- $13,700 losses per fire (estimated by the fire fighters)

In the same study there are 24,497 reported *commercial* (that is, all categories other *than residential) structure fires* from 1989 to 1993 that result in thirty *civilian fatalities* and one *fire fighter fatality, 745 civilian* and 461 *fire fighter injuries* and A$ 1.3 billion *estimated property loss.* The resulting *casualty rates* for Australian *commercial are:*

- 1.2 civilian fatalities per 1000 fires
- 0.04 fire fighter fatalities per 1000 fires
- 30.4 civilian injuries per 1000 fires
- 18.8 fire fighter injuries per 1000 tires
- $54,100 losses per fire (estimated by the fire fighters)

In the USA for the period 1983 to 1991 there are *27,669* fires in *office buildings* is resulting in 31 *civilian fatalities* and one *fire fighter fatality, 539 civilian* and 1417 *fire fighter injuries* and total *estimated* losses of US$676 million. The resulting casualty rates for USA *offices* are:

- 1.1 civilian fatalities per 1000 fires
- 0.04 fire fighter fatalities per 1000 fires
- 19.5 civilian injuries per 1000 fires
- 51.2 fire fighter injuries per 1000 fires
- US$24,500 per fire

In NSW for the period 1986 to 1992 there are 2524 reported fires *in retail* premises resulting in two *civilian* and zero *fire fighter fatalities* and *57 civilian* and 26 *fire fighter injuries.* The resulting *casualty rates* for *NSW retail are:*

- 0.8 civilian fatalities per 1000 fires
- 22.6 civilian injuries per 1000 fires
- 10.3 fire fighter injuries per 1000 fires

In the USA for the period 1983 to 1993 excluding 1986 there are 420,3 15 fires in *apartment buildings* resulting in *3,111 civilian* and 14 *fire fighter fatalities, 28,635 civilian* and 18,458 *fire fighter injuries* and total *estimated losses* of US$3,237 million. The resulting casualty rates for USA *apartments are:*

- 7.4 civilian fatalities per 1000 fires
- 0.03 fire fighter fatalities per 1000 tires

- 68.1 civilian injuries per 1000 fires
- 43.9 fire fighter injuries per 1000 fires
- US$7700 per fire

Comparison of the above rates and those presented earlier for *USA retail* shows remarkable similarity in *the civilian fatality rates* (range 0.8 to 1.2) and *civilian injury rates* (range 19.5 to 30.4) for the *non-residential* categories. The *Australian* and *USA residential rates* for these cases are significantly higher (7.1 to 7.4 for *civilian fatalities* and 62.1 to 68.1 for *civilian injuries)* as is generally expected for *residential fires.*

There is more variation in the *fire fighter rates* particularly between the *USA* and *Australian* figures for the *injury rate.* The range for *fire fighter injuries* for *Australia* (including the *NSW* figures) is 10.3 to 18.8, but the range for *USA offices* and *retail* is 51.2 to 58.7. It appears that there is a significantly higher *rate* for *fire fighter injuries* in the *USA than Australia.* This may also be the case for the *fire fighter fatality rate,* but as the numbers of fatalities in many of these cases are low it is difficult to be confident that the apparent differences are meaningful.

3 COMPLEX

The NFIRS field *complex* enables the distinction to be made between fires in retail establishments that are part of a *shopping complex* and those that are not - presumably isolated retail establishments (and possibly those in strip shopping areas).

The relevant categories for *complex are:*

Corn **58 Shopping complex** - this includes department stores, malls, discount houses, and shopping centres. Also include are groups of business and commercial establishments which may contain theatres and other places of assembly

Corn **98 No complex**

Corn 99 **Other** - not defined in other complex categories.

(Note that *shopping complex (Corn 58)* contains the fires with 119 *civilian injuries* and three and five *civilian fatalities* and *no complex (Corn 98)* contains the fire with four *civilian fatalities.)*

Figure 1 and Table 2 show the majority of fires to be in *shopping complexes* and these fires result in the majority of civilian and fire fighter injuries, the largest number of fire fighter fatalities, but **not** the largest number of civilian fatalities. In terms of *the casualty rates,* there is little variation between the categories except for *the civilian fatality and injury rates.*

Note that in Figure 1 and most subsequent figures the line across each graph is a reference line showing the overall average rate for the data.

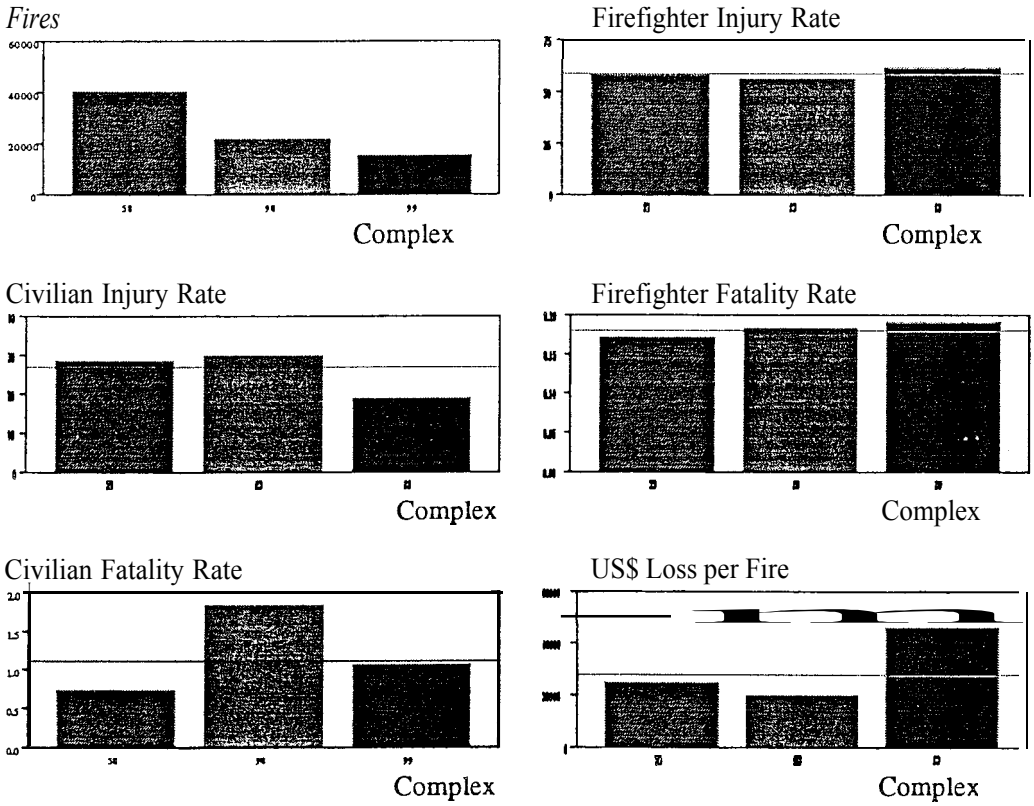


FIGURE 1 COMPLEX

The *civilian injury rate* is *lower* for the *other* category than for the remaining categories (which are approximately equal), but the *civilian fatality rate* is very much higher than average for *no complex* and lower than average for *shopping complex.*

TABLE 2 COMPLEX

Complex	*Fires (% of known)*	*Fire Fighter Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fire Fighter Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (loss/fire)*
Shopping	40,539	2375	1160	7	30	7.3085e8
	(65)	(58.6)	(28.6)	(0.17)	(0.74)	(46,400)
No complex	21,710	1232	654	4	40	1.0202e9
	(35)	(56.8)	(30.1)	(0.18)	(1.84)	(25,200)
Other	15,747	973	304	3	17	4.4202e8
	(25)	(61.8)	(19.3)	(0.19)	(1.08)	(20,400)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

Further investigation shows that the high *civilian fatality rate* in the *no complex* category is primarily associated with *fixed property use motor vehicle or boat sales, services (FPU 57)* (Table 3). Only two of the thirty *civilian fatalities* in *shopping* complexes and only three of the seventeen *civilian fatalities* in *other* complexes are in *FPU 57.* These are markedly different to the proportion of *civilian fatalities* in the *no complex* category where twenty-eight of the forty *civilian fatalities are* in *FPU 57.*

TABLE 3 COMPLEX AND FPU

Complex	*FPU*	*Fires*	*Fire Fighter Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fire Fighter Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*
Shopping	57	2977	170	145	0	2
			(57)	(49)	(#)	(0.7)
No complex	57	8657	447	439	3	28
			(52)	(51)	(0.3)	(3.2)
Other	57	3287	216	140	a	3
			66	(43)	(0.3)	(0.9)
Shopping	all other	37,562	2205	1015	7	28
			(59)	(27)	(0.2)	(0.7)
No *complex*	all other	13,053	785	215	1	12
			(60)	(16)	(0.1)	(0.9)
Other	all other	12,468	757	164	2	14
			(61)	(13)	(0.2)	(1)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

As a result *the rate of civilian fatalities* in *no complex* and *FPU 57 (fixed property use motor vehicle or boat sales, services)* is 3.2 compared with the overall average of 1.12 and the values are less than this average for all of the other categories. Thus it is clear the high *civilian fatality rate* for *no complex* is entirely due to *the* high *civilian fatality rate* recorded for *FPU* 57. It is apparent below that this high *civilian fatality rate* is also associated with the involvement of gas and liquid fuels, as has previously been noted in a companion report'.

Thus it appears that:

- *the fire jighter fatality* and *injury rates are* largely unaffected by *complex* and whether the *jixed property use is motor vehicle or boat sales, services* or not
- *the civilian fatality rate* is significantly higher for *motor vehicle or boat sales, services* occurring in the *no complex* situation
- *the civilian injury rate* is significantly higher for *motor vehicle or boat sales, services than* for all other *fixed property* use cases for all *complex* categories

4 FIXED PROPERTY USE

The *fixed property use (FPU)* categories are:

FPU 51	Food, beverage sales
FPU 52	Textile, wearing apparel sales
FPU 53	Household goods sales, repairs
FPU 54	Specialty shops
FPU 55	Recreation, Hobby, or Home Repair Supply Sales, Personal Services
FPU 56	Professional Supplies, Services
FPU 57	Motor Vehicle or Boat Sales, Services
FPU 58	General Item Stores

(Note that *FPU 56 (professional supplies, services)* contains the fire with 119 civilian injuries and the fixed property uses that contain the fires with three, four and five civilian fatalities are respectively *FPU 58 (general item stores), FPU 57 (motor vehicle or boat sales, services)* and *FPU 5* 1 *(food, beverage sales).)*

The *fixed property* uses with the greatest number of fires are *food, beverage sales (27%)* and *motor vehicle or boat sales, services* (19%) (Figure 2 and Table 4).

The *fire fighter injury rate* is highest (and much greater *than* the *overall average rate)* for *FPU 53 (household goods sales, repairs)* but the *civilian injury rate* is highest *(also* well above *the overall average rate)* in *FPU 57 (motor vehicle or boat sales, services)* (Figure 2).

The *civilian fatality rate* is highest (and the only category significantly above average) for *FPU* 57 as noted above.

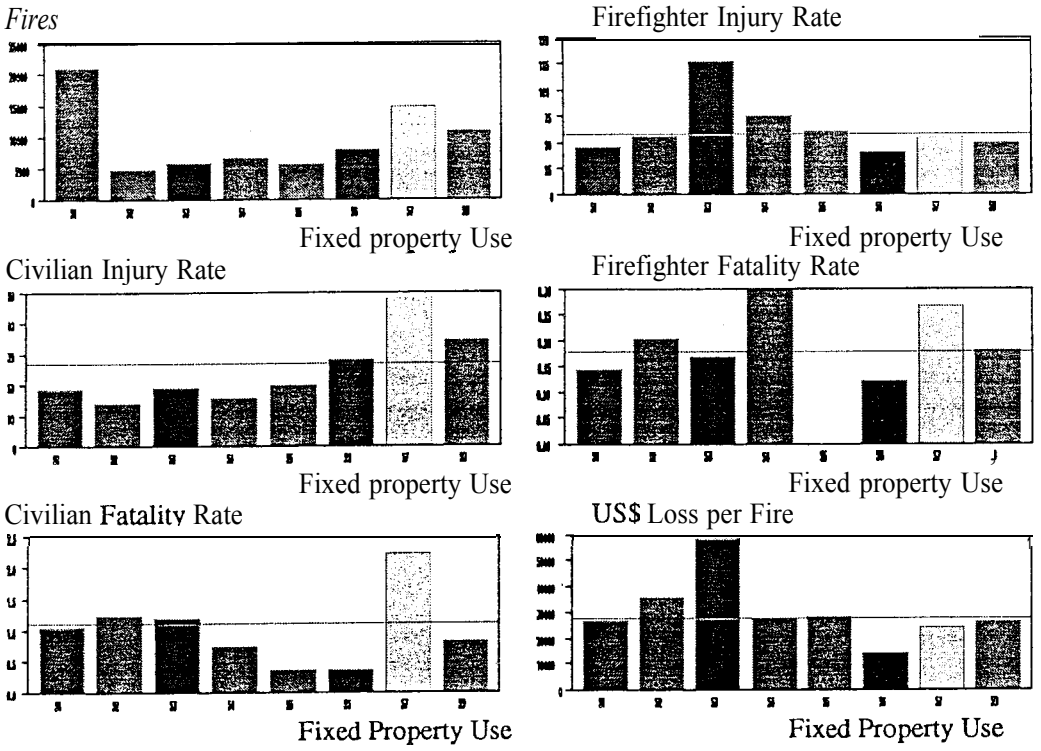


FIGURE 2 FIXED PROPERTY USE

Both *the civilian* and *fire fighter fatality rates are* particularly low for *FPU 55,* but why this is so is not apparent. There may be no particular significance in the fact that no *fire fighter fatalities* occur in this *FPU,* but the *civilian fatality rates* for *FPU 55* and *FPU* 56 do appear to be significantly below average as there are quite large numbers of fires in each category.

TABLE 4 FIXED PROPERTY USE

Fixed Property Use	*Fires (% of known)*	*Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fire Fighter Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (loss per fire)*
51	20987	985	390	3	22	5.6354e8
	(26.9)	(46.9)	(18.6)	(0.14)	(1.05)	(26,900)
52	4897	276	69	1	6	1.7722e8
	(6.3)	(56.4)	(14.1)	(0.20)	(1.23)	(36,200)
53	5865	750	113	1	7	3.4691e8
	(7.5)	(128)	(19.3)	(0.17)	(1.19)	(59,100)
54	6701	509	107	2	5	1.8693e8
	(8.6)	(76.0)	(16.0)	(0.30)	(0.75)	(27,900)
55	5538	344	111	0	2	1.5761e8
	(7.1)	(62.1)	(20.0)	(#)	(0.36)	(28,500)
56	8160	336	228	1	3	1.1351e8
	(10.4)	(41.2)	(27.9)	(0.12)	(0.37)	(13,900)
57	14921	833	724	4	33	3.5987e8
	(19.1)	(55.8)	(48.5)	(0.27)	(2.21)	(24,100)
58	10927	547	376	2	9	2.8751e8
	(14.0)	(50.1)	(34.4)	(0.18)	(0.82)	(26,300)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

As FPU 57 seems to stand out from all of the other *fixed property uses* in having generally higher *casualty rates* it is worthwhile examining in more detail the building uses that make up this category. FPU *57 (motor vehicle or boat sales, service)* includes such categories as public and private service stations; motor vehicle repair, paint shop; motor vehicle, trailer sales; motor vehicle accessory sales; boat, pleasure craft sales; marine service station; and car wash facilities. It is obvious that some of these building uses may result in the presence and use of flammable liquids and gases and also in the presence and use of sources of ignition and heat to a degree well above the norm for many other building uses.

In summary, it appears that:

- the *fire fighter fatality rate* is higher than average for *FPU 54* and *FPU 57*
- *the fire fighter injury rate* is unusually high for *FPU* 53
- *tie civilian fatality and injury rates are* both significantly higher than *the overall average rates* for *FPU 57*

5 EXTENT OF FLAME DAMAGE

The NFIRS field *extent of flame damage* is a measure of the degree of development and spread of a fire. The general classification of *extent of flame damage* is as follows:

EFD 1	Confined to the object of origin
EFD 2	Confined to the part of room or area of origin
EFD 3	Confined to the room of origin
EFD 4	Confined to the fire-rated compartment of origin
EFD 5	Confined to the floor of origin
EFD 6	Confined to the structure of origin
EFD 7	Extended beyond the structure of origin

(Note that *EFD* 6 contains the fire with 119 *civilian injuries* and also the fires with three and four *civilian fatalities* and *EFD 2 the* fire with five *civilian fatalities.)*

The largest group of fires (47% of fires with known *EFD)* cause *flame damage confined to the object of origin* and the next largest group (19% of fires with known *EFD) flame damage confined to the part of room or area of origin* (Figure 3 and Table 5). Overall, 78% of fires with known *EFD* reported to the fire brigades (or 70% of all fires) cause *flame damage confined within the room of origin.*

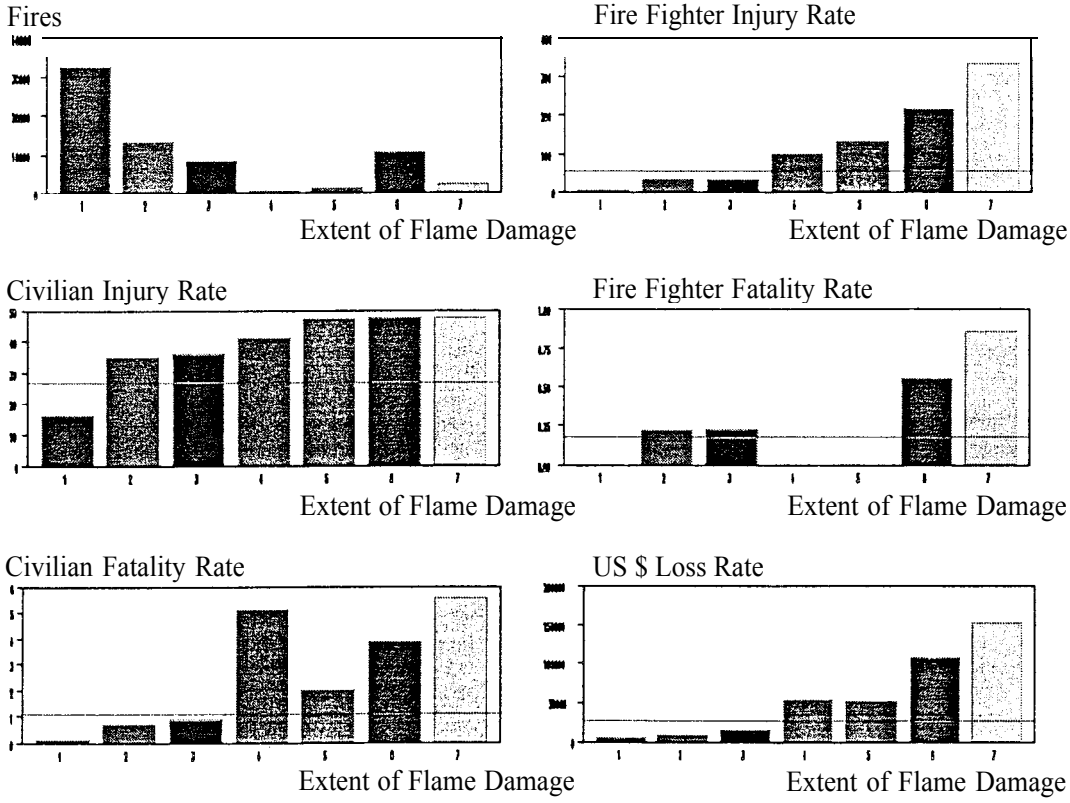


FIGURE *3* EXTENT OF FLAME DAMAGE

Of the fires that cause *flame damage that extended beyond the room of origin,* very few are recorded as having *flame damage confined to the fire-rated compartment of origin* or *confined to the floor of origin* (altogether 2.9% of fires with known *EFD).* Of the fires with *flame damage that extended beyond the room of origin the* largest proportion is *confined to the structure of origin* (16% of fires with known *EFD)* and a small proportion (3% of fires with known *EFD)* have *flame damage that extended beyond the structure of origin.*

The largest number of *fire fighter injuries (2374* or 52%) occur in the relatively small number of fires classified as having *flame damage confined to the structure of origin.* However, this do not result in the highest *rate of fire fighter injuries* (335 injuries per 1000 fires) which occur for fires causing flame *damage extending beyond the structure of origin.* There is a clear trend in the *rate* of *fire fighter injuries* from the lowest for *fires confined to the object of origin* to the highest for fires causing *extending beyond the structure of origin* (see [std rate] figures in Table 5: [std rate] is the rate in each category standardised by dividing by the rate for *EFD I).*

The largest number of *civilian injuries (527* or 25%) occur in the very large number of fires classified as having *flame damage confined to the object of origin.* This number of injuries is almost equalled by those that occur in the relatively small number of fires classified as having *confined to the structure of origin* with 516 *civilian injuries* (or 24%). The highest *rate of civilian injuries* occurs in fires with *flame damage that extended beyond the structure of origin* but two other categories *(confined to the floor of origin* and *confined to the structure of origin)* have virtually the same rate. There is a clear pattern of increasing *civilian injury rate* with increasing *extent of flame damage.*

The relatively small number of *fire fighter fatalities* and relatively small number of fires in some categories results in some gaps in the pattern for *the fire fighter fatality rate.* The largest number of *fire fighter fatalities* occur in fires with *flame damage confined to the structure of origin* but the highest *fire fighter fatality rate* is for fires with *flame damage that extended beyond the structure of origin.* Although there are some gaps in the data the clear trend is for the *fire fighter fatality rate* to increase with increasing *extent of flame damage.*

The largest number of *civilian fatalities* occur in fires with *flame damage confined to the structure of origin,* but as with the previous casualty rates, the highest *civilian fatality rate* is for fires that *extended beyond the structure of origin.* There is a trend for the *civilian fatality rate* to increase with increasing *extent of flame* damage but this is interrupted by a peak for fires *confined to the fire-rated compartment of origin.* This disturbance to the trend needs to be treated with some caution as the number of fires (and fatalities) in this category is very low, so the high rate may be an aberration. However, a similar feature is observed with other data analysed and the high rate may indeed be a feature of fires classified as having *flame damage confined to the fire-rated compartment of origin.*

The trend *in estimatedproperty* losses is very clear, with the rate increasing with increasing *extent of flame damage.*

TABLE 5 EXTENT OF FLAME DAMAGE

EFD	*Fires (% of known)*	*Injuries (Rate*) [std rate]*	*Civilian Injuries (Rate*) [std rate]*	*Fatalities (Rate*) [std rate]*	*Civilian Fatalities (Rate*)*	*US $ Loss (US $ Loss/Fire) [std rate]*
1	32580	256	527	0	4	1182510000
	(46.6)	(7.86)	(16.2)	(0)	(0.12)	(5601)
		[1]	[1]	[0]	[1]	[1]
2	13460	448	473	3	10	143770000
	(19.2)	(33.3)	(35.1)	(0.22)	(0.74)	(10681)
		r4.21	[2.2]	I-l	[6.2]	Il.91
3	8679	288	315	2	8	147600000
	(12.4)	(33.2)	(36.3)	(0.23)	(0.92)	(17006)
		[4.2]	[2.2]	r-l	[7.7]	[3.0]
4	579	61	24	0	3	31558352
	(0.8)	(105)	(41.4)	(#)	(5.18)	(54504)
		[13]	[2.5]	[-]	[43]	[9.7]
5	1499	205	71	0	3	78454149
	(2.1)	(137)	(47.4)	(#)	(2.00)	(52337)
		[17]	[2.9]	I-l	[17]	[9.3]
6	10829	2374	516	6	42	11740000oo
	(15.5)	(219)	(47.7)	(0.55)	(3.88)	(108412)
		[28]	[2.9]	I-l	[32]	[19]
7	2325	778	111	2	13	354830000
	(3.3)	(335)	(47.7)	(0.86)	(5.59)	(152615)
		[43]	[2.9]	I-l	[47]	[27]
unknown, etc	8045	170	81	l	4	80394966
	(11.5)	(21.1)	(10.1)	(0.12)	(0.50)	(9993)
		[2.7]	[0.6]	[-]	[4.2]	[1.8]

Notes: • The overall avenge rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1
• Rate per 1000 fires unless noted otherwise

It is clear from the above and from Table 1 that confining the extent *of flame damage* of fires to a minimum may be expected to be, on average, very worthwhile in limiting the number of casualties and amount of property damage.

If all of the fires *are* such that the *extent of flame damage* is able to be *confined to the object of origin,* and the *rates of casualties and property damage* in that category remained the same, *then:*

- there will be no *fire fighter fatalities*
- the number *of fire fighter injuries* will be reduced by a factor of more than *seven*
- *the civilian fatalities* reduced by a factor of more than nine
- *the civilian injuries* reduced by a factor of almost two
- *the property* losses reduced by a factor of five

Alternatively, if all of the fires *are* such that *the extent of flame damage* is able to be *confined to the room of origin,* and the rates of casualties and property damage in that category remained the same, then:

- the number of *fire fighter fatalities* will be reduced by a factor of two
- *the fire fighter injuries* reduced by a factor of more than three
- the civilian fatalities reduced by a factor of almost three
- the civilian injuries reduced by a small amount
- the property losses reduced by a factor of more than three

It should be pointed out here that it may not realistic to assume that the same *casualty andproperty* damage *rates* will be maintained if all fires are so confined. However, the above figures probably represent an optimistic estimate of the benefits that might be gained if tires could be confined as assumed.

It can be seen that major benefits may be gained by *confining fires to the room of origin* (or even better, *the object of origin).* Therefore, in the following sections, the effectiveness of many of the building systems represented by the NFIRS fields is compared in terms of their effect on the *extent of flame damage,* particularly on their effect on the percentage of fires with *flame* damage that is **not** *confined to the room of origin.*

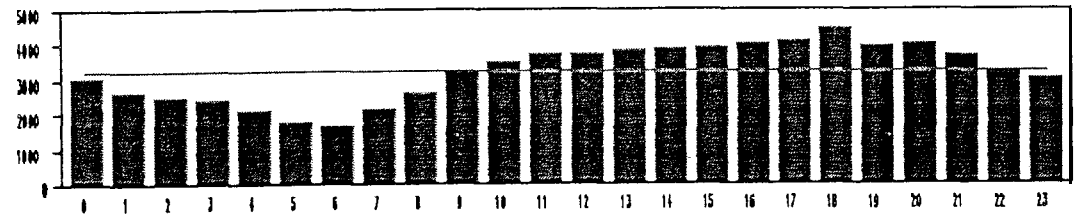
In summary then:

- overall, only 22% of the fires with known extent of *flame* damage have *flame* damage **not** *confined to the room* of origin
- of the fires that have **not** *confined to the room* of origin the great majority have the extent of *flame damage* classified as *confined to the structure of origin* or *extended beyond the structure of origin* (in total 19% of fires with known extent of *flame damage)*
- in general, casualty and property loss rates increase substantially with increasing *extent of flame damage*
- for fires in which *flame damage* extends beyond the *room of fire origin* compared with those where it is *confined to the room of fire origin the civilian fatality rate* is ten times higher, the *fire fighter fatality rate* is nearly six times higher, the *civilian injury rate* nearly twice as high, *the fire fighter injury rate* over twelve times higher and the *estimated property loss* rate is twelve times higher

6 ALARM TIME

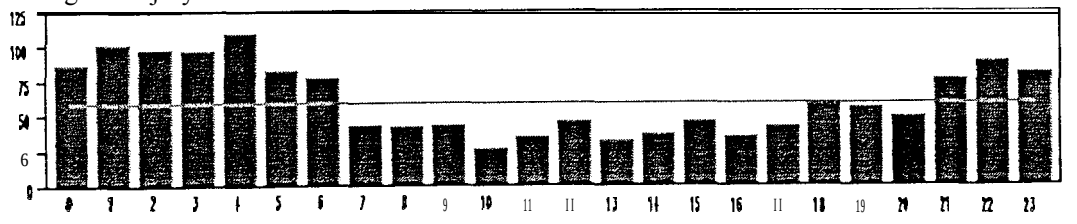
The variation of the number of fires by *time of alarm* (Figure 4 and Table 6) is clearly very significant, and the variation is clearly systematic. In Figure 4 the vertical axis is the number of fires during the following hour and the horizontal line within the graph is the overall average number of fires per hour.

Fires



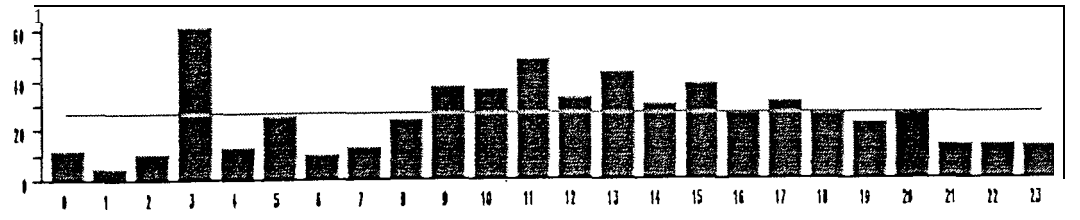
Hour of Alarm

Firefighter Injury Rate



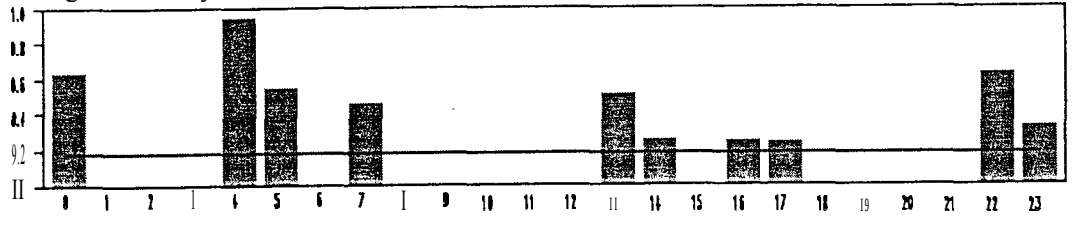
Hour of Alarm

Civilian Injury Rate



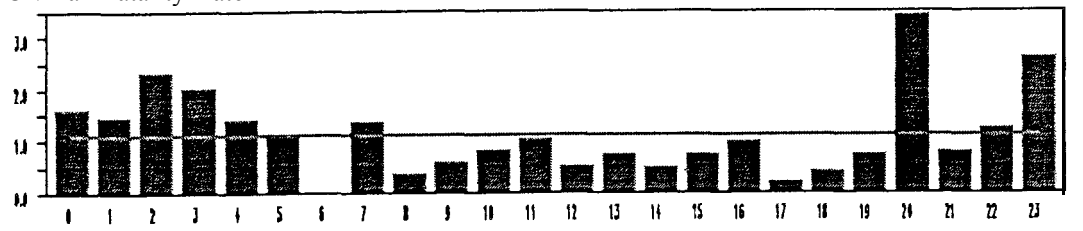
Hour of Alarm

Firefighter Fatality Rate



Hour of Alarm

Civilian Fatality Rate



Hour of Alarm

FIGURE 4 HOUR OF ALARM

TABLE 6 HOUR OF ALARM

Hour	*Fires*	*Fire-Fighter Injuries*	*Fire-Fighter Injury Rate*	*Civilian Injuries*	*Civilian Injury Rate*	*Fire-Fighter Fatalities*	*Fire-Fighter Fatality Rate*	*Civilian Fatalities*	*Civilian Fatality Rate*
0	3110	269	86.50	38	12.22	2	0.64	5	1.61
1	2701	276	102.18	13	4.81	0	(#)	4	1.48
2	2562	252	98.36	27	10.54	0	(#)	6	2.34
3	2453	240	97.84	152	61.96	0	(#)	5	2.04
4	2113	234	110.74	28	13.25	2	0.95	3	1.42
5	1797	148	82.36	46	25.60	1	0.56	2	1.11
6	1690	131	77.51	97	80.06	0	(#)	0	0.00
7	2169	96	44.26	29	13.37	1	0.46	3	1.38
8	2638	113	42.84	65	24.64	0	(#)	1	0.38
9	3303	144	43.60	125	37.84	0	(#)	2	0.61
10	3542	93	26.26	132	37.27	0	(#)	3	0.85
11	3757	136	36.20	182	48.44	0	(#)	4	1.06
12	3750	173	46.13	124	33.07	0	(#)	2	0.53
13	3864	126	32.61	169	43.74	2	0.52	3	0.78
14	3894	142	36.47	119	30.56	1	0.26	2	0.51
15	3938	183	46.47	153	38.85	0	(#)	3	0.76
16	4027	145	36.01	113	28.06	1	0.25	4	0.99
17	4120	175	42.48	131	31.80	1	0.24	1	0.24
18	4530	261	57.62	119	26.27	0	(#)	2	0.44
19	3977	227	57.08	93	23.38	0	(#)	3	0.75
20	4046	200	49.43	106	26.20	0	(#)	14	3.46
21	3698	285	77.07	53	14.33	0	(#)	3	0.81
22	3178	283	89.05	44	13.85	2	0.63	4	1.26
23	3039	248	81.61	40	13.16	1	0.33	8	2.63

Notes: • The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per
• 1000 noted

In the following discussion (and the remainder of this report) the *time of alarm* is characterised by the time at the start of the hour, and references to, for example, 6 am (or 0600 hours) should be understood to mean the period from 6 am to 7 am (0600 hours to 0700 hours).

The peak in alarms occurs in the hour after 6.00 pm and the minimum (which is only 37% of the peak) in the hour after 6.00 am. The alarm rate falls virtually continuously through the evening and night, rises quite sharply in the morning (after 6.00 am) and continues rising slowly during the day.

The variation in the *rate of fire fighter injuries* (Figure 4) also seems to be quite systematic with the rate being consistently lower during the day and higher during the night, particularly from about 9.00 pm to 6.00 am. The low number of *fire fighter fatalities* makes it difficult to see any meaningful variation in the *fire fighterfatality rate* through the 24 hour period.

The *civilian injury rate* also seems to vary systematically with the exception of the high rate at 3.00 am, but this aberration is explained by noting that this is the

time period with the fire with 119 civilian injuries. Otherwise the *civilian injury rate* is consistently higher during the day particularly from 9.00 am to 5.00 pm and lower, particularly from 10.00 pm until 7.00 am. However, the *civilian fatality rate* seems to be somewhat lower during the day and higher during the night, particularly from 10.00 pm to 5.00 am. The peaks at 8.00 pm and 11.00 pm are (at least partly) due to the fires with multiple casualties: Note that the hour after 8.00 pm (20) contains the fires with three and five civilian injuries and the hour after 11.00 pm (23) contains the fire with four civilian injuries. However, even disregarding the multiple fatalities, 8.00 pm has a high number and rate of civilian injuries.

Careful study will be required to establish with confidence the reasons for these systematic variations. However, it is hypothesised that:

- *the fire fighter injury rate* is increased during the night due to extra difficulty in fighting fires in darkness and/or fires at night, on average, having greater *extent of flame spread* than fires during the day
- the *civilian fatality rate* is increased during the night due to a greater proportion of the population in these buildings being asleep or impaired than during the day and/or fires at night, on average, having greater *extent of flame spread* than fires during the day
- *tie civilian injury rate* is reduced during the night due to, on average, a much smaller number of people being in these buildings during the night than during the day and/or people in the building being directly involved in, or noticing, fewer fire starts

Accurate figures for the number of people in these buildings at any particular time *is,* of course, not known. However, it may well be that *the civilian casualty rates,* if standardised on the average numbers of people in the building, will actually change rather differently. As the average number of people in the buildings during the day could be expected to be much greater than during the night it is reasonable to speculate that the change in the *standardised civilian fatality rate* (fatalities per 1000 fires per person in the building) will be much greater than for the un-standardised *rate* (as above) and that the *standardised civilian injury rate* will increase during the night rather than decrease, as noted above for the un-standardised *rate.*

Some aspects of these hypotheses are addressed in the next section on variation of extent of flame damage with alarm time.

Thus, in summary on the effect of alarm time:

- the peak number of fires per hour (at 6.00 pm) is nearly three times the minimum (at 6.00 am)
- *the jire fighter injury* and *civilian fatality rates are* consistently higher during the night than during the day
- *the civilian injury rate* is consistently lower during the night than during the day

7 VARIATION OF EXTENT OF FLAME DAMAGE WITH ALARM TIME

The variation in the number of fires in each *extent of flame damage* category over the twenty-four hour day is shown in Figure 5.

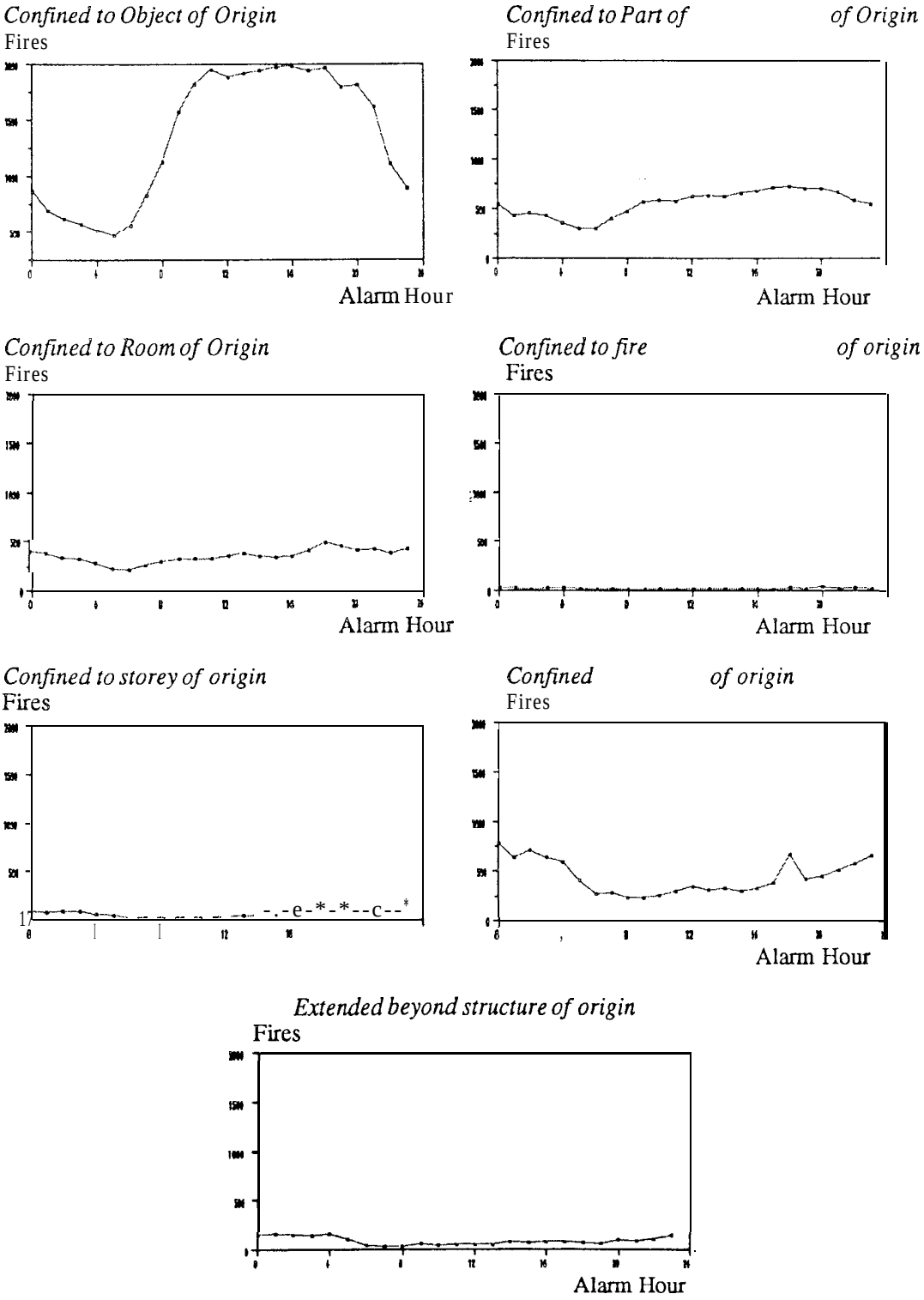


FIGURE 5 FIRES FOR EACH EXTENT OF FLAME DAMAGE BY ALARM HOUR

It is obvious that a major feature is the variation in the number of fires *confined to the object of origin* through the day. The number of fires *confined to the object of origin:*

- is a minimum of 473 at 5 am
- is a maximum of 1987 at 4 pm
- is reasonably constant during the period 11 am to 6 pm averaging 1951 during that period
- from 6 pm falls fairly rapidly and consistently to 900 at midnight
- from midnight falls more slowly until reaching the minimum at about 5 am
- from 6 am rises quite rapidly until about 11 am

There is a somewhat similar pattern of variation for fires *confined to the part of room or area of origin,* but the magnitude and significance of the change is much lower: minimums of about 310 at 5 am and 6 am, and a maximum of 734 at 6 pm.

The *same* is true for fires *confined to the room of origin* but the variation is greater, with the number of fires continually increasing from a minimum at 5 am to the more prominent peak at 6 pm (the minimum is 230 at 5 am and 6 am, the maximum is 493 at 6 pm).

The numbers of fires *confined to the fire-rated compartment of origin* and *confined to the floor of origin* are so small in comparison with those confined to other *extent of flame* damage categories as to be insignificant, and it is clear from the relevant graphs in Figure 5 that their variation is also comparatively insignificant.

The variations in the number of fires in the *extent of flame damage* categories *confined to the structure of origin* and *extended beyond the structure of origin are* quite different to those discussed above. In both of these categories the maximum occurs at about midnight, although the minimum still occurs at about 6 am, with a slow rise during the day and evening. A feature in the variation in the number of fires *confined to the structure of origin* is a sharp peak that occurs at 6 pm. This is largely due to fires associated with the Los Angeles riots that took place on 29 April 1992.

The pattern of variation shown in Figure 5 is similar to that previously obtained for Australian non-residential buildings' but different from that obtained for Australian and USA residential buildings[3,5].

These data are also presented in terms of the total percentage of fires with *flame damage not confined to the room of origin* in Figure 6. This figure shows that the percentage of fires with flame damage *extending beyond the room of origin* is a minimum of 12% (at 10 am) and a maximum of 43% (at 4 am), a more than threefold increase.

It appears likely that the variations noted above in the frequency of occurrence of fires, in the percentages of fires in *the* various *extent of flame damage* categories, and the total percentage of fires *confined to the room of origin* is related to the presence and activities of people (civilians) in the buildings.

It appears that the presence of people (and presumably some of their activities) during the hours that retail establishments are commonly open greatly increases the frequency of fire starts. But it also appears that their presence also reduces substantially the likelihood that a individual fire start will develop such that *flame damage* will extend *beyond the object of origin* or any subsequent stage of fire growth. The effect of these changes on the consequences of fires (in terms of *casualties and property losses)* are discussed below.

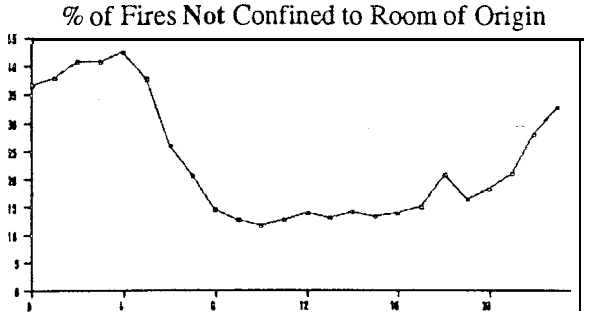


FIGURE 6 VARIATION IN THE PERCENTAGE NOT CONFINED ROOM OF ALARM TIME

The peak in the number of fires at 6.00 pm may, for example, be associated with people cooking dinner or socialising after closing for the day and/or a greater proportion of fires initiated directly or indirectly by the activities of people before the establishments close for the day, but shortly after closing progressing to a stage where the services of the fire department is required due to the presence of fewer people (to notice and perhaps rapidly extinguish the fire) after closing.

Both *the number* of *fire fighter injuries* (Table 6) and (as noted above) the *rate of fire fighter injuries* (Figure 4) is greater during the night than during the day. This is a reflection of two factors:

- the percentage of fires with *flame damage confined to the room of origin* is greater during the day than during the night (Figure 6), and (as may be intuitively expected) the *rate of fire jighter casualties* is much lower for fires *confined to the room of origin than* for other fires
- the *rate of jire jighter casualties* even in fires with *flame damage confined to the room of origin* is lower during the day than during the night (13.7 for the eight hours 8am to 5pm, 21.0 for the remainder)

In contrast, both the *number* and *rate of civilian injuries* (Table 6 and Figure 4) are substantially greater during the day than during the night. This is a result of three factors, two of which compete against the other:

- there is a substantial increase in the number of fires during the day (Figure 4)
- *tie rate of civilian casualties* increases during the day for all fires whether they have *flame damage confined*

to the room of origin or not *(eg* for fires *confined to the room of origin* the *rate* is 10 (for the four hours midnight to 4 am) and 33 (for the four hours from midday to 4 pm), a more than threefold increase)

- the number of fires *confined to the room of origin* increases during the day (Figure 6) having the reverse effect to the points above because *tie rate of civilian injuries* is substantially lower for fires *confined to the room of origin* than for those not so confined

Despite the increased number of fires during *the* day *the number of civilian fatalities* reduces during the day due to the decrease in the number of fires not *confined to the room of origin* and due to a reduction in *the rate of civilian fatalities* during *the* day even for fires *confined to the room of origin.*

It is also notable that *the estimated property* losses for fires during the day are substantially less than for those at night, again for two reasons:

- fires with *flame damage confined to the room of origin* have, on average, substantially lower *estimated property losses* than others and, of course, more fires remain so confined
- the *estimated property* losses are substantially lower for fires during the day than during the night, whether *they* are *confined to the room of origin* or not

In summary:

- *the extent of flame spread* of fires varies substantially with *alarm time*
- the greatest variation takes place in fires with *flame spread confined to the object of origin* - these increase greatly during the day
- the percentage of fires with *extent of flame damage not confined to the room of origin* increases from 12% during the day to 43% during the night
- these variations have predictable effects on the *casualty and property loss rates*

8 SPRINKLER PERFORMANCE

The general classification of sprinkler performance is as follows:

SP 1	Equipment operated
SP 2	Equipment should have operated but did not
SP 3	Equipment present but fire too small to require operation
SP 8	No equipment present in room or space of fire origin
SP 9	Unknown, etc

(Note that *SP* 8 contains the fire with 119 civilian injuries and *SP 9, SP 8 and SP 1* contain the fires with three, four and five civilian fatalities respectively.)

The number *of* fires with *sprinklers not present* and *sprinkler presence unknown* is substantially greater than that for *those* with *sprinklers present,* whether they operated or not (Figure 7 and Table *7).* The fires with *sprinklers not present* therefore result in the overwhelming majority of *casualties and property losses.* However, they do not necessarily result in the highest *rates of casualties or losses.*

Sprinklers *do not operate* in 69% of fires recorded as having *sprinklers present* in *the room of origin.* However, in 93.5% of these cases the fire is classified as too small to trigger or require sprinkler operation. That is, *sprinklers do not operate* in *64%* of *the* fires where there *are sprinklers present* **because the fire is too small** to **activate them.** Conversely, *sprinklers do nut operate* in 12.7% of the fires where it is judged by the reporting fire fighter that they should have operated. In some cases these judgements may be somewhat subjective, and these figures should be treated with caution.

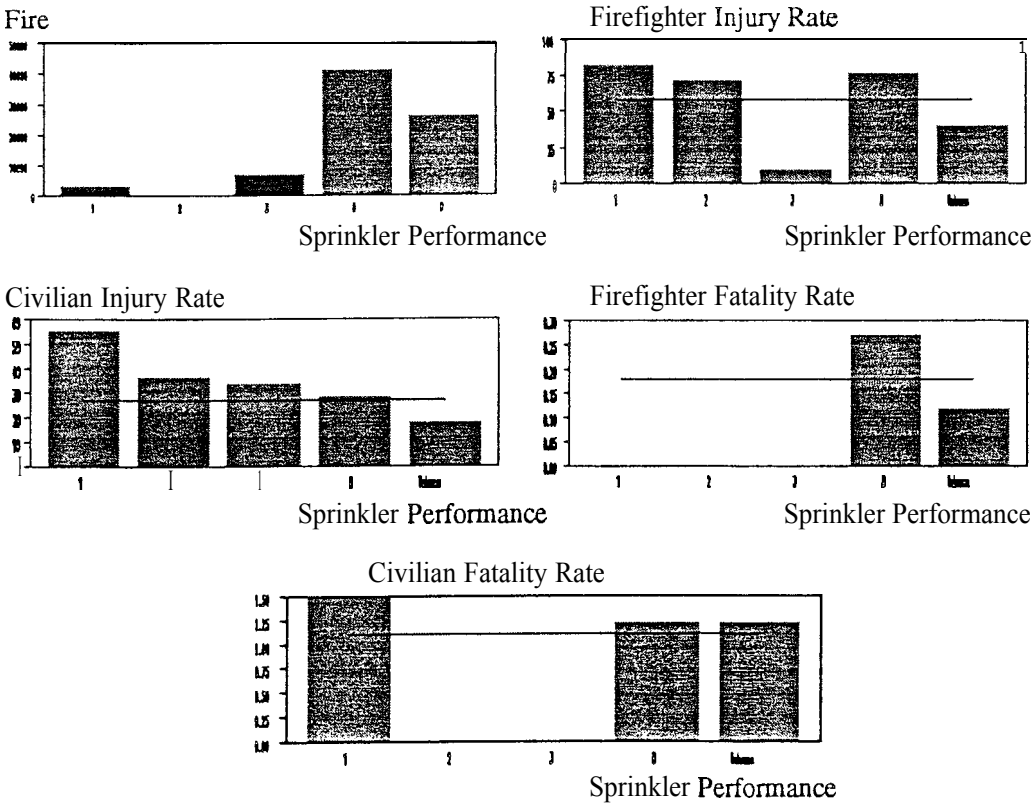


FIGURE7 SPRINKLER PERFORMANCE

TABLE 7 SPRINKLER PERFORMANCE

Sprinkler Performance	*Fires*	*Fire-Fighter Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (Rate*)*
1	3361	275	186	0	5	1.0511e8
		(81.8)	(55.3)	(#)	(1.5)	(31273)
2	489	35	18	0	0	69393OOQ
		(71.6)	(36.8)	(#)	(#)	(141,908)
3	6978	68	238	0	0	3099372
		(9.7)	(34.1)	(#)	(0)	(4442)
8	41,133	3152	1196	11	50	1.1321e9
		(76.6)	(29.8)	(0.3)	(1.2)	(27,522)
Unknown	26,035	1050	480	3	32	8.5548e8
		(40.3)	(18.4)	(0.1)	(1.2)	(32,859)
1 + 2 + 3	10,828	378	442	0	5	2.055e8
		(34.9)	(40.8)	(0)	(0.5)	(18,978)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

The *firefighter injury rate* is lowest by far for those fires classified as having *sprinklers present* but *fire too small to require operation.* It is fairly similar (slightly above the overall average rate) for the remaining categories except *sprinkler presence unknown* for which it is substantially lower than the *overall average rate.* The overall *fire fighter injury rate* for fires with *sprinklers present (whether they operated or not)* is 35.1 which is well under the overall average rate of 58.7 and is *also* below the rate for *unknown sprinkler presence,* although this rate is also well below *tie overall average rate.*

The *civilian injury rate* is highest for fires with *sprinklers present and operated* and lowest for fires with *sprinklers unknown.* The rate for all of *the sprinkler present (whether they operated or not)* cases combined of 45.0 is well above the *overall average rate* for all fires of 27.2.

There *are* no *fire fighter fatalities* at fires with *sprinklers present.* If fire fighter fatalities occur at the same rate *as* for fires with *sprinklers not present* about three fatalities are expected, so it appears likely that a lower *fire fighter fatality rate* might apply to fires with *sprinklers present (whether they operated or not).*

Five *civilian fatalities* occur in one fire where the sprinklers *are present and operated, the* only fire with *sprinklers present* resulting in fatalities. This gives a *civilian fatality rate* for fires with *sprinklers present and operated* of 1.5, above *the overall average rate* for all fires of 1.12. However, the overall rate for fires with *sprinklers present (whether they operated or not)* is 0.5 well below the overall average.

The average *estimated loss per fire* is very low for fires in which the *sprinklers are present but do not operate* because the fire is too small to require operation but is very high for those in which the *sprinklers* should have *operated* but *do not* (Table 7). However, the overall rate for all fires with *sprinklers present (whether they operated or not)* is substantially below the *overall average* at US$ 19,000 (compared with the overall average of US$ 28,100.

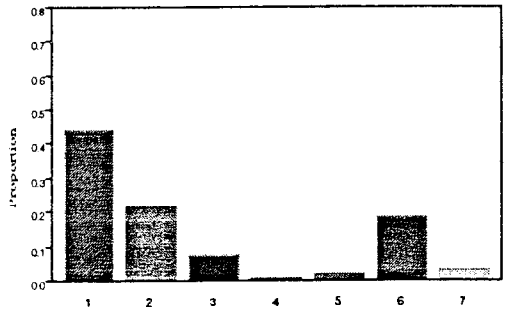
In summary:

- sprinklers do not operate in 69% of fires where they *are present* however in 94% of these cases the fire is judged *too small to require operation*
- *the fire fighter fatality and injury rates, civilian fatality rate* and *estimated property loss per fire are* lower for fires with *sprinklers present than* for fires with *sprinklers not present*
- *the civilian injury rate* is higher for fires with *sprinklers present* than for fires with *sprinklers not present*

9 EFFECT OF SPRINKLER PRESENCE ON EXTENT OF FLAME DAMAGE

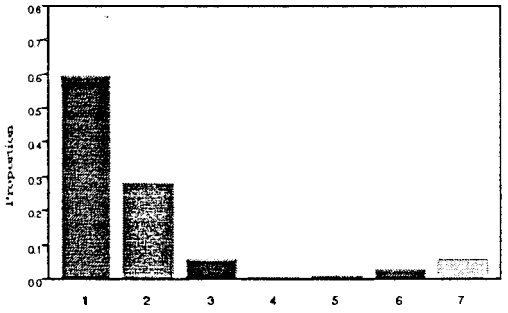
The action of sprinklers could reasonably be expected to have an influence on the *extent of flame damage* (Figure 8 and Tables 8 to 12). In this figure and the tables five sprinkler cases are considered:

- sprinklers *notpresent* (Figure **8(a))**
- sprinklers *present* (Figure 8(b))
- sprinkler *presence unknown* (Figure 8(c))
- sprinklers *present and operated* ((Figure 8(d))
- sprinklers *present and do not operate* (for whatever reason) (Figure 8(e))



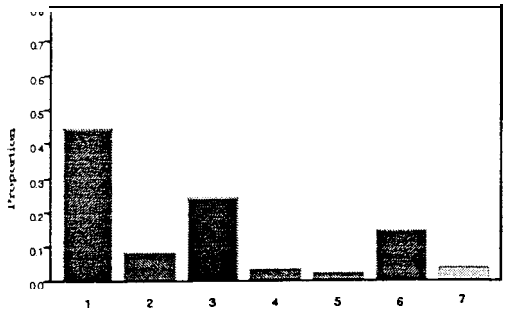
Extent of Flame Damage

(a) sprinklers not present



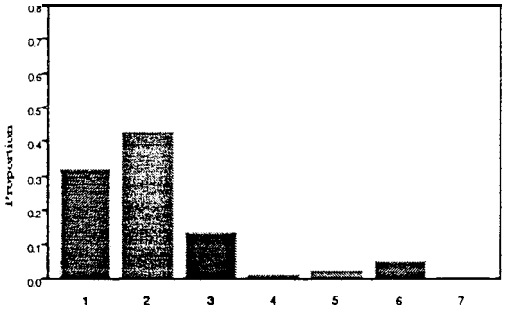
Extent of Flame Damage

(b) sprinklers present



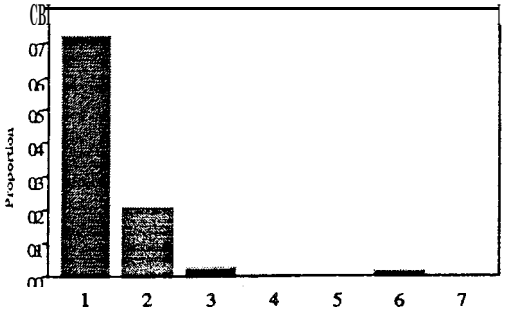
Extent of Flame Damage

(c) sprinkler presence unknown



Extent of Flame Damage

(d) sprinklers present and operated



Extent of Flame Damage

(e) sprinklers present but do not operate

Extent of Flame Damage Categories:

1 Confined to the object of origin
2 Confined to part of room or area of origin
3 Confined **to** room of origin
4 Confined to the fire-rated compartment of origin
5 Confined to the floor of origin
6 Confined to structure of origin
7 Extended beyond structure of origin

FIGURE 8 EXTENT OF FLAME DAMAGE FOR SPRINKLER PRESENCE AND ACTION

TABLE 8 EXTENT OF FLAW DAMAGE WITH SPRINKLERS NOT PRESENT

EFD	*Fires (%)*	*Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (Rate*)*
1	17404	134	277	0	2	44822658
	(44.2)	(7.7)	(15.9)	(0.0)	(0.1)	(2580)
2	8799	272	236	3	3	78207563
	(22.3)	(30.9)	(26.8)	(0.3)	(0.3)	(8890)
3	3021	176	129	2	2	69012780
	(7.7)	(58.3)	(42.7)	(0.7)	(0.7)	(22,800)
4	417	49	18	0	3	20732021
	(1.1)	(118)	(43.2)	(#)	(7.2)	(50,000)
5	881	144	45	0	3	44601405
	(2.2)	(164)	(51.1)	(#)	(3.4)	(51,000)
6	7472	1811	403	4	28	6.3412e8
	(19.0)	(242)	(53.9)	(0.5)	(3.7)	(84,900)
7	1428	552	74	2	9	2.2542e8
	(3.6)	(387)	(51.8)	(1.4)	(6.3)	(158,000)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,003 fires
- Rate per 1000 fires unless noted otherwise

The last two cases are subsets of the second and take account of the categories used in the data, but avoid the subjective distinction between sprinklers that *should* or *should not* have operated.

It is clear from the bar charts of Figure 8 (a), (b) and (c) that there are clear differences between *the* three *cases.* In *the sprinkler present* case about 60% of the fires *are confined to the object of origin,* whereas in *the sprinklers not present* and *sprinklers unknown* cases this is only about 44%. Similarly, only about 3% of fires *are confined to the structure of origin* in the *sprinkler present case* compared with about 19% and 15% for the other cases. The distribution in the *sprinklers unknown* case is clearly different from the other two in the low proportion of fires with flame damage *confined to the part of room or area of origin* - only about 9% against 22% and 28% in the other cases.

Overall, about 74% and 78% of fires have flame damage *confined to the room of origin* in *the sprinklers not present* and *sprinklers unknown* cases respectively, compared with over 94% in the *sprinklers present case.*

As it is clearly preferable to prevent fires growing to the extent that the *extent of flame damage* exceeds the *room of origin* it is better to view these figures from the opposite perspective:

- with *sprinklers not present* between 22% and 26 % of fires cause *flame damage beyond the room of origin*
- with *sprinklers present* this is reduced to 6%, a fourfold reduction

Note that caution should be exercised in using the *rate* data in some categories in Tables 8 to 12 as the numbers of fires and casualties are low, and the rates calculated may be subject to a great deal of variation as further data becomes available.

Nevertheless, the trends are generally quite clear, with increasing rates for casualties and estimated property losses with increasing extent *of flame spread* for all cases where there is sufficient data for trends to be apparent.

Comparison of Tables 8 and 9 shows:

- generally the *civilian injury rate* is higher in the case of *sprinklers present* than with *sprinklers notpresent*
- generally the *estimated property* loss is higher in the *case* of *sprinklers present* than with *sprinklers not present*

It should be noted that because of the small numbers of fires in the *sprinklers present* categories neither *jire fighter* or *civilian fatalities are* expected - even if these casualty rates are the same for fires with *sprinklers present as sprinklers not present.* (This comment applies also to Tables 11 and 12.)

The *casualty and property loss rates* in the *sprinklers unknown* case (Table 10) are sufficiently similar to the rates for the other cases (Tables 8 and 9) so as not to cause concern.

Note that in Tables 8, 9 and 10 the trend identified above of increased *fatality, injury and property loss rates* with increasing *extent of flame damage* generally remains the case.

Note that in Table 11 *the civilian fatalities* all occur in one fire, the only tire with more than four *civilian fatalities.*

TABLE 9 EXTENT OF FLAME DAMAGE WITH SPRINKLERS PRESENT

EFD	*Fires (%)*	*Fire Fighter Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fire Fighter Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (Rate*)*
1	6107	63	155	0	0	34330105
	(59.7)	(10.3)	(25.4)	(#)	(0.0)	(5600)
2	2899	131	190	0	5	46026295
	(28.3)	(45.2)	(65.5)	(#)	(1.7)	(15,900)
3	654	26	44	0	0	20961534
	(6.4)	(39.8)	(67.3)	(#)	(#)	(32,000)
4	86	2	4	0	0	5705291
	(0.8)	(23.3)	(46.5)	(#)	(#)	(66,000)
5	115	13	13	0	0	7639161
	(1.1)	(113)	(113)	(#)	(#)	(66,000)
6	310	124	18	0	0	83602410
	(3.0)	(400)	(58.1)	(#)	(#)	(270,000)
7	60	11	0	0	0	6515341
	(0.6)	(183)	(#)	(#)	(#)	(109,000)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

TABLE 10 EXTENT OF FLAME DAMAGE WITH SPRINKLERS UNKNOWN

EFD	Fires (%)	Injuries (Rate*)	Civilian Injuries (Rate*)	Fatalities (Rate*)	Civilian Fatalities (Rate*)	US$ Loss (Rate*)
1	9069	59	95	0	2	1.0336e8
	(44.7)	(6.5)	(10.5)	(0.0)	(0.2)	(11,400)
2	1762	45	47	0	2	19538962
	(8.7)	(25.5)	(26.7)	(#)	(1.1)	(11,100)
3	5004	86	142	0	6	57623739
	(24.7)	(17.2)	(28.4)	(#)	(1.2)	(11,500)
4	76	10	2	0	0	5121040
	(0.4)	(132)	(26.3)	(#)	(#)	(67,400)
5	503	48	13	0	0	26213583
	(2.5)	(95.4)	(25.8)	(#)	(#)	(52,100)
6	3047	439	95	2	14	4.5625e8
	(15.0)	(144)	(31.2)	(0.7)	(4.6)	(150,000)
7	837	215	37	0	4	1.2289e8
	(4.1)	(257)	(44.2)	(#)	(4.8)	(147,000)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

TABLE 11 EXTENT OF FLAME DAMAGE WITH SPRINKLERS PRESENT AND OPERATED

EFD	Fires (%)	Fire Fighter Injuries (Rate*)	Civilian Injuries (Rate*)	Fire Fighter Fatalities (Rate*)	Civilian Fatalities (Rate*)	US$ Loss (Rate*)
1	1065	23	37	0	0	7653655
	(32.6)	(21.6)	(34.7)	(#)	(#)	(7187)
2	1421	102	98	0	5	41748098
	(43.5)	(71.8)	(69.0)	(#)	(3.5)	(29379)
3	453	24	24	0	0	17843758
	(13.9)	(53.0)	(53.0)	(#)	(#)	(39390)
4	46	2	3	0	0	3926600
	(1.4)	(43.5)	(65.2)	(#)	(#)	(85360)
5	77	12	12	0	0	6481050
	(2.4)	(156)	(156)	(#)	(#)	(84169)
6	177	99	12	0	0	22513350
	(5.4)	(559)	(67.8)	(#)	(#)	(127194)
7	30	10	0	0	0	4502601
	(0.9)	(333)	(#)	(#)	(#)	(150087)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

TABLE 12 EXTENT OF FLAME DAMAGE WITH SPRINKLERS PRESENT BUT DO NOT OPERATE (FOR WHATEVER REASON)

EFD	*Fires (%)*	*Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fire Fighter Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (Rate*)*
1	5042	40	118	0	0	26676450
	(72.4)	(7.9)	(23.4)	(#)	(0.0)	(5291)
2	1478	29	92	0	0	4278197
	(21.2)	(19.6)	(62.2)	(#)	(#)	(2895)
3	201	2	20	0	0	3117776
	(2.9)	(10.0)	(99.5)	(#)	(#)	(15511)
4	40	0	1	0	0	177869 1
	(0.6)	(#)	(25.0)	(#)	(#)	(44467)
5	38	1	1	0	0	1158111
	(0.5)	(26.3)	(26.3)	(#)	(#)	(30477)
6	133	25	6	0	0	61089060
	(1.9)	(188)	(45.1)	(#)	(#)	(4593 16)
7	30	1	0	0	0	2012740
	(0.4)	(33.3)	(#)	(#)	(#)	(67091)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 tires unless noted otherwise

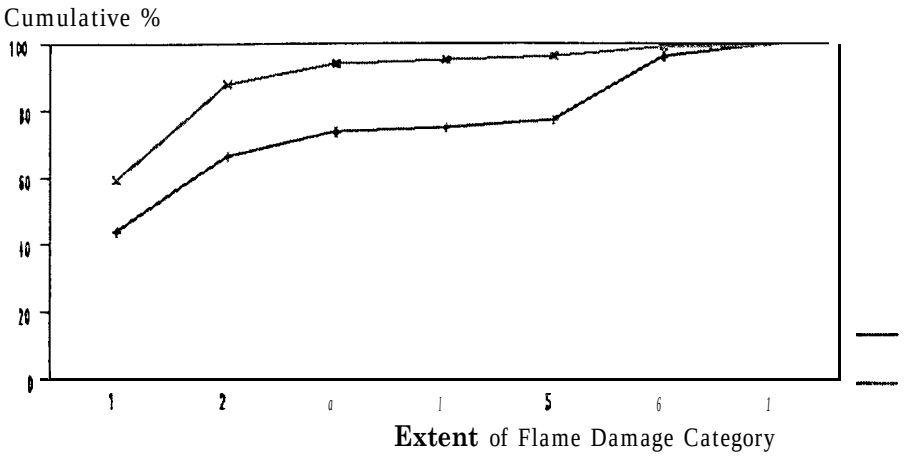


FIGURE 9 COMPARISON OF CUMULATIVE % OF EXTENT OF FLAME DAMAGE FOR SPRINKLERS NOT PRESENT AND SPRINKLERS PRESENT CASES

It can be seen from Figure 9 that with *sprinklers present* the proportion of fires with extent *of flame damage* exceeding each category is significantly lower than when *sprinklers are not present.* The differences can be seen to be fairly constant for *extent of* flame *damage* from *confined to the area or part of room of origin* to *confined to the storey of origin* - thus the differences principally occur in *confined to the object of origin* and *confined to the structure of origin.*

Using the data in Tables 8 and 9 it is possible to estimate the effect of the *presence of sprinklers* on the *casualties and fire* losses. Ideally such an estimate is based purely on the data from fires with *sprinklers present.* However there are not enough fires in certain *extent of flame spread* categories to obtain reliable

estimates of some of the casualty *rates*. Therefore it is necessary to use the rates from the *sprinklers not present* case.

Based on the percentages of fires in each *extent of flame spread* category for fires with *sprinklers present* and the *casualty and property damage rates* for each of the *extent of flame spread* categories of the *sprinklers not present case* it is predicted that for *sprinklers present* at all of the retail fires in the USA covered by the data in this report the casualties and property damage will be the following proportions of the actual casualties and losses:

- civilian fatalities 35%
- fire fighter fatalities 58%
- civilian injuries 75%
- fire fighter injuries 37%
- estimated property loss 35%

Similarly, based on the percentages of fires in each *extent of flame spread* category and *the casualty and property damage rates* for each of *the extent of flame spread* categories for fires with *sprinklers present* it is predicted that the casualties and property damage will be the following proportions of the actual casualties and losses:

- civilian fatalities (39%)
- civilian injuries 138%
- fire fighter injuries 45%
- estimated property loss 70%

It is not possible to estimate the fire fighter fatalities on this basis and the civilian fatality estimate may be unreliable, both due to the relatively small number of fires.

The two estimates above give fairly similar results for *civilian fatalities* and *fire fighter injuries*. However, the estimates for *civilian injuries* and *estimated property* loss differ substantially. These differences reflect the substantially higher *rates* for the *sprinkler present* case for these quantities.

Overall, except perhaps for *civilian injuries,* it is expected that the *presence of sprinklers* leads to substantially reduced *casualties and property losses* due to the combined effects of reduced *extent of flame* damage and generally reduced *casualty andproperty loss rates* in each *extent of flame damage category.*

Thus, in summary:

- with *sprinklers present* about 6% of fires have *flame damage not confined to the room of fire origin* compared with about *25%* for fires with *sprinklers not present*
- *the civilian injury rate* and *estimated property losses per fire* are higher with *sprinklers present,* but all other *casualty rates are* lower with *sprinklers present*
- it is estimated that substantially lower *casualties* (except perhaps for *civilian injuries)* and *property losses* will occur if *sprinklers are present* in the fires covered by this data

10 EFFECT OF SPRINKLER PRESENCE ON EXTENT OF SMOKE DAMAGE

It might be expected that the *extent of smoke damage* in fires will be affected in a similar manner to *extent of flame* damage by the presence and/or operation of sprinklers. The data in Figures 10 and 11 and Tables 13 to 17 show that broadly this is the case. (The sprinkler categories represented in these figures and graphs are the same as those in the previous section.)

The NFIRS field extent of smoke damage is a measure of the degree of development and spread of a fire. The general classification of extent of smoke damage is as follows:

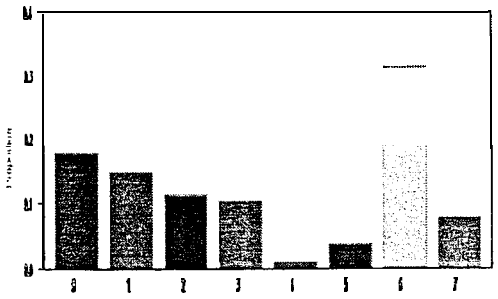
ESD 9	No damage of this type
ESD 1	Confined to the object of origin
ESD 2	Confined to the part of room or area of origin
ESD 3	Confined to the room of origin
ESD 4	Confined to the fire-rated compartment of origin
ESD 5	Confined to the floor of origin
ESD 6	Confined to the structure of origin
ESD 7	Extended beyond the structure of origin

Comparison of the graphs in Figure 10 indicates that there are significant differences between *the sprinkler presence cases, as* there is for *extent of flame damage.*

In *the sprinkler not present case* a total of almost 40% of fires have *extent of smoke damage* in *the* categories *confined to the structure of origin* or *extended beyond the structure of origin,* whereas with *sprinklers present* this total is nearly half at about 23%.

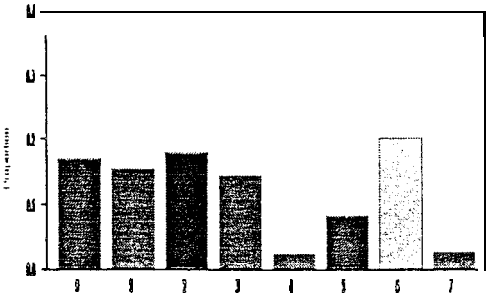
In *the sprinklers present and operated case 40%* of fires have *smoke damage* in *the* categories *confined to the structure of origin* or *extended beyond the structure of origin* compared with the *sprinklers present* but *do not operate case* where this proportion is less than half this figure, at 16%. Thus it is clear that the reduced percentage of fires with smoke *damage* in the categories *confined to the structure of origin or extended beyond the structure of origin* when *sprinklers are present* (compared with the *sprinklers not present* case) is largely due to the fires with *sprinklers present* but *they do not operate.*

As for *extent of flame damage,* with increasing *extent of smoke damage* the rates of casualties *(fatalities, injuries, estimated property* losses) increase quite consistently in Table 13. The trends in Tables 14 and are similar except for *estimated property losses* where there is initially a reduction in the *rate* in Table 14 and an extraordinarily high *rate* in Table 15 with low *extent of smoke damage.*



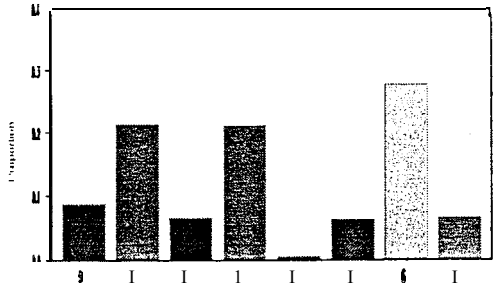
Extent of Smoke Damage

(a) sprinklers not present



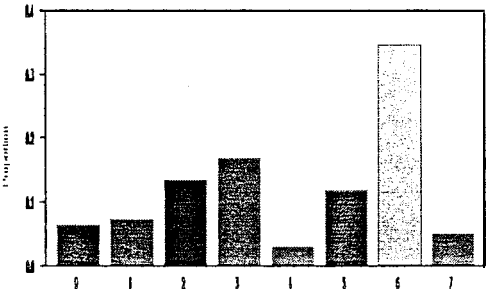
Extent of Smoke Damage

(b) sprinklers present



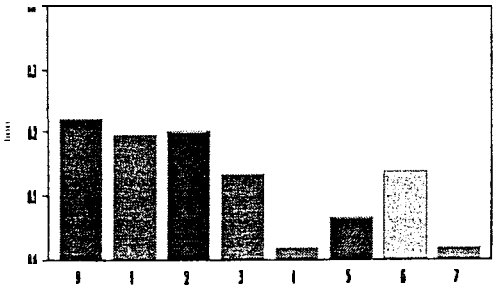
Extent of Smoke Damage

(c) sprinkler presence unknown



Extent of Smoke Damage

(d) sprinklers present and operated



Extent of Smoke Damage

(e) sprinklers present but do not operate

Extent of Smoke Damage Categories:

9 No damage of this type
1 Confined to the object of origin
2 Confined to part of room or area of origin
3 Confined to room of origin
4 Confined to the fire-rated compartment of origin
5 Confined to the floor of origin
6 Confined to structure of origin
7 Extended beyond structure of origin

FIGURE 10 EXTENT OF SMOKE DAMAGE FOR SPRINKLER PRESENCE AND ACTION

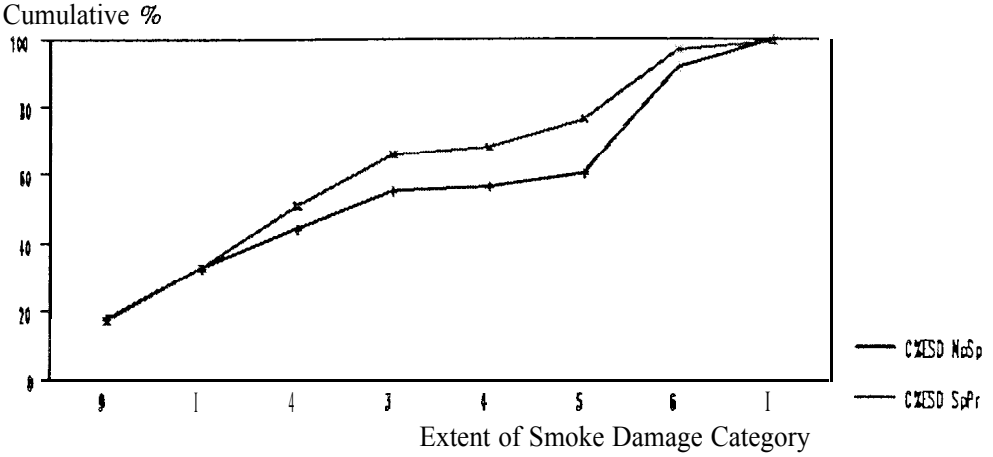


FIGURE 11 COMPARISON OF CUMULATIVE % OF EXTENT OF FLAME DAMAGE FOR SPRINKLERS NOT PRESENT AND SPRINKLERS PRESENT CASES

TABLE 13 EXTENT OF SMOKE DAMAGE WITH SPRINKLERS NOT PRESENT

ESD	*Fires (%)*	*Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fire Fighter Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (Rate*)*
9	7245	77	105	0	4	30505437
	(18.0)	(10.6)	(14.5)	(#)	(0.6)	(4210)
1	6078	49	55	0	0	21620853
	(15.1)	(8.1)	(9.0)	(#)	(0)	(3560)
2	4656	54	93	1	0	7986743
	(11.6)	(11.6)	(20.0)	(0.2)	(0)	(1720)
3	4255	53	120	1	a	18252867
	(10.6)	(12.5)	(28.2)	(0.2)	(0.2)	(4290)
4	463	15	18	0	0	4824646
	(1.1)	(32.4)	(38.9)	(#)	(#)	(10,400)
5	1609	59	62	0	4	37173707
	(4.0)	(36.7)	(38.5)	(#)	(2.5)	(23,100)
6	12751	1733	502	5	31	6.1316e8
	(31.7)	(136)	(39.4)	(0.4)	(2.4)	(48,100)
7	3230	1083	235	4	10	3.8165e8
	(8.0)	(335)	(72.8)	(1.2)	(3.1)	(118,000)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

TABLE 14 EXTENT OF SMOKE DAMAGE WITH SPRINKLERS PRESENT

ESD	*Fires (%)*	*Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fire Fighter Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (Rate*)*
9	1839	15	42	0	0	36087307
	(17.3)	(8.2)	(23)	(#)	(#)	(19,600)
1	1680	5	14	0	0	16749846
	(15.8)	(3.0)	(8.3)	(#)	(#)	(9,970)
2	1932	19	76	0	0	11446237
	(18.2)	(9.8)	(39)	(#)	(#)	(5,920)
3	1547	23	50	0	0	5538613
	(14.6)	(15)	(32)	(#)	(#)	(3,580)
4	241	10	8	0	0	1607561
	(2.2)	(42)	(33)	(#)	(#)	(6,670)
5	887	34	53	0	0	9360761
	(8.4)	(38)	(60)	(#)	(#)	(10,600)
6	2167	200	180	0	5	98130878
	(20.4)	(92)	(83)	(#)	(2.3)	(45,300)
7	308	62	10	0	0	25967297
	(2.9)	(201)	(32)	(#)	(#)	(84,300)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1 000 fires unless noted otherwise

TABLE 15 EXTENT OF SMOKE DAMAGE WITH SPRINKLERS PRESENCE UNKNOWN

ESD	*Fires (%)*	*Fire Fighter Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*(Rate*)*
9	1425	13	7	0	0	7154311
	(8.9)	(9.1)	(4.9)	(#)	(#)	(5020)
1	3425	41	26	0	0	94588530
	(21.4)	(12.0)	(7.6)	(#)	(0)	(276,000)
2	1079	6	18	0	2	30863 16
	(6.7)	(5.6)	(17)	(#)	(1.9)	(2860)
3	3394	32	74	0	1	19140157
	(21.2)	(9.4)	(22)	(#)	(0.3)	(5640)
4	91	6	2	0	0	3349556
	(0.6)	(66)	(22)	(#)	(#)	(36,800)
5	1044	46	33	0	1	20133109
	(6.5)	(44)	(32)	(#)	(1.0)	(19,300)
6	4459	435	164	0	13	4.4094e8
	(27.9)	(98)	(37)	(#)	(2.9)	(98,900)
7	1086	286	52	2	3	1.4689e8
	(6.8)	(260)	(48)	(1.8)	(2.8)	(135,000)

Notes:
- 'he overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fire.9
- Rate per 1000 fires unless noted otherwise

TABLE 16 EXTENT OF SMOKE DAMAGE WITH SPRINKLERS PRESENT AND OPERATED

ESD	*Fires (%)*	*Fire Fighter Injuries (Rate*)*	*Civilian Injuries (Rate*)*	*Fatalities (Rate*)*	*Civilian Fatalities (Rate*)*	*US$ Loss (Rate*)*
9	215	3	5	0	0	440898
	(6.5)	(14.0)	(23.3)	(#)	(#)	(2051)
1	245	2	1	0	0	703360
	(7.4)	(8.2)	(4.1)	(#)	(#)	(2900)
2	456	9	25	0	0	4572653
	(13.8)	(20)	(55)	(#)	(#)	(10,000)
3	563	11	12	0	0	394983 1
	(17.0)	(20)	(21)	(#)	(#)	(7000)
4	106	10	6	0	0	1272960
	(3.2)	(94)	(57)	(#)	(#)	(12,000)
5	399	27	24	0	0	7629275
	(12.1)	(68)	(60)	(#)	(#)	(19,100)
6	1151	158	105	0	5	67912713
	(34.8)	(137)	(91)	(#)	(4.3)	(59,000)
7	171	50	6	0	0	18153372
	(5.2)	(292)	(35)	(#)	(#)	(106,200)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

TABLE 17 EXTENT OF SMOKE DAMAGE WITH SPRINKLERS PRESENT AND DO NOT OPERATE (FOR WHATEVER REASON)

ESD	Fires (%)	Fire Fighter Injuries (Rate*)	Civilian Injuries (Rate*)	Fire Fighter Fatalities (Rate*)	Civilian Fatalities (Rate*)	US$ Loss (Rate *)
9	1624	12	37	0	0	35,646,409
	(22.3)	(7.4)	(22.8)	(#)	(#)	(21,950)
a	1435	3	13	0	0	16,046,486
	(19.7)	(2.1)	(9.1)	(#)	(#)	(11,182)
2	1476	10	51	0	0	6,873,584
	(20.2)	(6.8)	(34.6)	(#)	(#)	(4657)
3	984	12	38	0	0	1,588,782
	(13.5)	(12.2)	(38.6)	(#)	(#)	(1615)
4	135	0	2	0	0	334,601
	(1.9)	(#)	(14.8)	(#)	(#)	(2479)
5	488	7	29	0	0	1,731,486
	(6.7)	(14.3)	(59.4)	(#)	(#)	(3548)
6	1016	42	75	0	0	30,218,165
	(13.9)	(41.3)	(73.8)	(#)	(#)	(29,742)
7	137	12		0	0	7,813,925
	(1.9)	(87.6)	(2942)	(#)	(#)	(57,036)

Notes:
- The overall average **rates** are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

It can be seen from Figure 11 that with ***sprinklers*** *present* the proportion of fires with smoke *damage* exceeding each category from *ESD 2 (confined to the part of room or area* ***of*** *origin)* to *ESD 6 (confined to the structure* ***of*** *origin)* is somewhat lower than when *sprinklers are not present.*

Using the data in Tables 13 and 14 it is possible to estimate the effect of the presence of sprinklers on the *rates* ***of*** *casualties and property losses. As* for the estimate based on the *extent* ***of*** *flame spread,* ideally such an estimate is based purely on *the* data from fires with *sprinklers present.* However there are not enough fires in certain *extent* ***of*** *smoke spread* categories to obtain reliable estimates of some of the casualty ***rates.*** Therefore it is necessary to use the rates from *tie sprinklers notpresent case.*

Based on the percentages of fires in each *extent* ***of*** *smoke spread* category for fires with *sprinklers present* and the *casualty and property damage rates* for each of the *extent* ***of*** *smoke spread* categories of the *sprinklers not present case* it is predicted that for *sprinklers present* at all of the retail fires in the USA covered by the data in this report the casualties and property damage will be the following proportions of the actual casualties and losses:

- civilian fatalities 75%
- fire fighter fatalities 69%
- civilian injuries 88%
- fire fighter injuries 62%
- estimated property loss 64%

Comparison of these estimates with those presented in the previous section based on *extent of flame spread* shows that these estimates are generally higher, in some cases by a substantial amount.

Similarly, based on the percentages of fires in each *extent of smoke spread* category and the *casualty and property damage rates* for each of the *extent of smoke spread* categories for fires with *sprinklers present* it is predicted that the casualties and property damage will be the following proportions of the actual casualties and losses:

- civilian fatalities (38%)
- civilian injuries 138%
- fire fighter injuries 45%
- estimated property loss 70%

It is not possible to estimate the *firefighter fatalities* on this basis and the *civilian fatality* estimate may be unreliable, both due to the relatively small number of fires.

Comparison of these estimates with those presented in the previous section based on *extent of flame spread* shows that all of these estimates are remarkably similar.

The two estimates above give reasonably similar results for *estimated property loss* but the estimates for *civilian fatalities* and *injuries* differ substantially and those for *fire fighter injuries* differ somewhat. These differences primarily reflect the different *rates* for the *sprinkler present* and *sprinklers not present cases* for those quantities where the estimates differ substantially.

Thus, in summary:

- with *sprinklers present* about 34% of fires have *smoke damage **not** confined to the room of fire origin* compared with about 45% for fires with *sprinklers not present*
- the *civilian injury rate* is generally higher with *sprinklers present* but the other *casualty and loss rates* are generally lower with *sprinklers present*
- it is estimated that lower *casualties* (except perhaps for *civilian injuries)* and *property losses* will occur if *sprinklers are present* at all of the fires covered by this data

1% AREA OF FIRE ORIGIN

The general classification of *area of fire origin (AFO)* is as follows:

AFO 0	Means of egress
AFO 1	Assembly, sales areas (groups of people)
AFO 2	Function areas (largely residential and office)
AFO 3	Function areas (various technical functions)
AFO 4	Storage areas
AFO 5	Service facilities
AFO 6	Service, equipment areas
AFO 7	Structural areas
AFO 8	Transportation, vehicle areas
AFO 9	Other, unknown, etc

A more detailed classification is recorded in the data but here it is summarised for this general level of classification. Note that *AFO 9* contains the fire with 119 civilian injuries and *AFO* 0, *AFO* 9 and *AFO 1* contain the fires with three, four and five civilian fatalities respectively.

It is apparent from Figure 12 and Table 18 that the major areas in which fires originated *are structural areas (22%* of fires with known *AFO); storage areas (20%* of known); *Junction areas (largely residential and office)* (19% of known); and assembly, *sales areas* (14% of known). Very small proportions of fires started in *transportation, vehicle; function; service facilities and means of egress areas.*

The *fire fighter fatality rate* is well above average for fires originating in *storage areas* and the *civilian fatality rate* is well above average for *means of egress; service, equipment areas; and assembly, sales areas* but well below average for *function areas (various technical functions); structural areas; and function areas (largely residential and office).*

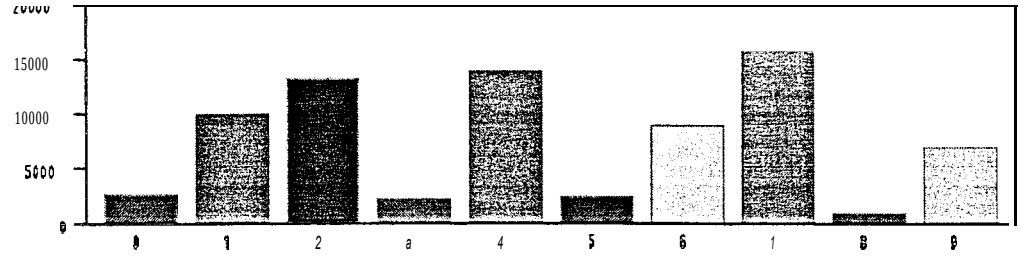
The fire fighter injury rate is well above average for fires originating in *storage areas;* and *unknown, etc areas* and well below average in *function area:, service facilities;* and *transportation, vehicle areas.*

The *civilian injury rate* is well above average for *transportation, vehicle; service, equipment; and function (various technical functions) areas* and well below average for *structural; and service facilities areas.*

In summary:

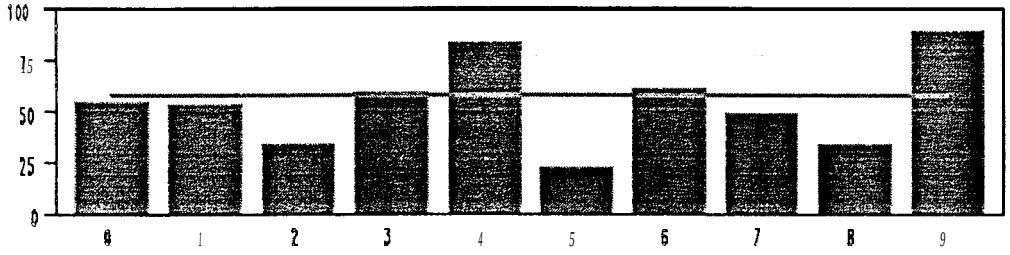
- there is a wide variation in the proportions of fires from various *areas of fire origin*
- there is substantial variation in the casualty *rates* for fires from various *areas of fire origin*

Fires



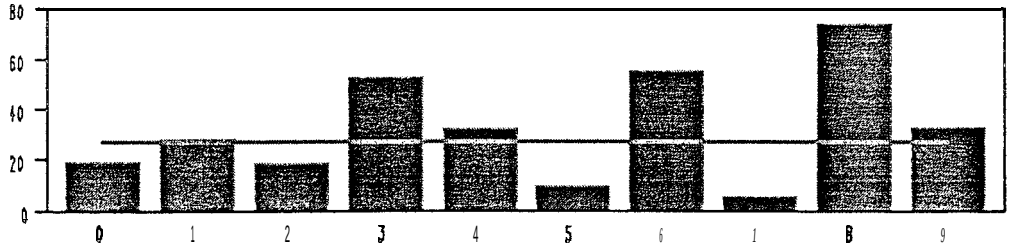
Area of Fire Origin

Firefighter Injury Rate



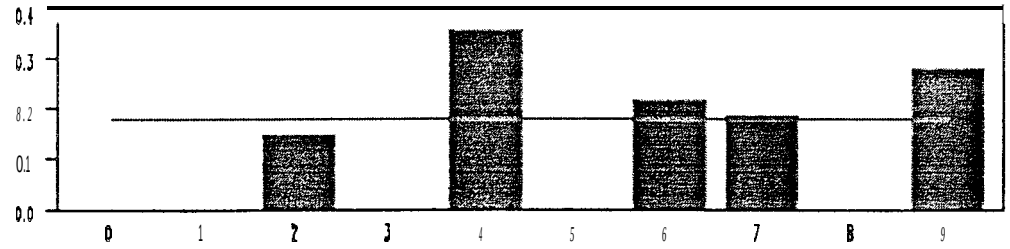
Area of Fire Origin

Civilian Injury Rate



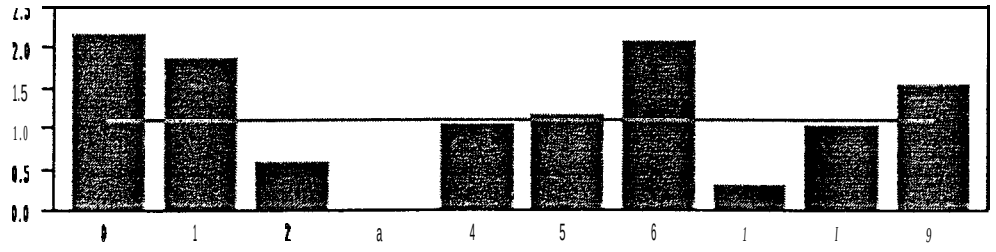
Area of Fire Origin

Firefighter Fatality Rate



Area of Fiie Origin

Civilian Fatality Rate



Area of Fiie Origin

FIGURE 12 AREA OF FIRE ORIGIN

TABLE 18 AREA OF FIRE ORIGIN

Area of Fire Origin	*Fires (% of known)*	*Fire Fighter Injuries (rate*)*	*(rate*)*	*Fire Fighter Fatalities (rate*)*	*Civilian Fatalities (rate*)*
0	2732	152	55	0	6
	(3.9)	(55.6)	(20.1)	(#)	(2.2)
1	1013%	553	290	0	19
	(14.3)	(54.6)	(28.6)	(#)	(1.9)
2	13207	465	256	2	8
	(18.6)	(35.2)	(19.4)	(0.15)	(0.6)
3	2384	144	127	0	0
	(3.4)	(60.4)	(53.3)	(#)	(#)
4	13972	1180	452	5	15
	(19.7)	(84.4)	(32.4)	(0.36)	(1.1)
5	2528	58	25	0	3
	(3.6)	(22.9)	(9.80)	(#)	(1.2)
6	9085	561	504	2	19
	(12.8)	(61.8)	(55.5)	(0.22)	(2.1)
7	15904	792	102	3	5
	(22.4)	(49.8)	(6.41)	(0.19)	(0.3)
8	963	34	72	0	1
	(1.4)	(35.3)	(74.8)	(#)	(1.0)
9	7090	641	235	2	11
	(10.0)	(90.4)	(33.2)	(0.28)	(1.6)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 tires unless noted otherwise

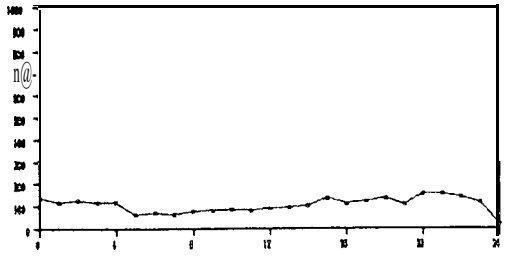
12 FIRES BY AFO BY ALARM HOUR

It might be expected that there is some variability with *alarm time* in the variation in the rate of fire starts for the various *areas of fire origin.* The variation in the number of fires that occur at each time of the day (that is, each *alarm hour)* for each *area of origin* is shown in Figure 13.

It is obvious from comparison of the graphs in Figure 13 that indeed there is considerable variation in the total number of fires for each *alarm hour* for many of the *areas of fire origin.* In all cases the number of fires for each is generally lower during the night than during the day. Specific observations for each *area of fire origin* include:

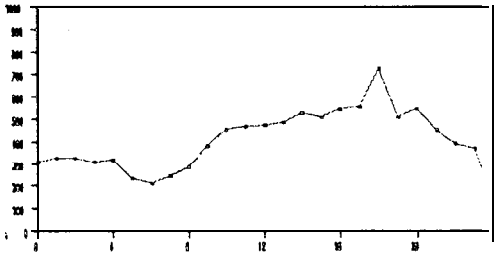
- in *means of egress* the minimum number of fires in an hour for *means of egress* is 65 fires at 7 am and the maximum number 159 at both 8 and 9 pm (a factor of **2.4)**
- for *assembly,* sales *areas* (a classification relating to places where groups of people meet in both commercial and residential situations) the minimum number of fires in an hour is 215 fires at 6 am and the maximum number 729 at 6 pm (a factor of 3.4)
- *function areas* relating largely to *residential and office* activities have a minimum number of fires in an hour of 256 fires at 4 am and the maximum of 801 at 6 pm (a factor of 3.1)
- notably different *are function areas* relating to *commercial* activities with a minimum number of fires in an hour of 30 tires at 5 am and a maximum of 140 at 11 am (a factor of 4.7)
- for *storage areas* the minimum number of fires in an hour is 308 fires at 6 am and the maximum number 775 at 6 pm (a factor of 2.5)
- in *service facilities* is relatively small with the minimum number of fires in an hour is 35 fires at 4 am and the maximum 177 at 11 am. (a factor of 5.1)
- for *service, equipment areas* the minimum number of fires in an hour is 145 fires at 5 am and the maximum number 610 at 12 noon (a factor of 4.2)
- the largest number of fires originated in *structural areas* where the minimum number of fires in an hour is 3 16 fires at 6 am and the maximum number 871 at 5 pm (also 867 at 9 pm) (a factor of 2.8)
- the smallest number of fires occur in *transportation, vehicle areas,* with the minimum number of fires an hour being 13 at 4 am and the maximum 74 at 4 pm (a factor of 5.7)

AFO = 0 (means of egress)
Fires



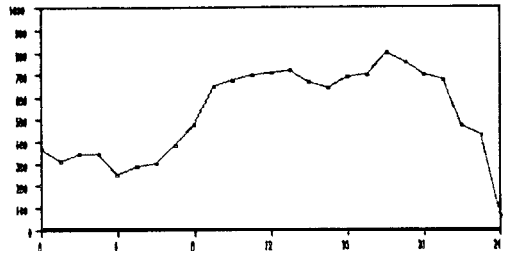
Alarm Hour

AFO = 1 (assembly, sales area)
Fires



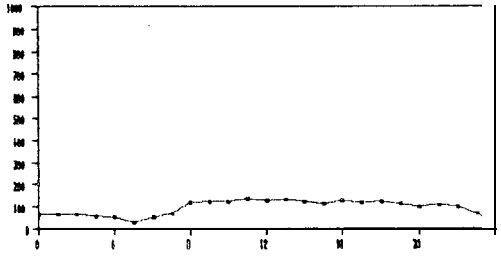
Alarm Hour

AFO = 2 (function areas (residential))
Fires



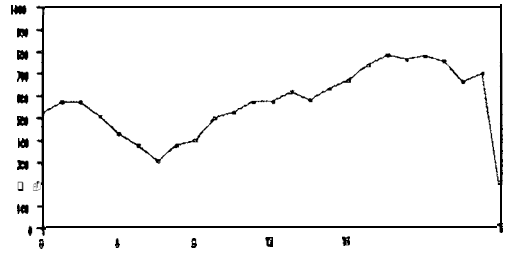
Alarm Hour

AFO = areas (commercial))
Fires

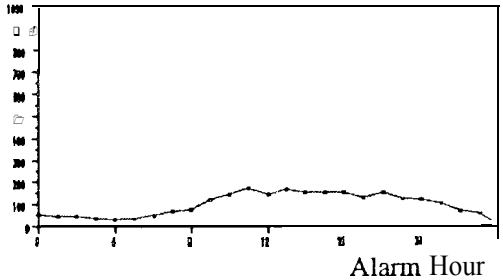


Alarm Hour

AFO = 4 (storage areas)
Fires

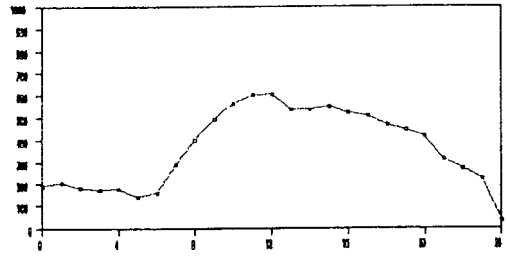


AFO = facilities)
Fires



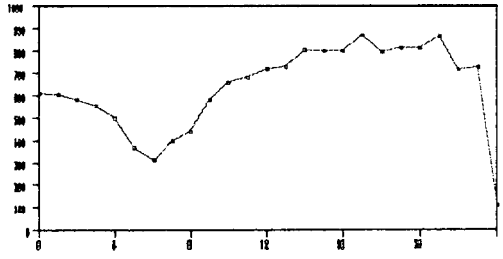
Alarm Hour

AFO = 6 areas)
Fires



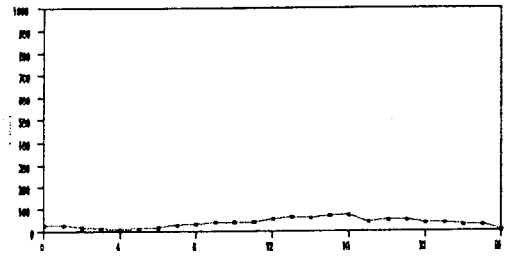
Alarm Hour

AFO = areas)
Fires



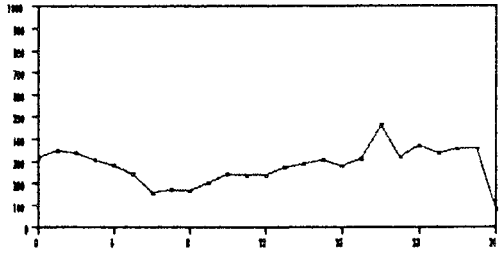
Alarm Hour'

AFO = areas)
Fires



Alarm Hour

AFO = areas)
Fires



Alarm Hour

FIGURE 13 VARIATION OF AREA OF FIRE ORIGIN WITH HOUR OF ALARM

- finally, for other, *unknown,* etc the minimum number of fires an hour is 163 at 6 am and the maximum number 446 at 6 pm. (a factor of 2.7)

Overall the pattern of variation is quite clear:

- the fewest fires per hour generally occurs between 4 and 6 am for all categories of area *of fire origin*
- there is greater variation in the timing of the maximum number of fires per hour
- the maximum occur late in the afternoon (between 4 and 6 pm) for most categories
- the maximum is between 2.4 and 5.7 times the minimum

This pattern appears to indicate that the lowest rate of fire starts occurs when human activity is at its least and that the rate increases as human activity increases. As the level of activity (and presumably) level of risk of fire initiation varies with the activities undertaken in various areas of buildings (perhaps as classified by *area of fire* origin) the increase in fire starts also varies in different areas of the buildings. Further study is necessary to understand the patterns that are shown in Figure 13.

The following pages contain boxed summaries of data and graphs of the number of fires and *casualty and estimated property loss rates* for each *extent of flame damage* category for each general *urea of fire origin* (Figures 14 to 23). The graphs for each rate are plotted on the same axes for ease of comparison.

Examination of Figures 14 to 23 and the notes within the associated boxes shows:

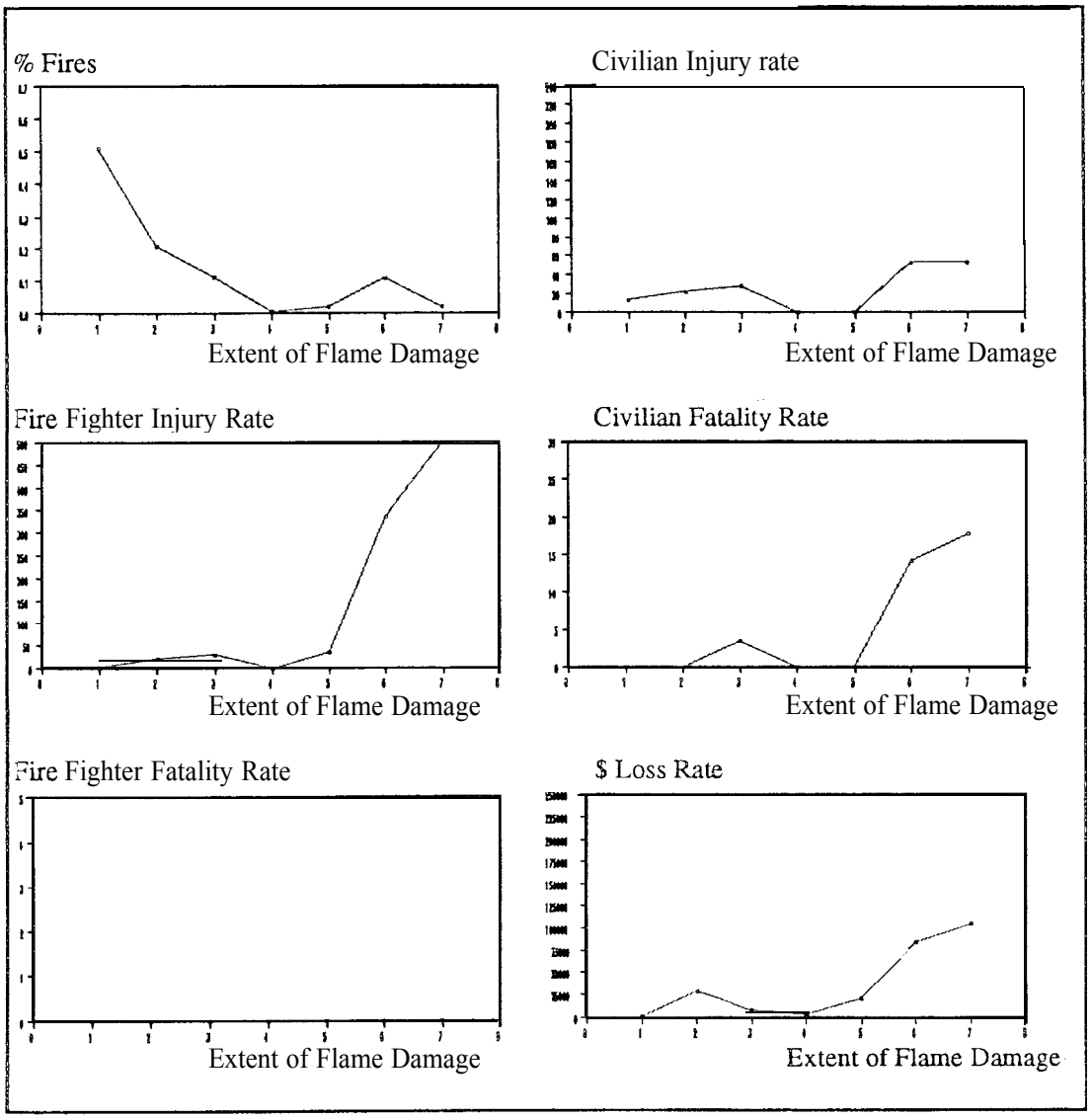
- there is considerable variation in the percentage of fires in each *extent of flame damage* category for the various *areas of fire origin*
- the percentage of fires with *extent of flame damage not retained within the room of origin* varies between *10%* for *service facilities* and *50%* for *other areas (AFO 9)*
- the ratio of the rate of civilian ***fatalities*** for fires where *the extent of* ***flame*** *damage extended to or beyond the structure of* ***fire*** *origin* and that for fires with *extent* ***of flame*** *damage retained within the room of origin* varied between *25* for *means of egress* and zero for *transportation, vehicle areas* (one or both rates are zero for some *AFOs*)
- the ratio of the rate of ***fire fighter*** *fatalities* for fires where *the extent of flame damage* extended *to or beyond the structure of* ***fire*** *origin* and that for fires with *extent* ***of flame*** *damage* retained *within the room of origin* varied between *8.9* for *storage areas* and zero for several *AFOs* (one or both rates are zero for some *AFOs*)

- the ratio of the rate of ***civilian injuries*** for fires where the *extent of flame damage* extended *to or beyond the structure of fire origin* and that for fires with ***extent of flame*** *damage* retained *within the room* ***of origin*** varied between *4* for *other areas* and 0.2 for *transportation, vehicle areas*
- the ratio of the rate of ***fire fighter injuries*** for fires where the *extent* ***of*** *flame* ***damage*** extended ***to or*** *beyond the structure* ***of*** *fire origin* and that for fires with ***extent*** *of flame damage* retained *within the room* ***of*** *origin* varied between 28 for *means* ***of egress*** and *3.5* for *transportation, vehicle areas*
- the ratio of the rate of ***estimated property loss*** for fires where the *extent of flame damage* extended ***to or*** *beyond the structure* ***of*** *fire origin* and that for fires with ***extent*** *of flame damage* retained *within the room* ***of*** *origin* varied between 25 for *function areas (largely residential and office)* and 7.7 for *transportation, vehicle areas*

In summary on fires by area of fire origin by alarm hour:

- there is considerable variation in the total number of fires for each *alarm hour* for many of the *areas of fire origin*
- further study is necessary to properly evaluate this aspect

AFO: MEANS OF EGRESS



Extent of flame damage retained *within room of origin:*			*83%* of fires
Rates of Casualties:	Civilian fatalities	0.5 per 1000 tires	Injuries 18 per 1000 fires
	Fire fighter fatalities	0 per 1000 tires	Injuries 11 per 1000 fires
	Property damage	$9400 per fire	
Extent of flame damage extended to *structure of origin or beyond:*			14% of fires
Rates of Casualties:	Civilian fatalities	12 per 1000 fires	Injuries 44 per 1000 fires
	Fire fighter Fatalities	0 per 1000 fires	Injuries 303 per 1000 fires
	Property damage	*$74,300* per fire	

Therefore the rates of casualties for fires with *Extent of flame damage* extended to *structure of origin or beyond compared with fires with Extent of flame damage* retained *within room of origin are:*

Civilian fatalities	*25* times	Injuries 2.4 times
Fire fighter fatalities	- times	Injuries 28 times
Property damage	7.9 times	

AFO: ASSEMBLY, SALES AREAS

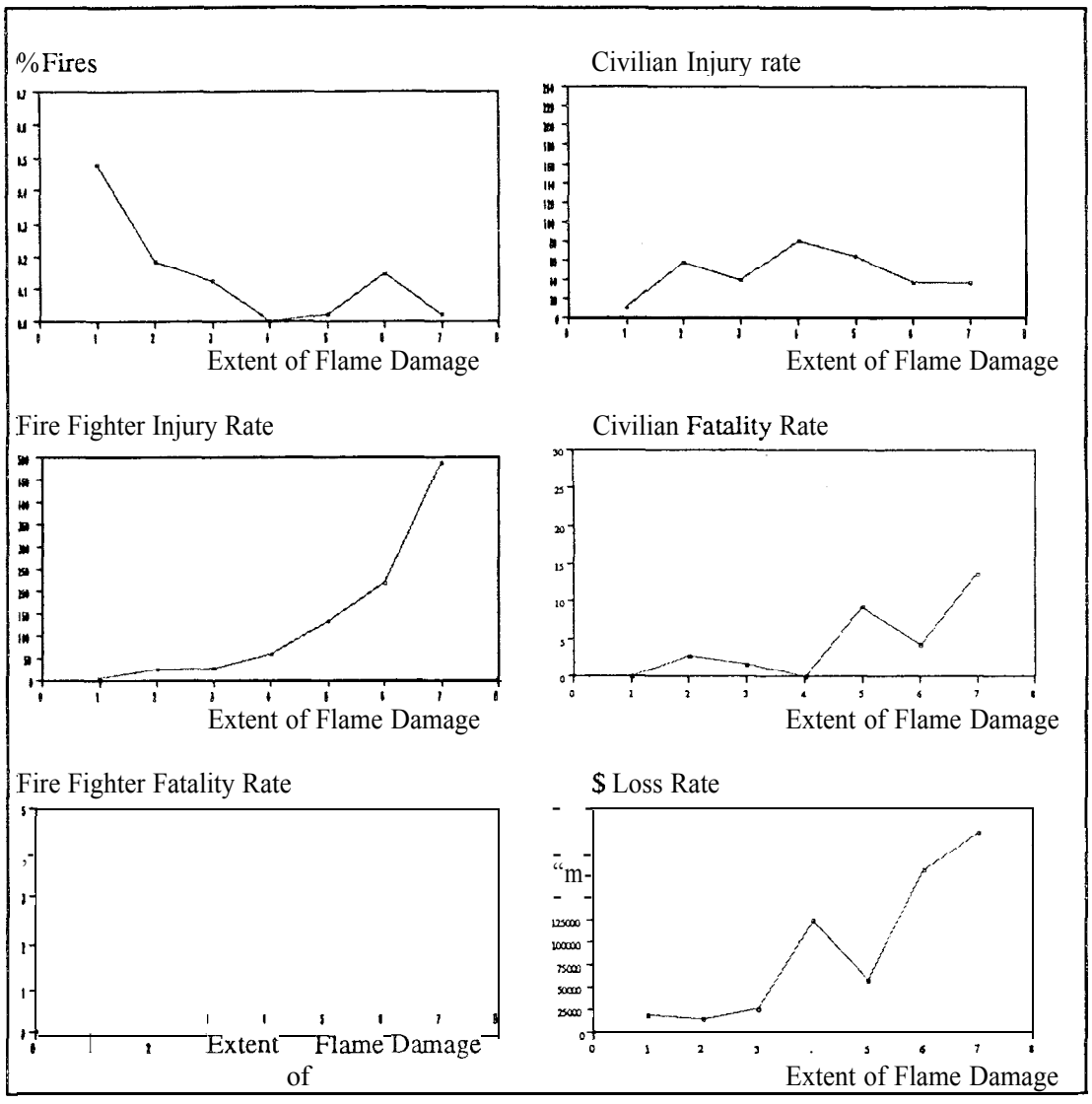


FIGURE 15 **VARIATION** OF **CASUALTIES** AND **ESTIMATED** PROPERTY LOSSES WITH EFD

Extent of flame damage retained *within room* ***of*** *origin:*			80% of fires
Rates of Casualties:	Civilian fatalities	0.9 per 1000 fires	Injuries 27 per 1000 fires
	Fire fighter fatalities	0 per 1000 fires	Injuries 14 per 1000 fires
	Property damage	$19,900 per fire	
Extent of flame damage extended to *structure* ***of*** *origin or beyond*			17% of fires
Rates of Casualties:	Civilian fatalities	5.9 per 1000 fires	Injuries 42 per 1000 fires
	Fire fighter Fatalities	0 per 1000 fires	Injuries 236 per 1000 fires
	Property damage	$171,000 per fire	
Therefore the rates of casualties for fires with *Extent of flame* damage extended to *structure of origin or beyond compared withjires with Extent of flame damage* retained *within room* ***of*** *origin are:*	Civilian fatalities	6.3 times	Injuries 1.5 times
	Fire fighter fatalities	- times	Injuries 17 times
	Property damage	8.6 times	

AFO: FUNCTION AREAS (RESIDENTIAL)

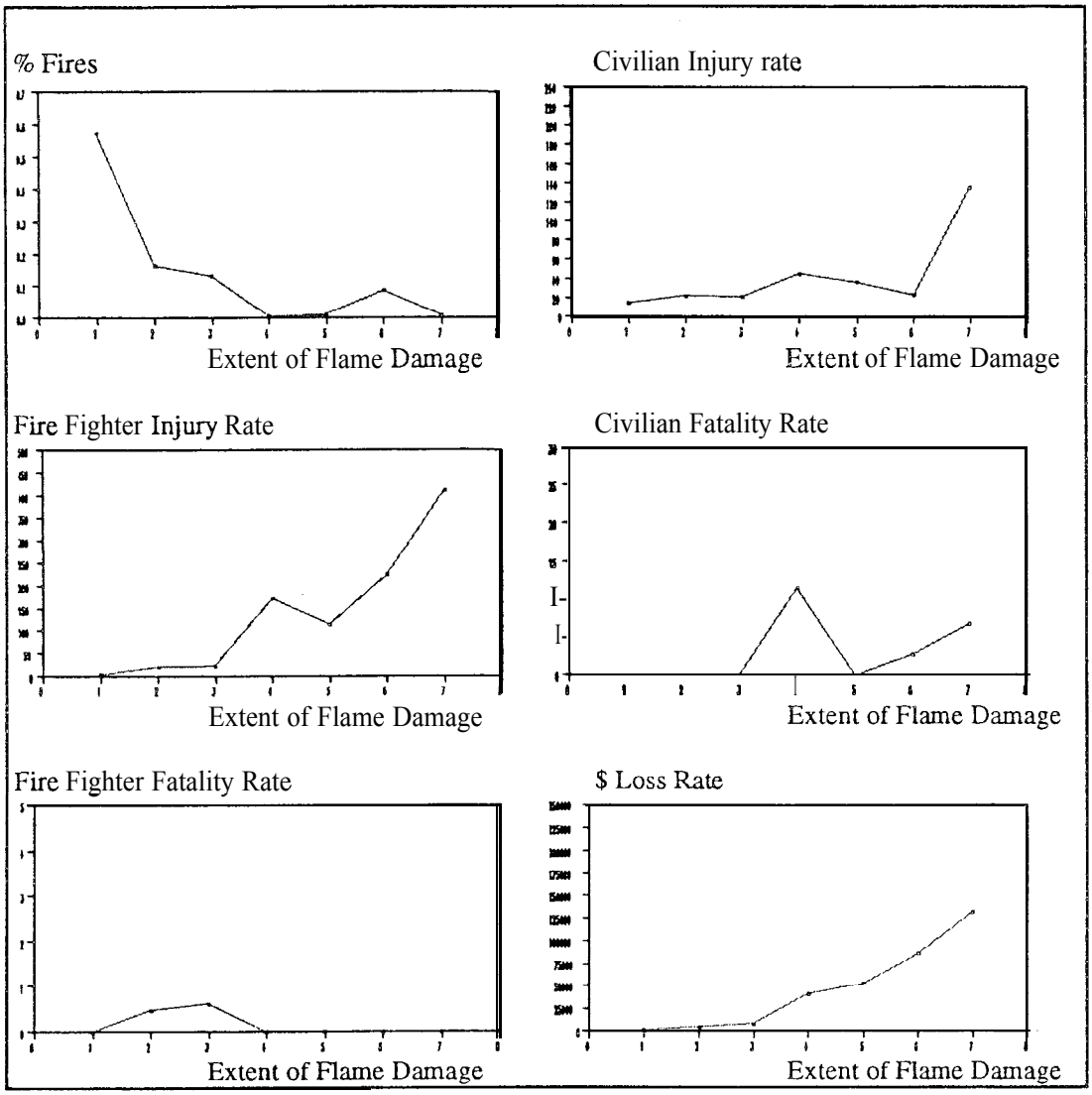


FIGURE 16 VARIATION OF CASUALTIES AND ESTIMATED PROPERTY LOSSES WITH EFD

Extent of flame damage retained *within room* ***of*** *origin:*			80% of fires	
Rates of Casualties:	Civilian fatalities	0.09 per 1000 fires	Injuries	18 per 1000 fires
	Fire fighter fatalities	0.2 per 1000 fires	Injuries	11 per 1000 fires
	Property damage	$3300 per fire		
Extent of flame damage extended to *structure* ***of*** *origin or beyond:*			10% of fires	
Rates of Casualties:	Civilian fatalities	*3* per 1000 fires	Injuries	*38* per 1000 fires
	Fire fighter Fatalities	0 per 1000 fires	Injuries	*228* per 1000 fires
	Property damage	*$84,400* per fire		
Therefore *tie* rates of *casualties* for fires with *Extent of flame damage* extended to *structure* ***of*** *origin or beyond compared* ***with fires*** *with Extent of flame* damage retained *within room* ***of*** *origin are:*	Civilian fatalities	*3.8* times	Injuries	2.1 times
	Fire fighter Fatalities	0 times	Injuries	20 times
	Property damage	*25* times		

AFO: FUNCTION AREAS (COMMERCIAL)

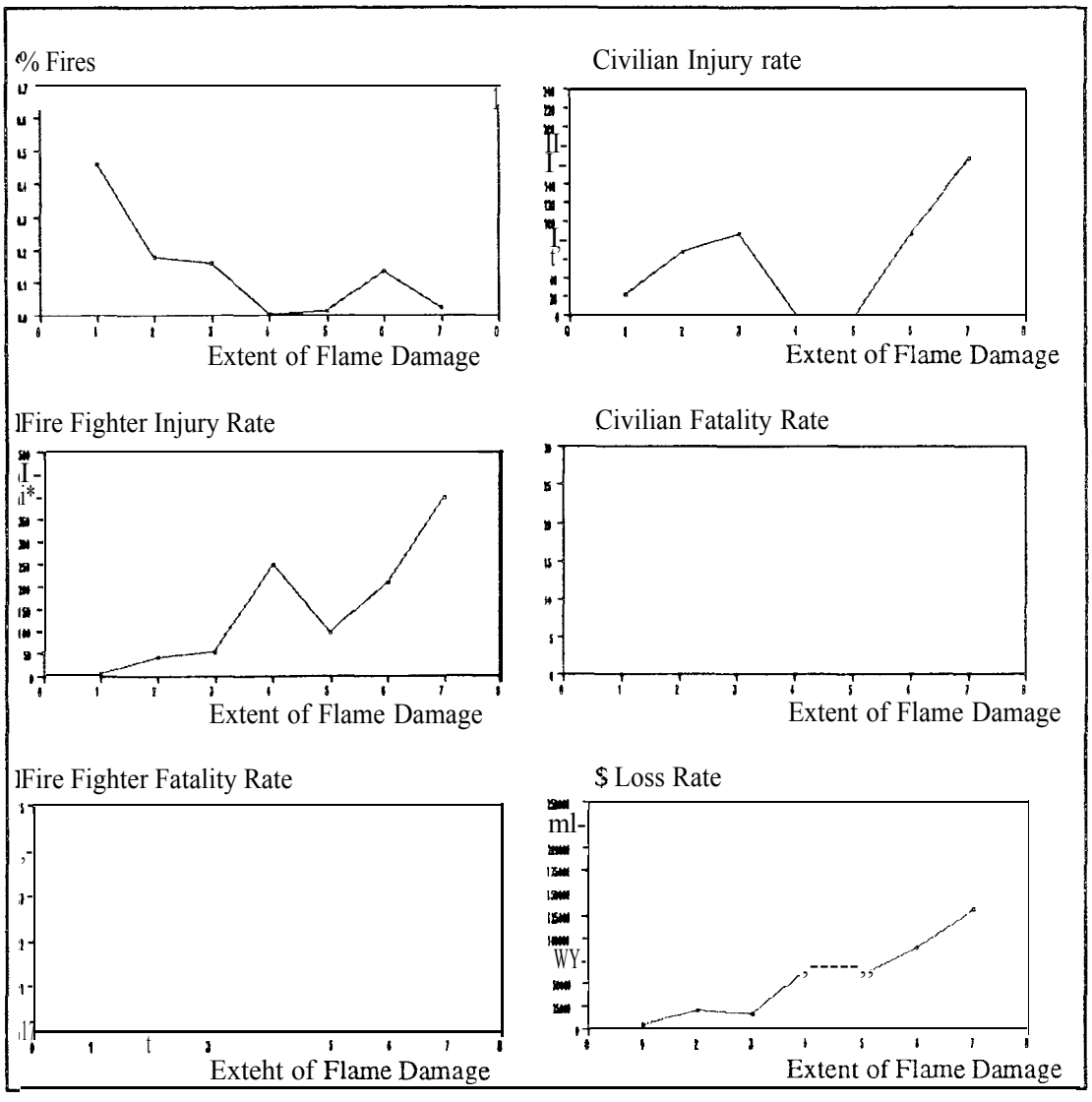


FIGURE 17 VARIATION OF CASUALTIES AND ESTIMATED **PROPERTY** LOSSES WITH EFD

Extent of flame damage retained *within room* ***of*** *origin:*			81% of fires
Rates of Casualties:	Civilian fatalities	0 per 1000 fires	Injuries 48 per 1000 fires
	Fire fighter fatalities	0 per 1000 fires	Injuries 26 per 1000 fires
	Property damage	$11,900 per fire	
Extent of flame damage extended to *structure* ***of*** *origin or beyond:*			16% of fires
Rates of Casualties:	Civilian fatalities	0 per 1000 fires	Injuries 113 per 1000 fires
	Fire fighter Fatalities	0 per 1000 fires	Injuries 231 per 1000 fires
	Property damage	$94,000 per fire	
Therefore the rates of casualties for tires with *Extent of flame damage* extended to *structure* ***of*** *origin or beyond compared* ***with fires*** *with Extent of flame damage* retained *within room* ***of*** *origin are:*	Civilian fatalities	- times	Injuries 2.4 times
	Fire fighter Fatalities	- times	Injuries 9 times
	Property damage	7.9 times	

AFO: STORAGE AREAS

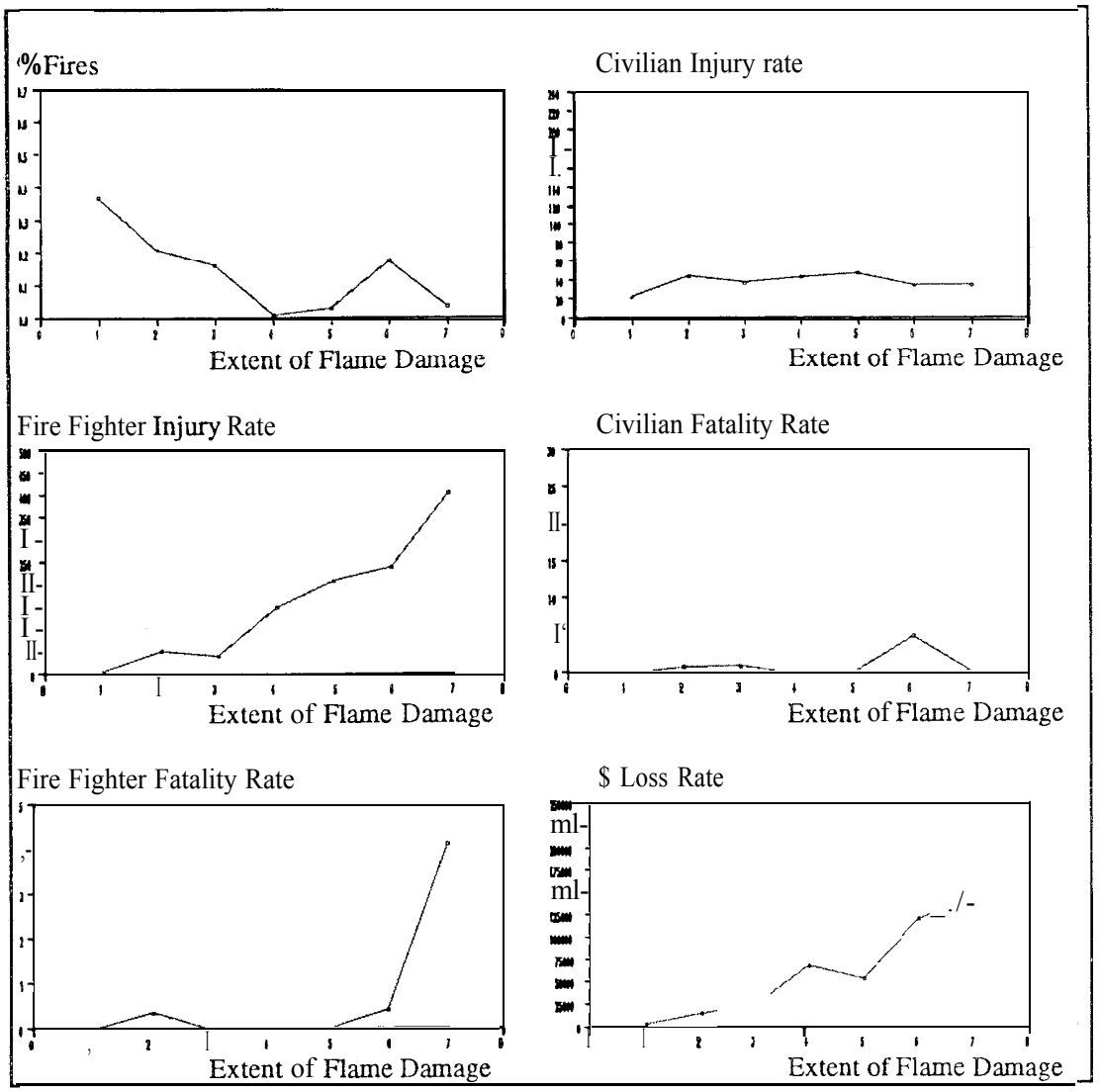


FIGURE 18 **VARIATION** OF CASUALTIES AND ESTIMATED PROPERTY LOSSES WITH EFD

Extent of flame damage retained *within room* ***of*** *origin:*			74% of fires
Rates of Casualties:	Civilian fatalities	0.4 per 1000 fires	Injuries 32 per 1000 fires
	Fire fighter fatalities	0.1 per 1000 fires	Injuries 28 per 1000 fires
	Property damage	$11,400 per tire	
Extent of flame damage extended to *structure of origin or beyond:*			21% of fires
Rates of Casualties:	Civilian fatalities	3.3 per 1000 fires	Injuries 37 per 1000 fires
	Fire fighter Fatalities	0.9 per 1000 fires	Injuries 255 per 1000 fires
	Property damage	$114,000 per fire	

Therefore the rates of casualties for fires with *Extent of flame damage* extended to *structure* ***of*** *origin or beyond compared with fires with Extent of flame damage* retained *within room* ***of*** *origin are:*

Civilian fatalities	8 times	Injuries	1.1 times
Fire fighter Fatalities	8.9 times	Injuries	9 times
Property damage	10 times		

AFO:SERVICE FACILITIES

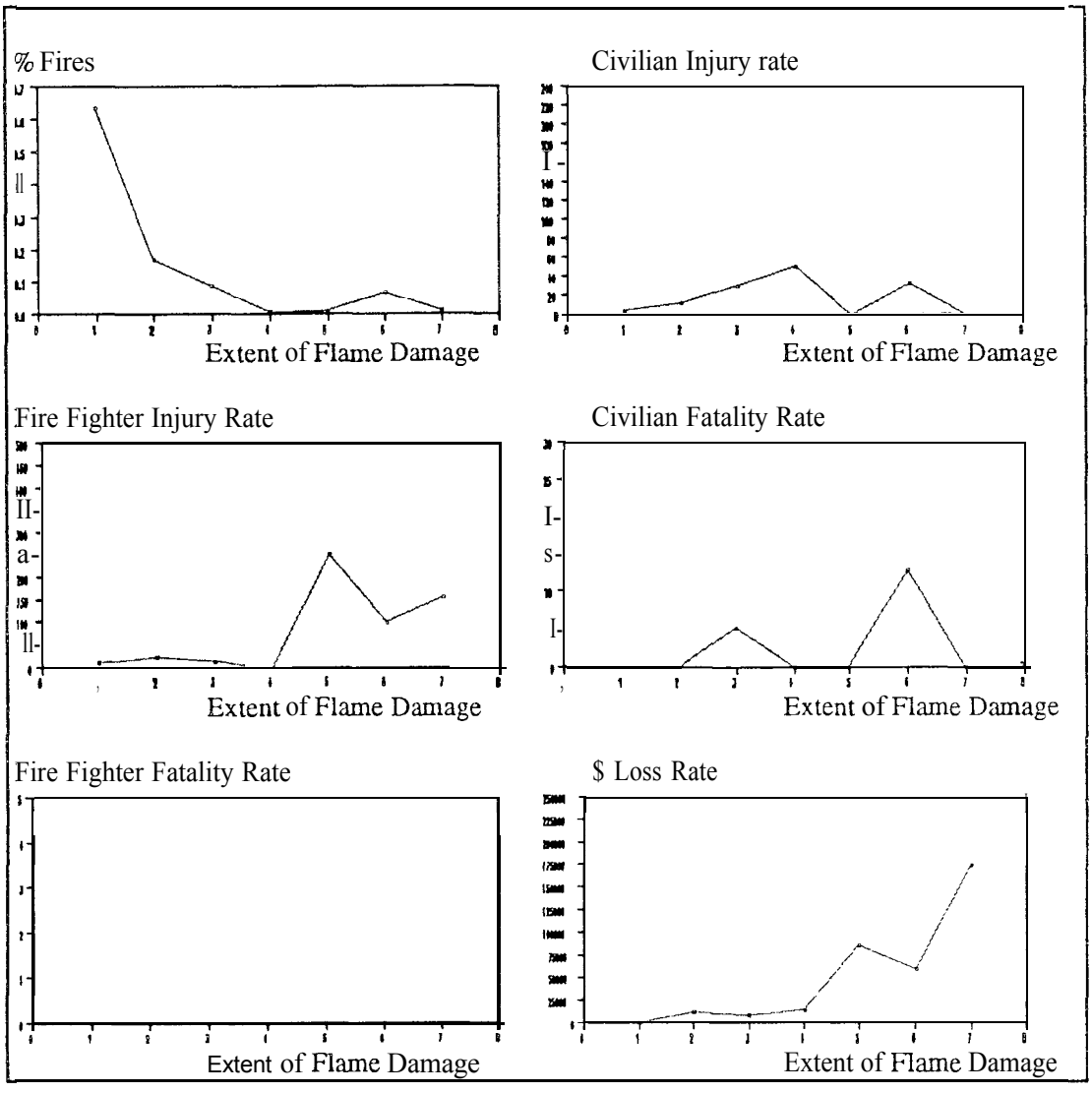


FIGURE 19 VARIATION OF CASUALTIES AND ESTIMATED PROPERTY LOSSES WITH EFD

Extent of flame damage retained *within room of origin*:			90% of fires
Rates of Casualties:	Civilian fatalities	*0.5* per 1000 fires	Injuries 9 per 1000 fires
	Fire fighter fatalities	0 per 1000 fires	Injuries 15 per 1000 fires
	Property damage	*$4300* per fire	
Extent of flame damage extended to *structure of origin or beyond:*			*8%* of fires
Rates of Casualties:	Civilian fatalities	9 per 1000 fires	Injuries 26 per 1000 fires
	Fire fighter Fatalities	0 per 1000 fires	Injuries 117 per 1000 fires
	Property damage	*$75,300* per fire	
Therefore the rates of casualties for fires with *Extent of flame damage* extended to *structure of origin or beyond compared with fires with Extent of flame damage* retained *within room of origin* are:	Civilian fatalities	*17* times	Injuries 3 times
	Fire fighter Fatalities	- times	Injuries 12 times
	Property damage	*17* times	

AFO: SERVICE, EQUIPMENT AREAS

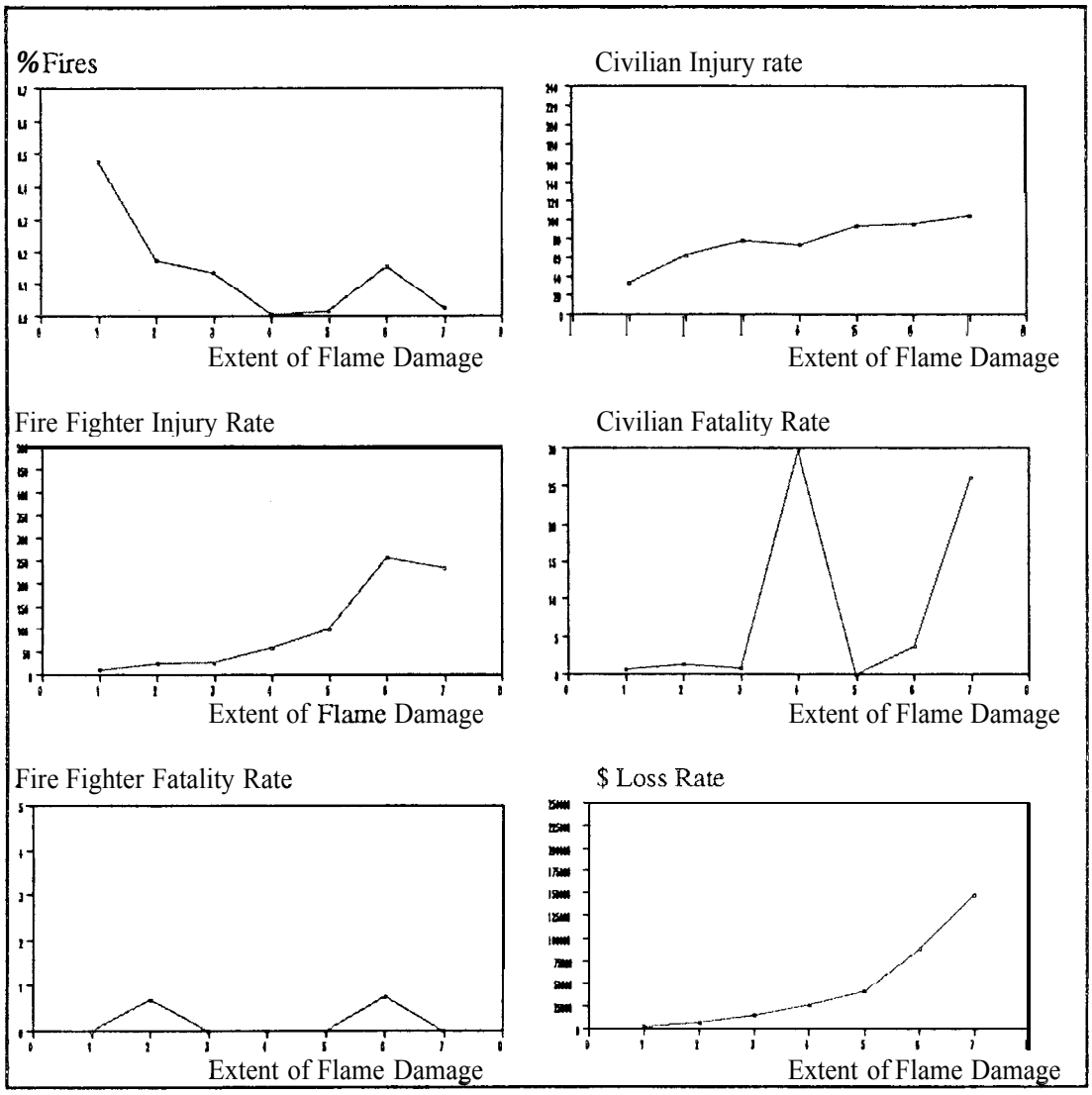


FIGURE 20 VARIATION OF CASUALTIES AND ESTIMATED PROPERTY LOSSES WITH EFD

Extent of flame damage retained *within room of origin*:			79% of fires
Rates of Casualties:	Civilian fatalities	0.9 per 1000 fires	Injuries 48 per 1000 fires
	Fire fighter fatalities	0.2 per 1000 fires	Injuries 18 per 1000 fires
	Property damage	*$6300* per fire	
Extent of flame damage extended *to structure* ***of*** *origin or beyond:*			18% of fires
Rates of Casualties:	Civilian fatalities	*7.4* per 1000 fires	Injuries 98 per 1000 fires
	Fire fighter Fatalities	0.6 per 1000 fires	Injuries 235 per 1000 fires
	Property damage	$90,200 per fire	
Therefore *the* rates of casualties for fires with *Extent of flame* damage extended *to structure* ***of*** *origin or beyond compared with fires with* ***Extent of flame*** damage retained *within room* ***of*** *origin* are:	Civilian fatalities	*8* times	Injuries 2 times
	Fire fighter Fatalities	4 times	Injuries 13 times
	Property damage	14 times	

AFO: STRUCTURAL AREAS

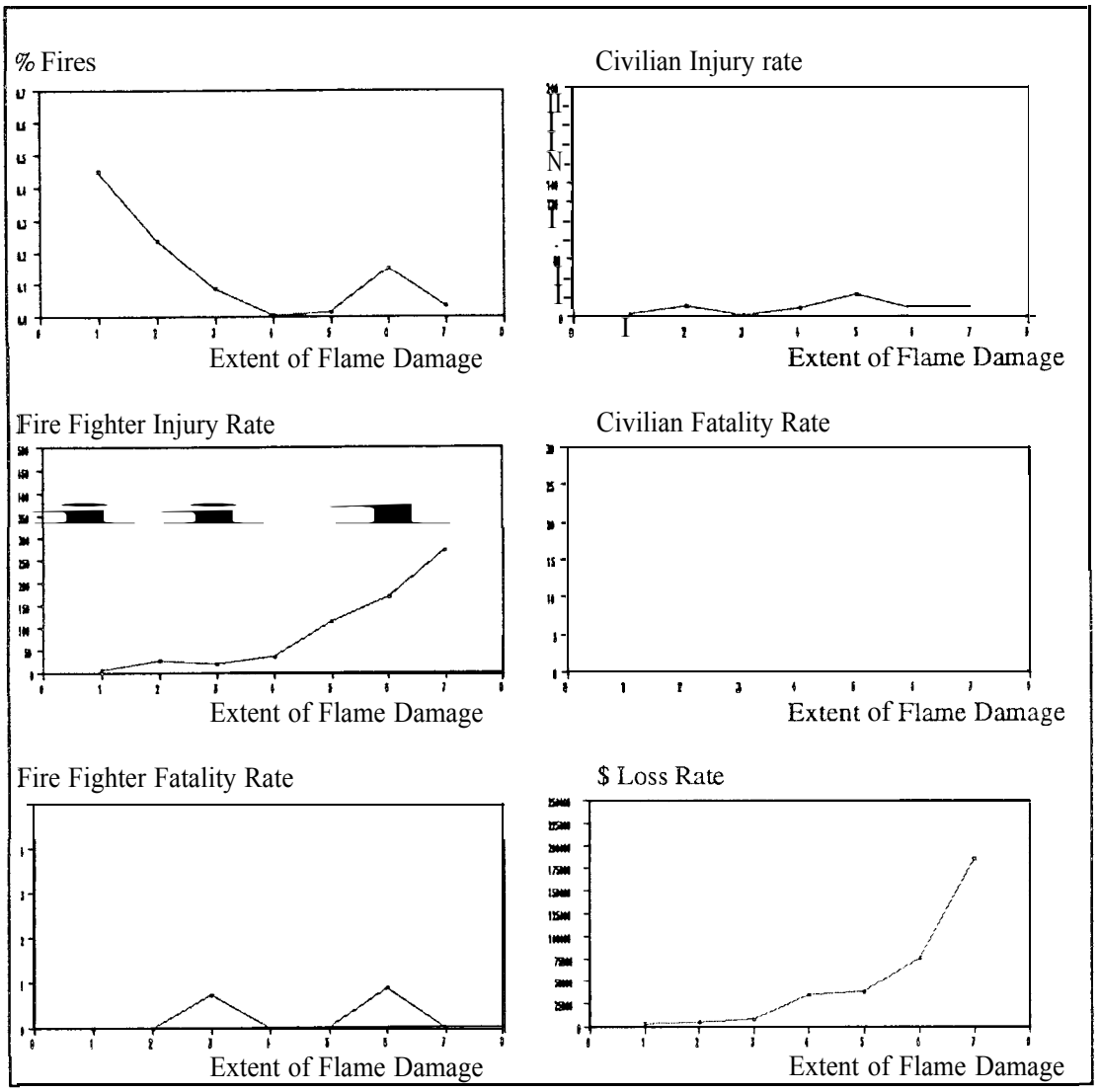
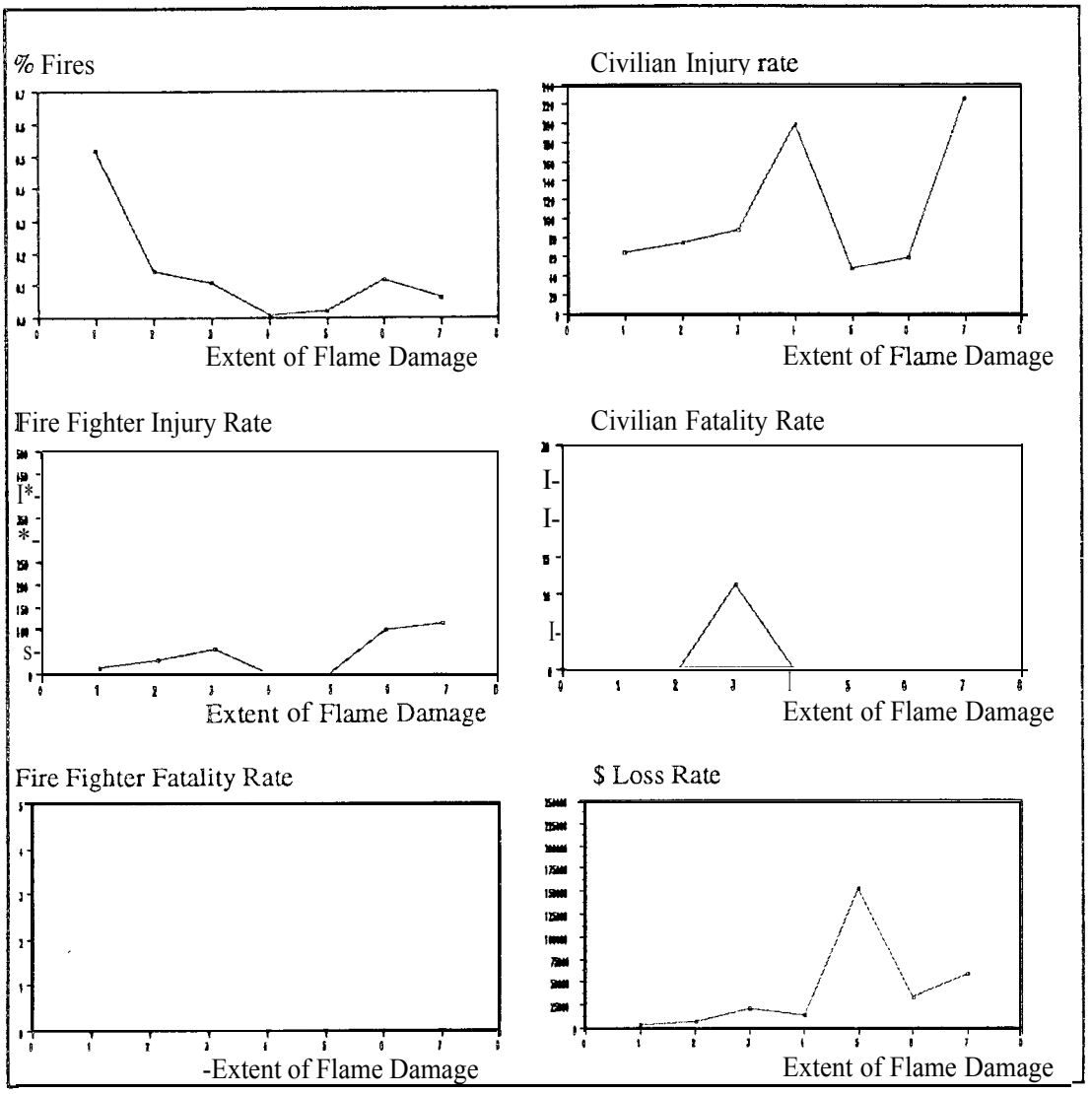


FIGURE 2 1 **VARIATION** OF CASUALTIES AND ESTIMATED PROPERTY LOSSES WITH EFD

Extent of flame damage retained *within room of origin*:			79% of fires
Rates of Casualties:	Civilian fatalities	0.1 per 1000 fires	Injuries 5.8 per 1000 fires
	Fire fighter fatalities	0.1 per 1000 fires	Injuries 16.7 per 1000 fires
	Property damage	$5 140 per fire	
Extent of flame damage extended *to structure of origin or beyond:*			18% of fires
Rates of Casualties:	Civilian fatalities	1.3 per 1000 fires	Injuries 10 per 1000 fires
	Fire fighter Fatalities	0.6 per 1000 fires	Injuries 179 per 1000 fires
	Property damage	$90,300 per fire	
Therefore *the* rates of casualties for fires with *Extent of flame* damage extended *to structure of origin or beyond compared with fires with Extent of flame damage* retained *within room of origin* are:	Civilian fatalities	14 times	Injuries 1.7 times
	Fire fighter Fatalities	7 times	Injuries 11 times
	Property damage	18 times	

AFO: **TRANSPORTATION, VEHICLE AREAS**



Extent of flame damage retained *within room* ***of*** *origin:*			78% of fires
Rates of Casualties:	Civilian fatalities	2 per 1000 tires	Injuries 70 per 1000 fires
	Fire fighter fatalities	0 per 1000 fires	Injuries 25 per 1000 fires
	Property damage	$7000 per fire	
Extent of flame damage extended to *structure* ***of*** *origin or beyond:*			19% of tires
Rates of Casualties:	Civilian fatalities	0 per 1000 fires	Injuries 11 per 1000 fires
	Fire tighter Fatalities	0 per 1000 fires	Injuries 87per 1000 fires
	Property damage	$53,500 per fire	

I'herefore the rates of casualties for fires with ***Extent*** *of flame* ***damage*** extended to *structure of origin or beyond compared* ***with fires*** *with Extent of flame* damage retained *within room* ***of*** *origin are:*

Civilian fatalities	0 times	Injuries 0.2 times
Fire fighter Fatalities	- times	Injuries 3.5 times
Property damage	7.7 times	

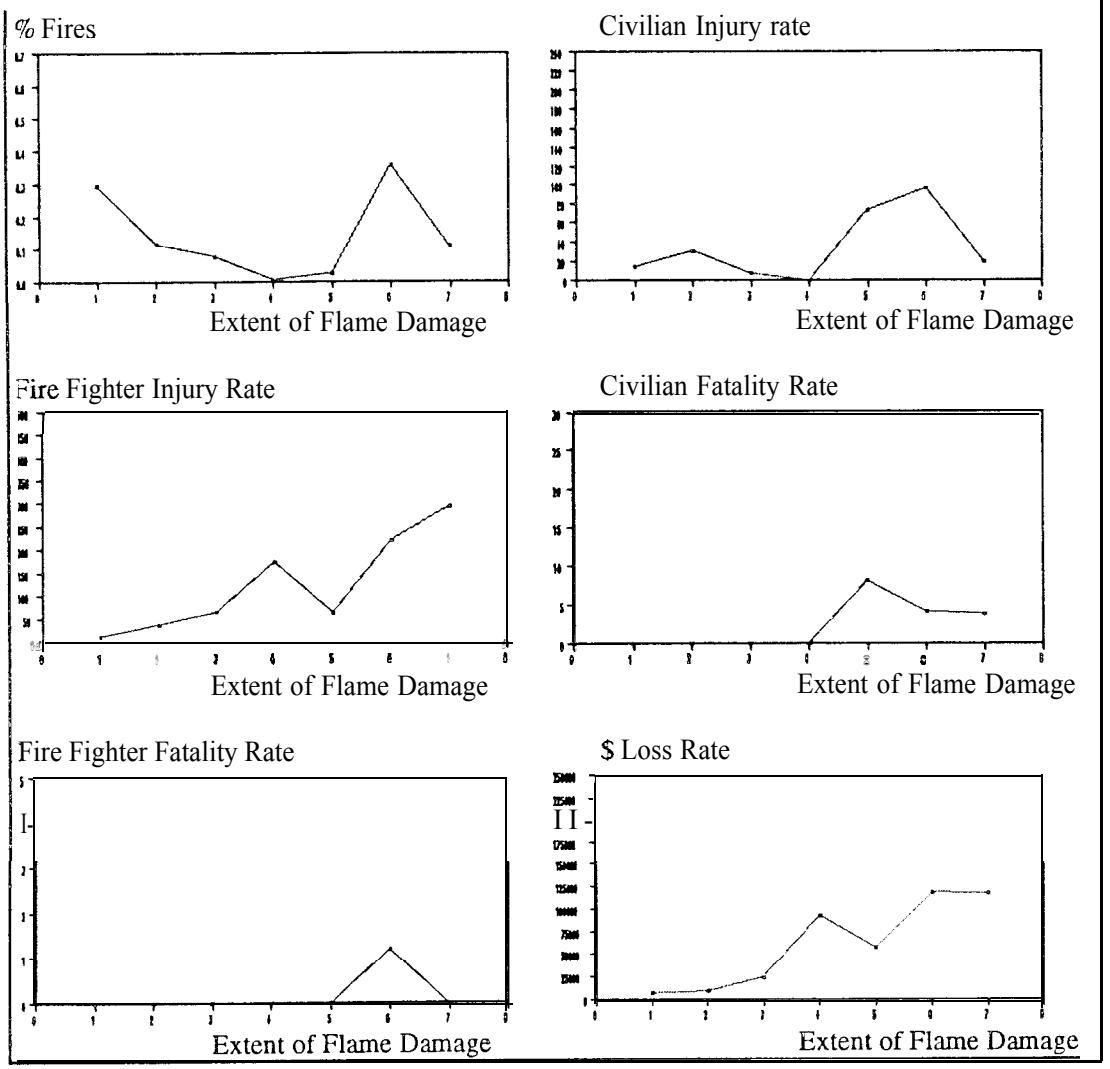


FIGURE 23 VARIATION OF CASUALTIES AND ESTIMATED PROPERTY LOSSES WITH EFD

Extent of flame damage retained *within room* ***of*** *origin:*			50% of fires
Rates of Casualties:	Civilian fatalities	0 per 1000 fires	Injuries 18 per 1000 fires
	Fire fighter fatalities	0 per 1000 fires	Injuries 30 per 1000 fires
	Property damage	$10,700 per fire	
Extent of flame damage extended to *structure* ***of*** *origin or beyond:*			37% of fires
Rates of Casualties:	Civilian fatalities	4.3 per 1000 fires	Injuries 78 per 1000 fires
	Fire fighter Fatalities	0.9 per 1000 fires	Injuries 229 per 1000 tires
	Property damage	$115,000 per fire	
Therefore *the* rates of casualties for fires with *Extent of flame damage* extended to *structure* ***of*** *origin or beyond compared with fires with* ***Extent of flame*** *damage* retained *within room of origin are:*	Civilian fatalities	- times	Injuries 4 times
	Fire fighter Fatalities	- times	Injuries 8 times
	Property damage	11 times	

13 TIME FROM ALARM TO FIRE BRIGADE ARRIVAL

In this report the *time from alarm to fire brigade arrival* (also referred to as *fire brigade arrival time)* is referred to by the beginning of the time period. Thus zero (0) minutes is the period from alarm (0) to 1 minute, two (2) minutes is the period from 2 to 3 minutes, etc. The *fire brigade arrival time* is obtained by subtraction of the field *arrival time* from the field *alarm time.*

The following analysis excludes 37,609 records where time of arrival is zero or where *arrival time* is recorded as before *alarm time* or similar, and those with less than twenty records. Some of the other times recorded are less obviously faulty, but appear likely to be so. Nevertheless, the overwhelming majority of times for alarms where calculation of *arrival time* is possible appear likely to be reliable.

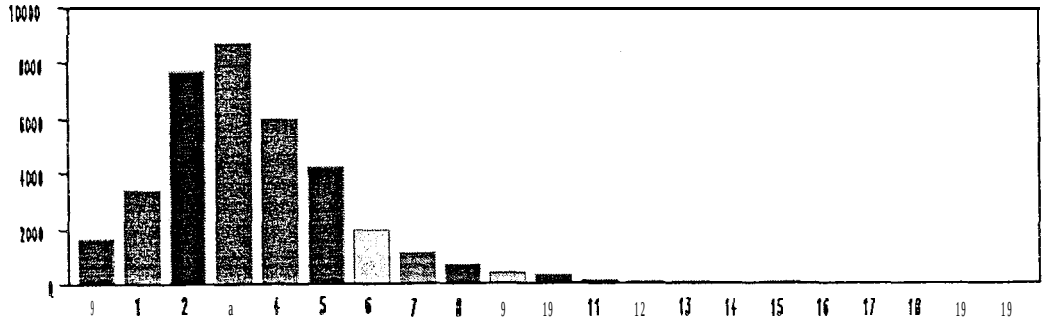
(Note that *time from alarm to fire brigade arrival* of 4 minutes contains the fire with 119 *civilian injuries* and the time 3 minutes contains the fire with four *civilian fatalities.* The fires with three and *five civilian fatalities* have *unknown fire brigade arrival times.)*

It is apparent in Figure 24 that in the great majority of fires notified to the fire brigade, the brigade arrives at the scene within ten minutes the median arrival time is 3 minutes, the 90 percentile 9 minutes, and the 97.5 percentile 46 minutes.

Identifying trends in *the casualty rates* with the increasing *fire brigade arrival time* is only possible for the period where the significant numbers of casualties occur and is difficult for the one minute intervals in Figure 24. A little more clarity is achieved by using 5 minute periods. Thus the overall *civilian fatality rate* for the period 0 to 4 minutes is 0.6 fatalities per 1000 fires, rising to 1.6 for 5 to 9 minutes and 1.2 for 10 to 14 minutes (based on only one casualty). Thus it rises substantially between the first and second periods and may stabilise or decline slightly in the third period. The overall *fire fighter fatality rate* is 0.1 for the period 0 to 4 minutes and 0.2 for 5 to 9 minutes, again a substantial rise. The *civilian injury rate* is 14 for 0 to 4 minutes and 29 for 5 to 9 minutes, 16 for 10 to 14 minutes and 15 for 15 to 19 minutes, thus it rises sharply between the first and second periods, but returns to near the initial level for the subsequent periods. The *fire fighter injury rate* is 3 1 for 0 to 4 minutes, 46 for 5 to 9 minutes, 41 for 10 to 14 minutes and 36 for 15 to 19 minutes, thus it appears to rise between the first and second periods and then gradually decline.

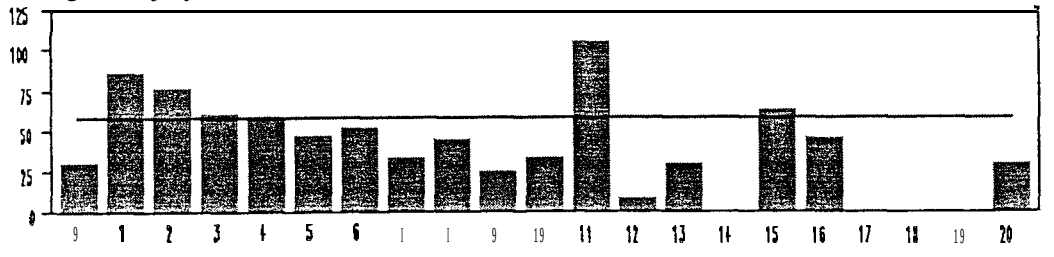
Thus a general trend seems to be for *casualty rates* to increase for the period 5 to 9 minutes compared with the initial period, and then to stabilise or decline slightly during subsequent periods.

Fire



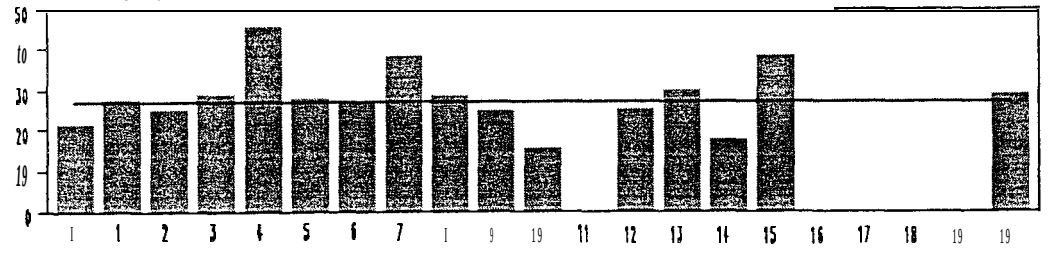
Time from Alarm to Firefighter Arrival (minutes)

Firefighter Injury Rate



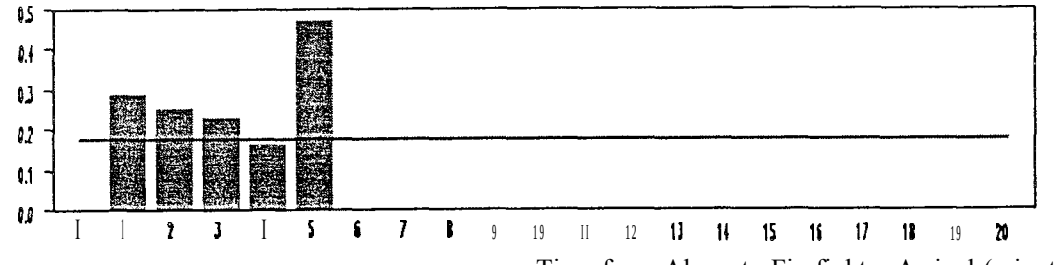
Time from Alarm to Firefighter Arrival (minutes)

Civilian Injury Rate



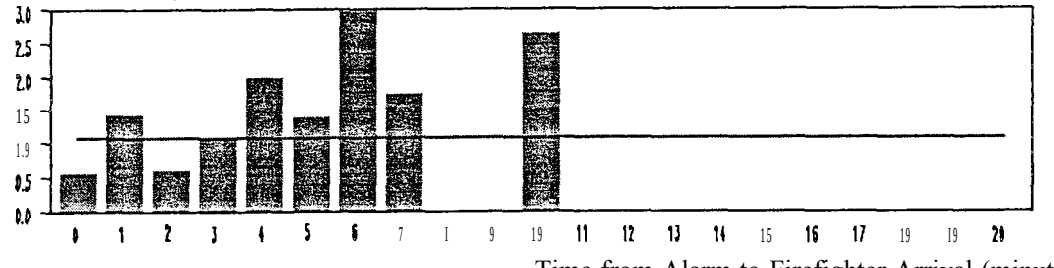
Time from Alarm to Firefighter Arrival (minutes)

Firefighter Fatality Rate



Time from Alarm to Firefighter Arrival (minutes)

Civilian Fatality Rate



Time from Alarm to Firefighter Arrival (minutes)

FIGURE 24 TIME FROM ALARM TO FIRE BRIGADE ARRIVAL

TABLE 19 TIME FROM ALARM TO FIRE BRIGADE ARRIVAL

Fire Brigade Arrival Time (minutes)	Fires	Fire-fighter Injuries	Fire-fighter Injury Rate	Civilian Injuries	Civilian Injury Rate	Fire-fighter Fatalities	Fire-fighter Fatality Rate	Civilian Fatalities	Civilian Fatality Rate
0	1664	51	30.65	36	21.63	0	0.00	1	0.60
1	3444	299	86.82	96	27.87	1	0.29	5	1.45
2	7768	599	77.1%	197	25.36	2	0.26	5	0.64
3	8732	538	61.61	254	29.09	2	0.23	10	1.15
4	5988	346	57.78	277	46.26	1	0.17	12	2.00
5	4228	198	46.83	119	28.15	2	0.47	6	1.42
6	2010	108	53.73	54	26.87	0	0.00	6	2.99
7	1135	39	34.36	44	38.77	0	0.00	2	1.76
8	698	31	44.41	20	28.65	0	0.00	0	0.00
9	442	11	24.89	11	24.89	0	0.00	0	0.00
10	378	13	34.39	6	15.87	0	0.00	1	2.65
11	151	16	105.96	0	0.00	0	0.00	0	0.00
12	117	1	8.55	3	25.64	0	0.00	0	0.00
13	100	3	30.00	3	30.00	0	0.00	0	0.00
14	56	0	0.00	1	17.86	0	0.00	0	0.00
15	78	5	64.10	3	38.46	0	0.00	0	0.00
16	43	2	46.51	0	0.00	0	0.00	0	0.00
17	25	0	0.00	0	0.00	0	0.00	0	0.00
18	28	0	0.00	0	0.00	0	0.00	0	0.00
19	21	0	0.00	0	0.00	0	0.00	0	0.00
20	34	1	29.41	1	29.41	0	0.00	0	0.00

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

14 VARIATION OF EXTENT OF FLAME DAMAGE WITH TIME FROM ALARM TO FIRE BRIGADE ARRIVAL

As shown in Figures 25 to 28 and Tables 20 to 23 increased fire *brigade arrival time* results in changes in the *extent of flame damage*. Also apparent from these tables is that increased *casualty rates* with more widespread *flame* damage occur consistently through the different time periods. (Note that as the fire *brigade arrival time* increases the numbers of fires and casualties in some groups becomes very small and consequently the calculated rates must be treated with discretion.)

Comparison of Figures 25 to 28 shows that the proportion of fires in each *extent of flame damage* category within the *room of fire origin (AFO I to AFO 3)* reduces *as the time of arrival* increases and correspondingly the *extent of flame* damage throughout or beyond the *structure of origin (AFO 6 and AFO 7)* increases. Thus *49%* of fires are *confined to the object of origin* in the 0 to 4 minute interval compared with 35% in the 15 to 19 minute interval.

Overall, 79% of fires *are confined to the room of origin* in the O-4 minute interval (compared with 15% *confined to the structure of origin),* 78% for the 5-9 minute interval (compared with 16%), 65% for the 10-14 minute interval (compared with 26%) and 55% for the 15-19 minute interval (compared with 36%).

Thus it can be see that *fire brigade arrival time* has a dramatic effect on the *extent of flame damage* and, to the extent possible with the relatively small proportion of fires with long *arrival times,* has similarly important effects on the casualties and property damage outcomes of fires.

In summary:

- the *fire brigade arrival time* is less than 10 minutes for 90% of fires
- between 21% and *22%* of fires have *extent of flame damage not confined to the room of origin* for *fire brigade arrival times* between 0 and 9 minutes
- between *35* and *45%* of fires have *extent of flame damage not confined to the room of origin* for *fire brigade arrival times* between 10 and 19 minutes

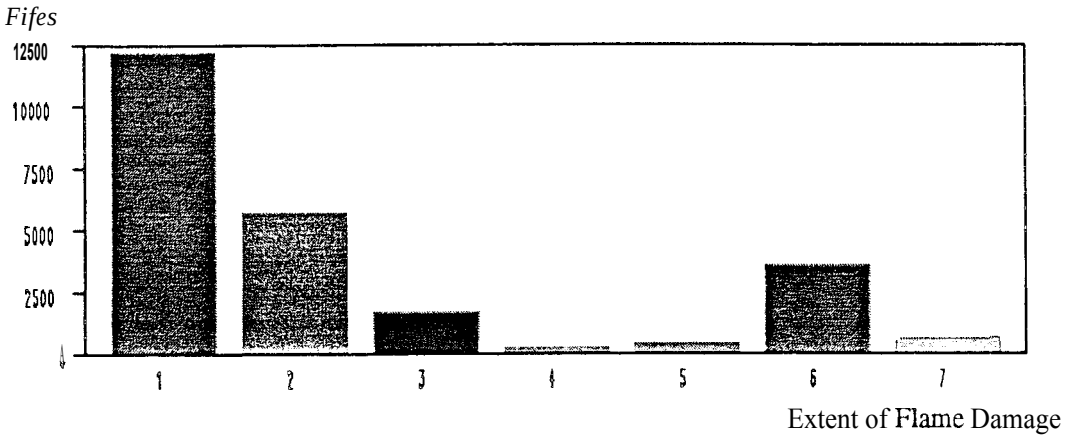


FIGURE *25* FIRES BY EXTENT OF FLAME DAMAGE CATEGORY FOR ARRIVAL TIME RANGE O-4 MINUTES

TABLE *20* ARRIVAL *O-4* MINUTES

EFD	*Fires (%)*	*Fire Fighter Injuries (Rate *)*	*Civilian Injuries (Rate *)*	*Fire Fighter Fatalities (Rate *)*	*Civilian Fatalities (Rate *)*	*US$ Loss (Rate *)*
1	12254	100	197	0	4	40406332
	(49.3)	(8.2)	(16.1)	(0.0)	(0.3)	(3297)
2	5723	179	187	2	3	55974277
	(23.0)	(31.3)	(32.7)	(0.3)	(0.5)	(9781)
3	1742	104	89	0	2	44744091
	(7.0)	(59.7)	(51.1)	(#)	(1.1)	(25685)
4	257	31	12	0	1	14074426
	(1.0)	(121)	(46.7)	(#)	(3.9)	(54764)
5	501	73	22	0	0	28435363
	(2.0)	(146)	(43.9)	(#)	(#)	(56757)
6	3640	1001	265	3	19	3.7057e8
	(14.7)	(275)	(72.8)	(0.8)	(5.2)	(101806)
7	727	299	53	0	3	1.1226e8
	(2.9)	(411)	(72.9)	(#)	(4.1)	(154421)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

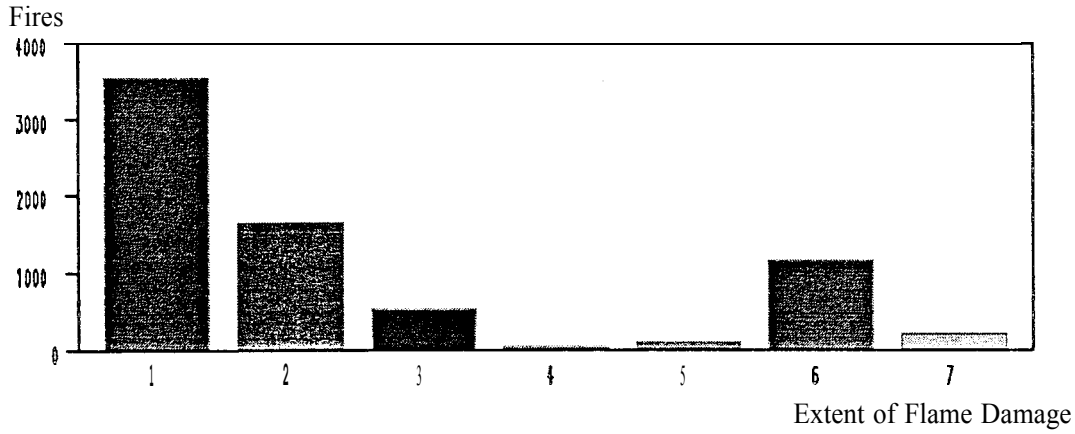


FIGURE 26 FIRES BY EXTENT OF FLAME DAMAGE CATEGORY FOR ARRIVAL TIME RANGE 5-9 MINUTES

TABLE 21 ARRIVAL TIME RANGE 5-9 MINUTES

EFD	*Fires (%)*	*Fire Fighter Injuries (Rate *)*	*Civilian Injuries (Rate *)*	*Fire Fighter Fatalities (Rate *)*	*Civilian Fatalities (Rate *)*	*US$ Loss (Rate *)*
1	3563	34	75	0	0	8532392
	(48.0)	(9.5)	(21.0)	(#)	(#)	(2395)
2	1680	47	64	0	1	21752115
	(22.6)	(28.0)	(38.1)	(#)	(0.6)	(12948)
3	547	30	21	0	0	118692844
	(7.4)	(54.8)	(38.4)	(#)	(#)	(34173)
4	74	6	5	0	2	6295250
	(1.0)	(81.1)	(67.6)	(#)	(27.0)	(85071)
5	132	17	16	0	2	7410983
	(1.8)	(129)	(121)	(#)	(15.2)	(56144)
6	1191	183	46	1	4	1.148e+8
	(16.0)	(154)	(38.6)	(0.8)	(3.4)	(96389)
7	243	56	7	1	3	25322003
	(3.3)	(231)	(28.8)	(4.1)	(12.3)	(104206)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

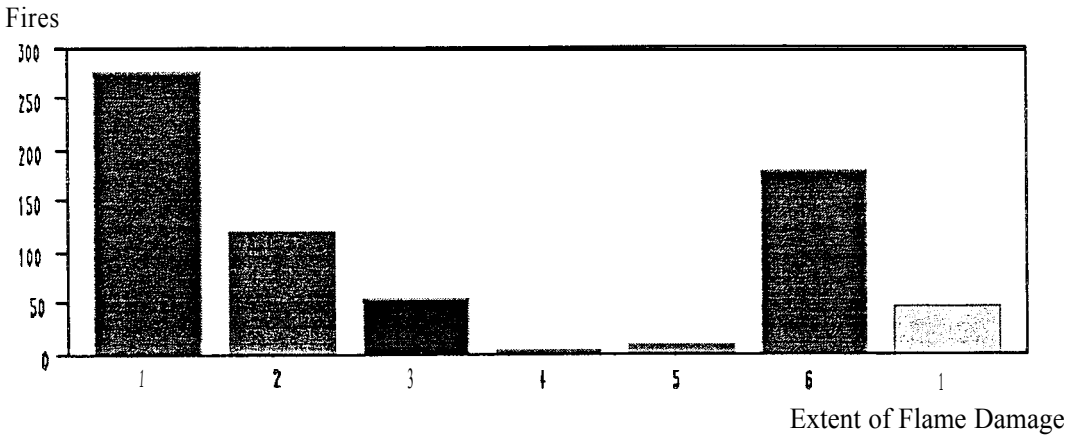


FIGURE 27 FIRES BY EXTENT OF FLAME DAMAGE CATEGORY FOR ARRIVAL TIME RANGE 10-14 MINUTES

TABLE 22 ARRIVAL TIME RANGE 10-14 MINUTES

EFD	*Fires (%)*	*Fire Fighter Injuries (Rate *)*	*Civilian Injuries (Rate *)*	*Fire Fighter Fatalities (Rate *)*	*Civilian Fatalities (Rate *)*	*US$ Loss (Rate *)*
1	278	1	5	0	0	717955
1	(39.7)	(3.6)	(18.0)	(#)	(#)	(2583)
2	122	2	0	0	0	1040115
2	(17.4)	(16.4)	(#)	(#)	(#)	(8526)
3	56	2	2	0	1	1786850
3	(8.0)	(35.7)	(35.7)	(#)	(17.9)	(31908)
4	6	0	0	0	0	16700
4	(0.9)	(#)	(#)	(#)	(#)	(2783)
5	11	1	0	0	0	231350
5	(1.6)	(90.9)	(#)	(#)	(#)	(21032)
6	180	26	4	0	0	12462100
6	(25.7)	(144)	(22.2)	(#)	(#)	(69234)
7	48	1	1	0	0	10601200
7	(6.9)	(20.8)	(20.8)	(#)	(#)	(220858)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fire.5 unless noted otherwise

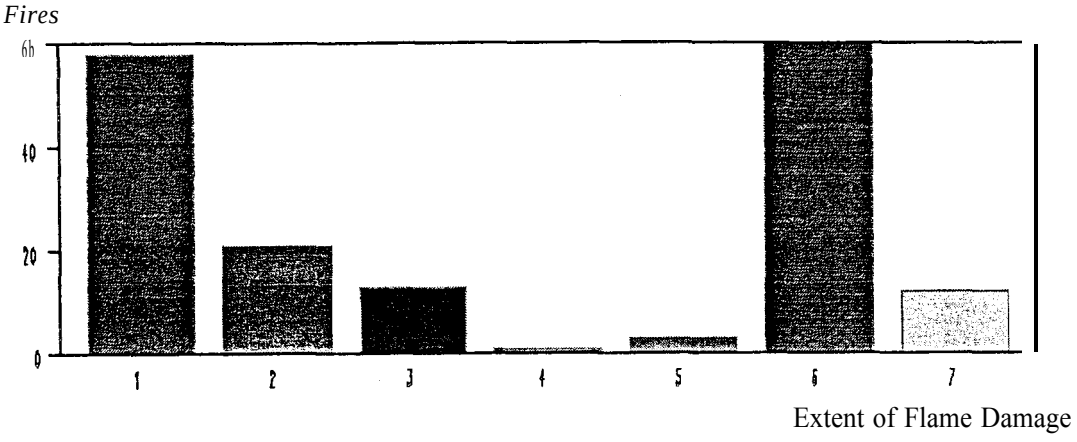


FIGURE 28 FIRES BY EXTENT OF FLAME DAMAGE CATEGORY FOR ARRIVAL TIME RANGE 15 - 19 MINUTES

TABLE 23 ARRIVAL TIME RANGE 15-19 MINUTES

EFD	*Fires (%)*	*Fire Fighter Injuries (Rate *)*	*Civilian Injuries (Rate *)*	*Fire Fighter Fatalities (Rate *)*	*Civilian Fatalities (Rate *)*	*US$ Loss (Rate *)*
1	58	0	0	0	0	205611
1	(34.5)	(#)	(#)	(#)	(#)	(3545)
2	21	0	0	0	0	160280
2	(12.5)	(#)	(#)	(#)	(#)	(7632)
3	13	1	0	0	0	276500
3	(7.7)	(76.9)	(#)	(#)	(#)	(21269)
4	1	0	0	0	0	20000
4	(0.6)	(#)	(#)	(#)	(#)	(20000)
5	3	2	3	0	0	88000
5	(1.8)	(667)	(1000)	(#)	(#)	(29333)
6	60	2	0	0	0	4407400
6	(35.7)	(33.3)	(#)	(#)	(#)	(73457)
7	12	2	0	0	0	649450
7	(7.1)	(167)	(#)	(#)	(#)	(54121)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

15 EXTENT OF SMOKE DAMAGE

The NFIRS field *extent* of *smoke damage* is another measure (in addition to *extent* of *flame damage*) of the degree of development and spread of a fire. The general classification of *extent of smoke damage* is as follows:

ESD 9	No damage of this type
ESD 1	Confined to the object of origin
ESD 2	Confined to the part of room or area of origin
ESD 3	Confined to the room of origin
ESD 4	Confined to the fire-rated compartment of origin
ESD 5	Confined to the floor of origin
ESD 6	Confined to the structure of origin
ESD 7	Extended beyond the structure of origin
ESD 0	Unknown, etc

(Note that *ESD 7* contains *the* fire with 119 *civilian injuries, ESD 0* contains the fire with three *civilian fatalities* and *ESD* 6 contains the fires with four and five *civilian fatalities.)*

Overall, 36% of fires reported to the fire brigades (or 42% of tires with known *ESD*) cause *smoke damage not confined within the room of origin* (Figure 29 and Table 24). The largest group of fires (29% of fires with known *ESD)* cause *smoke damage confined to the structure of origin (EFD 6)).*

Of *the* fires that cause *smoke damage that extended beyond the room of origin,* relatively few are recorded as having *smoke damage confined to the fire-rated compartment* ***of*** *origin* or *confined to the floor of origin (6.5%* in total of fires with known *ESD).*

It is clear in Figure 29 that there is generally a very strong trend for the *casualty rates* to increase with increased *extent of spread of smoke damage.* The overall *casualty rates* for the fires with *smoke damage confined within the room* of origin *(ESD 9, ESD 1, ESD 2 and ESD 3) are 0.1* and 10.0 for *fire fighter fatalities and injuries* respectively and *0.2* and 17.6 for *civilian fatalities and injuries* respectively.

Comparison of these figures with the overall *casualty rates* for fires with *smoke damage not confined to the room of origin (0.4* and 140 for *jire jighter fatalities and injuries* respectively and 2.4 and *47* for *civilian fatalities and injuries* respectively) shows that there are factors of *7.5* and *14* for *fire jighter fatalities and injuries* respectively and 11 and *2.7* for *civilian fatalities and injuries* respectively between these cases.

Thus it is clear that fires with *extent of smoke damage* **not** *confined to the room of origin* are, on average, very much more dangerous for *fire fighters and* civilians than fires where *smoke damage* is *confined to the room of origin.*

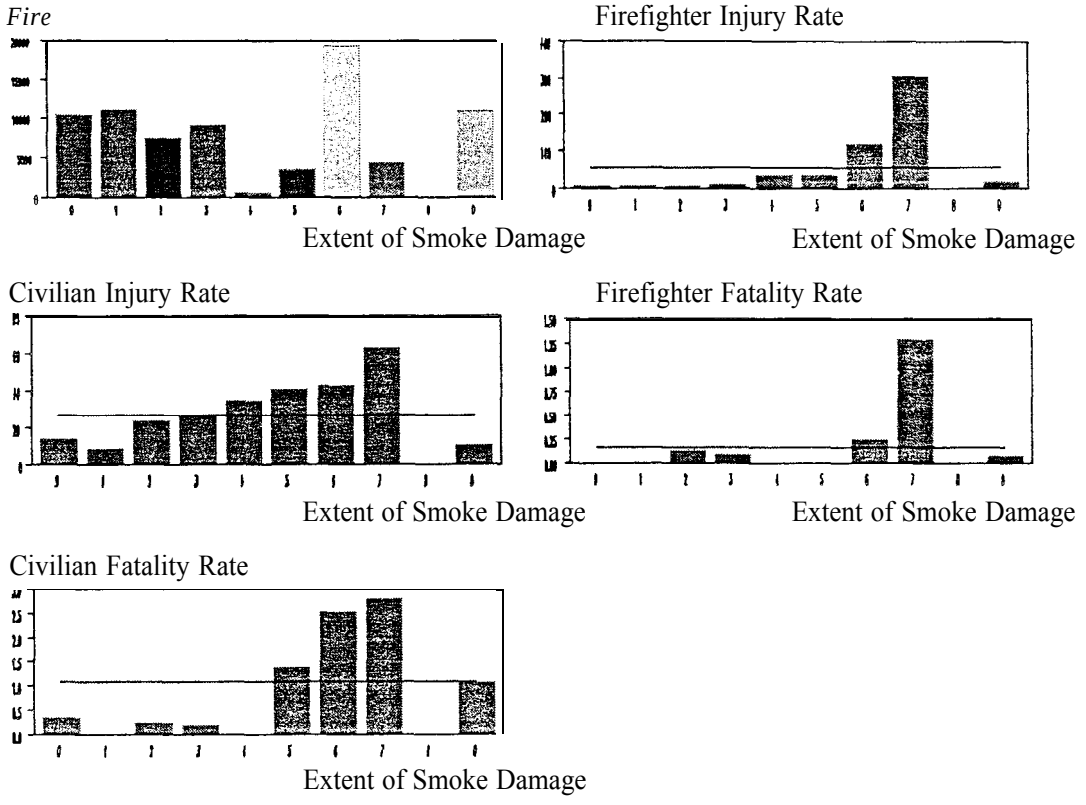


FIGURE *29* EXTENT OF SMOKE DAMAGE

TABLE 24 EXTENT OF SMOKE DAMAGE

Extent of Smoke Damage	*Fires (%)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
9	10509	105	154	0	4
	(15.7)	(10.0)	(14.7)	(0.0)	(0.38)
1	11183	95	95	0	0
	(16.7)	(8.5)	(8.5)	(0.0)	(0.0)
2	7667	79	187	1	2
	(11.5)	(10.3)	(24.4)	(0.13)	(0.26)
3	9196	108	244	1	2
	(13.7)	(11.7)	(26.5)	(0.11)	(0.22)
4	795	31	28	0	0
	(1.2)	(39.0)	(35.2)	(#)	(#)
5	3540	139	148	0	5
	(5.3)	(39.3)	(41.8)	(#)	(1.4)
6	19377	2368	846	5	49
	(29.0)	(122)	(43.7)	(0.26)	(2.5)
7	4624	1431	297	6	13
	(6.9)	(309)	(64.2)	(1.3)	(2.8)
Unknown, etc	11105	224	119	1	12
	(16.6)	((20.2)	(10.7)	(0.1)	(1.1)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 tires unless noted otherwise

In summary:

- overall 42% of fires with known *extent of smoke damage* cause *smoke damage not confined within the room of origin*
- there are factors of difference of 7.5 and 14 for fire *fighter fatalities and injuries* respectively and 11 and *2.7* for *civilian fatalities and injuries* respectively between the overall *casualty rates* for the fires with *smoke damage not confined to the room of origin* compared with fires with *smoke damage confined to the room of origin*

16 DETECTOR PERFORMANCE

The general classification of detector performance is as follows:

DP 1 Detector(s) in the room or space of fire origin and they operated
DP2 Detector(s) not in the room or space of fire origin and they operated
DP3 Detector(s) in the room or space of fire origin and they did not operate
DP4 Detector(s) not in the room or space of fire origin and they did not operate
DP5 Detector(s) in the room or space of fire origin but fire too small to require them to operate
DP 8 No detectors present
DP 9 Unknown, etc

(Note that DP 8 contains the fire with 119 civilian injuries and DP 9, DP 8 and DP 1 contain the fires with three, four and five civilian fatalities respectively.)

The majority of fires are recorded as having *no detectors present,* with almost as large a number *unknown, etc* (Figure 30 and Table 25).

Of the fires with *detectors present* in the *room of origin (DP 1, DP 3 and DP 5)* only 50% are recorded as having *operated.* Of the fires with *detectors* in the *room of origin* that *do not operate (DP 3 and DP 5)* in 57% the fire is judged to be *too small to require them to operate (DP 5),* although this judgement will be somewhat subjective and should be treated with caution.

It is notable that only 15% of the fires in *BP* 5 are classified as having *extent of smoke damage not confined to the room of origin,* whereas the comparable percentages for *DP1* and *DP 3* are 46% and 31% respectively. However, it is of some concern that it could be judged that detectors *should not operate* in fires with *smoke damage not confined to the room of origin.*

Of *the* fires with *detectors not in the room of fire origin* only 44% are recorded as having operated. No judgement of whether they should have operated is allowed for in *the* categories for *detectors not in the room of origin.*

As the number of fires with *detectors known to be present* is relatively small, caution should be exercised in assessing the signifkance of *tie casualty rates,* particularly the *fire fighter fatality rate,* for the individual *detector performance* categories. Nevertheless, it is notable that the overall rates (for all of the *detectors known to be present* categories) for *injury rates* (both for *fire fighters* and *civilians,* 47.7 and 28.4 respectively) are reasonably close to the *overall average rates,* but *the fatality rates* (0.09 and 0.27 for *fire fighters* and *civilians* respectively) are substantially below the *overall average rates.*

This appears to indicate that there may be a difference in the effect of *detector presence* for injuries compared with fatalities, for both civilians and *fire* fighters. Why this may be so is not clear.

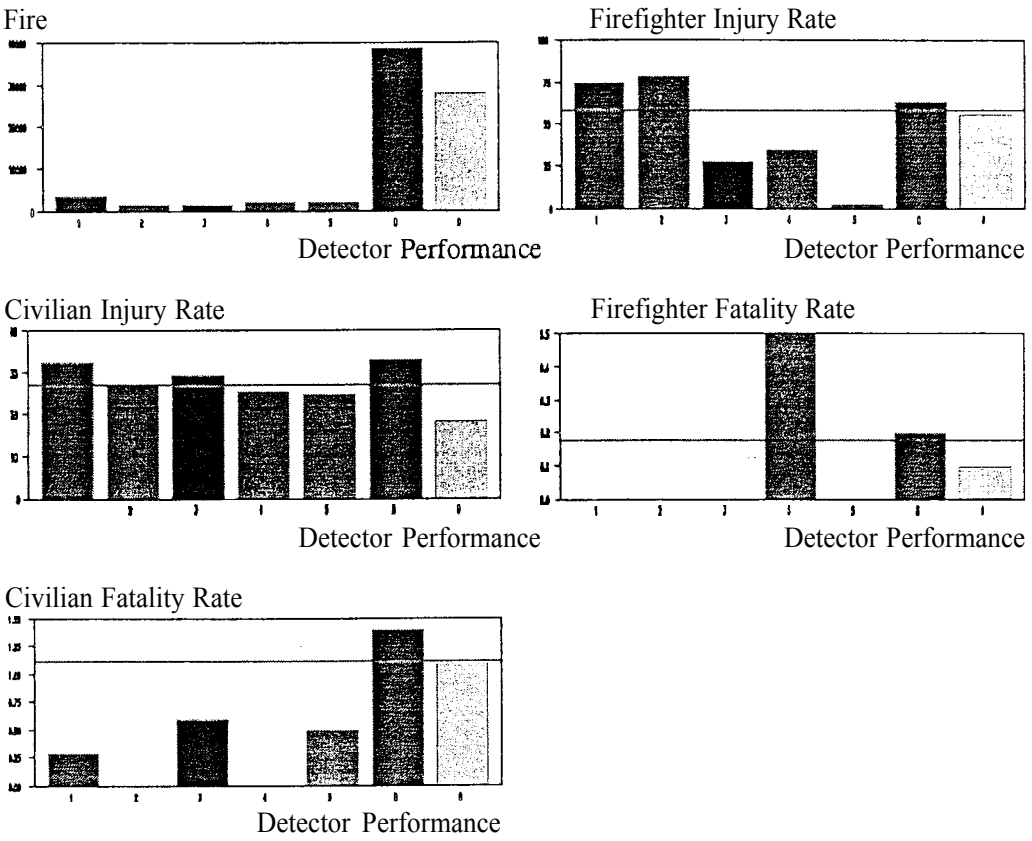


FIGURE 30 DETECTOR PERFORMANCE

TABLE 25

Detector Performance	*Fires (% of known)*	*Fire Fighter Injuries (rate*)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
1	3652	275	118	0	1
	0	(75)	(32)	(#)	(0.3)
2	1615	126	43	0	0
	0	(78)	(27)	(#)	(#)
3	1567	44	46	0	1
	0	(28)	(29)	(#)	(0.6)
4	2072	72	53	1	0
	0	(35)	(26)	(0.5)	(#)
5	2061	6	51	0	1
	0	(2.9)	(25)	(#)	(0.5)
8	38985	2500	1287	9	54
	0	(64)	(33)	(0.2)	(1.4)
Unknown, etc	28044	1557	520	4	30
	0	(55)	(19)	(0.1)	(1.1)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

In summary:

- detectors are known to be ***present*** at only a very small percentage of fires
- ***detectors*** do not operate in more than 50% of fires where they are known to be ***present*** (in some cases because the fires are too small)
- the ***presence of detectors*** does not seem to substantially improve the ***civilian and fire fighter injury rates*** but may improve the ***civilian and fire fighter fatality rates***

17 NUMBER OF STOREYS

The categories for number of storeys are:

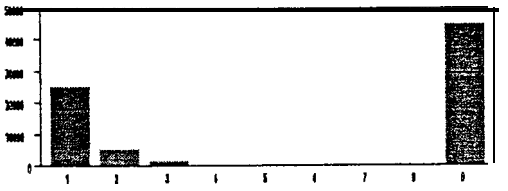
NS 1	1 storey
NS 2	2 storeys
NS 3	3 to 4 storeys
NS 4	5 to 6 storeys
NS 5	7 to 12 storeys
NS 6	13 to 24 s toreys
NS 7	25 to 49 storeys
NS 8	50 storeys or more
NS 9	Undetermined or unreported

(Note that NS 3 contains the fire with 119 civilian injuries, NS 9 contains the fires with three and five civilian fatalities and NS 1 contains the fire with four civilian fatalities.)

It is unfortunate that the number of storeys is unknown for the majority of the fires reported (Figure 31 and Table 26).

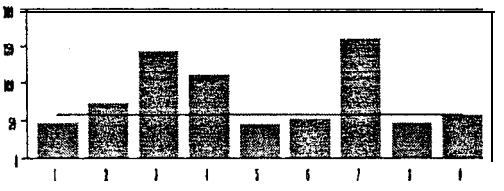
The vast majority of fires with reported storeys are single storey (77%), nearly 95% are in one or two storey buildings and nearly 99% are in one to four storey buildings. The numbers of fires in buildings of more than two storeys are so low that extreme caution should be exercised in assessing any of the ***rate*** data for these categories.

Fires



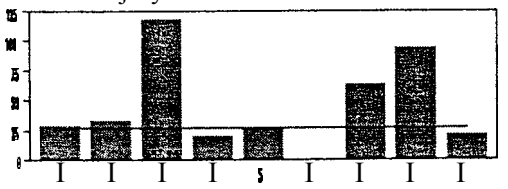
Category for Number of Storeys

Firefighter Injury Rate



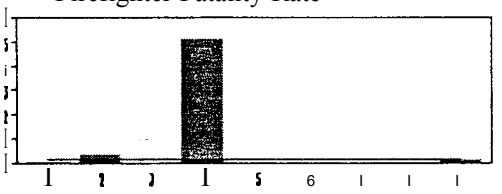
Category for Number of S toreys

Civilian Injury Rate



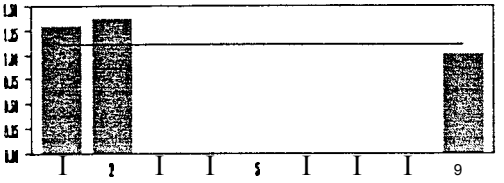
Category for Number of Storeys

Firefighter Fatality Rate



Category for Number of Storeys

Civilian Fatality Rate



Category for Number of Storeys

FIGURE 3 1 NUMBER OF STOREYS

TABLE 26 NUMBER OF STOREYS

Number of Storeys	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
NS 1	25436	1232	757	2	33
	(77.0)	(48)	(30)	(0.1)	(1.3)
NS2	5773	426	199	2	8
	(17.5)	(74)	(34)	(0.4)	(1.4)
NS 3	1372	200	162	0	0
	(4.2)	(146)	(118)	(#)	(#)
NS4	195	22	4	1	O-
	(0.6)	(113)	(21)	5.1)	(#)
NS5	111	5	3	0	0
	(0.3)	(45)	(27)	(#)	(#)
NS 6	75	4	0	0	0
	(0.2)	(53)	(#)	(#)	(#)
NS 7	31	5	2	0	0
	(0.1)	(161)	(65)	(#)	(#)
NS a	21	1	2	0	0
	(0.1)	(48)	(95)	(#)	(#)
NS9	44982	2685	989	9	46
	(136)	(60)	(22)	(0.2)	(1.0)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

18 EQUIPMENT INVOLVED IN IGNITION (IF ANY)

The general classification of equipment involved in ignition is as follows:

EII 1	Heating systems
EII 2	Cooking equipment
EII 3	Air conditioning, refrigeration equipment
EII 4	Electrical distribution equipment
EII 5	Appliances, equipment
EI16	Special equipment
EII 7	Processing equipment
EII 8	Service, maintenance equipment
EII 9	Unknown, etc

(Note that EII 9 contains the fire with 119 civilian injuries and the fires with three, four and five civilian fatalities.)

The equipment involved in ignition is unknown in the majority of fires (Figure 32 and Table 27). The number of fires in some categories is so low that caution should be exercised in assessing the *casualty rates,* particularly the *fire fighter fatality rate.*

Of the fires with recorded *equipment involved in ignition, the* equipment most commonly involved is *electrical distribution equipment (39%* of known) and *appliances, equipment* (17% of known).

The *fire fighter injury rate* is well below the overall average for *cooking equipment; air conditioning, refrigeration equipment; and appliances, equipment* and about average for the remainder.

The *civilian injury rate* is well below average for *air conditioning, refrigeration equipment* but well above average for *special equipment; processing equipment; and service, maintenance equipment.*

The *civilian fatality rate* is well below the overall average for *heating systems; cooking equipment; air conditioning, refrigeration equipment; electrical distribution equipment; appliances, equipment; and special equipment* and is particularly high for *service, maintenance equipment.*

In Summary:

- *the equipment involved in ignition* is unknown in the majority of fires
- *the equipment involved in ignition* in 39% (of known) fires is *electrical distribution equipment* and in 17% *(of* known) *appliances, equipment*
- *the civilian fatality rate* is particularly high for *service, maintenance equipment*
- the *civilian injury rate* is well above average for *special equipment; processing equipment; and service, maintenance equipment*

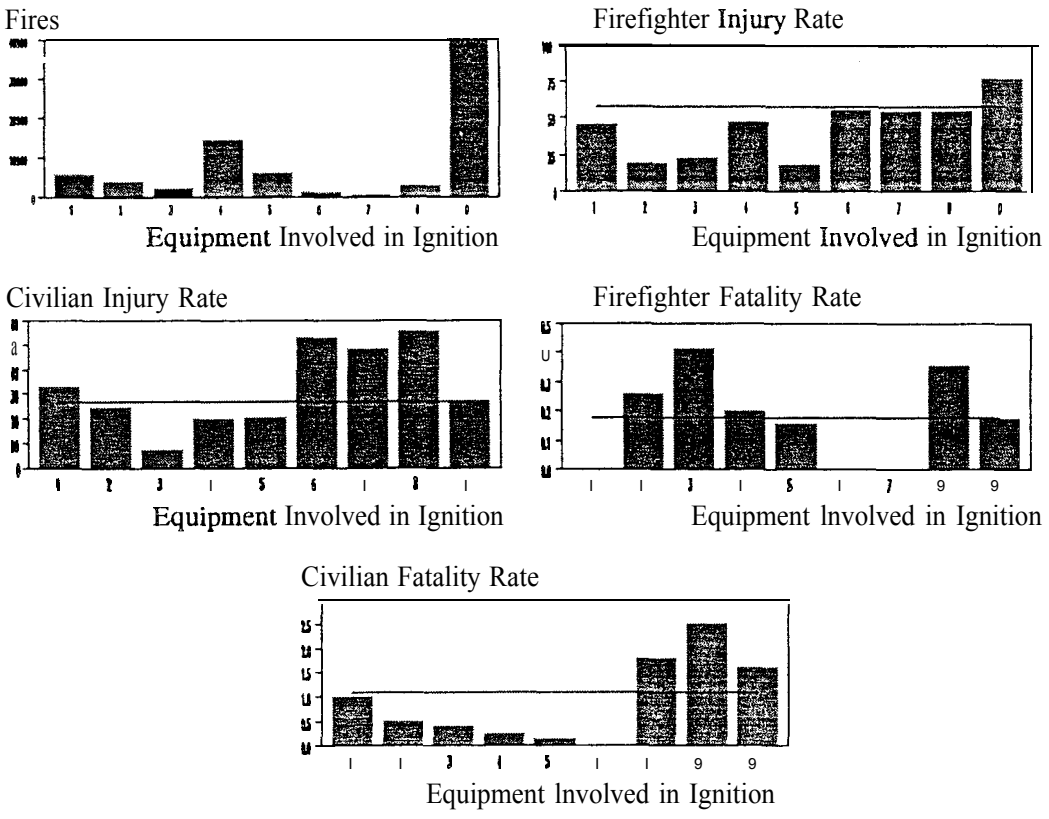


FIGURE *32* EQUIPMENT INVOLVED IN IGNITION

TABLE *27* EQUIPMENT INVOLVED IN IGNITION

Equipment Involved in Ignition	*Fires (% of known)*	*Fire Fighter Injuries (rate*)*	*Civilian Injuries (rate*)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate*)*
1	5919	274	199	0	6
	(15.6)	(46.3)	(33.6)	(#)	(1.0)
2	3864	77	96	1	2
	(10.2)	(19.9)	(24.8)	(0.3)	(0.5)
3	2424	57	19	1	1
	(6.4)	(23.5)	(7.8)	(0.4)	(0.4)
4	14786	717	304	3	4
	(38.9)	(48.5)	(20.6)	(0.2)	(0.3)
5	6480	125	135	1	1
	(17.1)	(19.3)	(2 0 . 8)	(0.2)	(0.2)
6	1176	66	63	0	0
	(3.1)	(56.1)	(53.6)	(#)	(#)
7	557	31	27	0	1
	(1.5)	(55.7)	(48.5)	(#)	(1.8)
8	2791	154	156	1	7
	(7.3)	(55.1)	(55.9)	(0.4)	(2.5)
9	39999	3079	1119	7	65
	(105)	(77.0)	(28.0)	(0.2)	(1.6)

Notes: • The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
° Rate per 1000 fires unless noted otherwise

19 FORM OF HEAT OF IGNITION

The general classification of form of heat of ignition is as follows:

FHI 1	Heat from fuel fired, fuel powered object
FHI 2	Heat from electrical equipment arcing, overload
FHI 3	Heat from smoking material
FHI 4	Heat from open flame, spark
FHI 5	Heat from hot object
FHI 6	Heat from explosive, fireworks
FHI 7	Heat from natural source
FHI 8	Heat spreading from another fire (exposure)
FHI 9	Other, unknown, etc

(Note that *FHI* 9 contains the fire with 119 civilian injuries and *FHI 5, FHI 9 and FHI 4* contain the fires with three, four and five civilian fatalities respectively.)

The *form of* heat *of* ignition is recorded for a remarkably high proportion of fires (Figure 33 and Table 28).

The largest number of fires by far is attributed to *heat from electrical equipment arcing, overload (36%* of known) with *heat from open flame, spark (20%* of known) next.

The fire fighter fatality and injury and *civilian fatality rates* are notably above their respective overall average rates for *other, unknown, etc.* Also notably high is the *civilian fatality rate* for *heat from open flame, spark.* Notably low is the *civilian fatality rate* for *heat from electrical equipment arcing.*

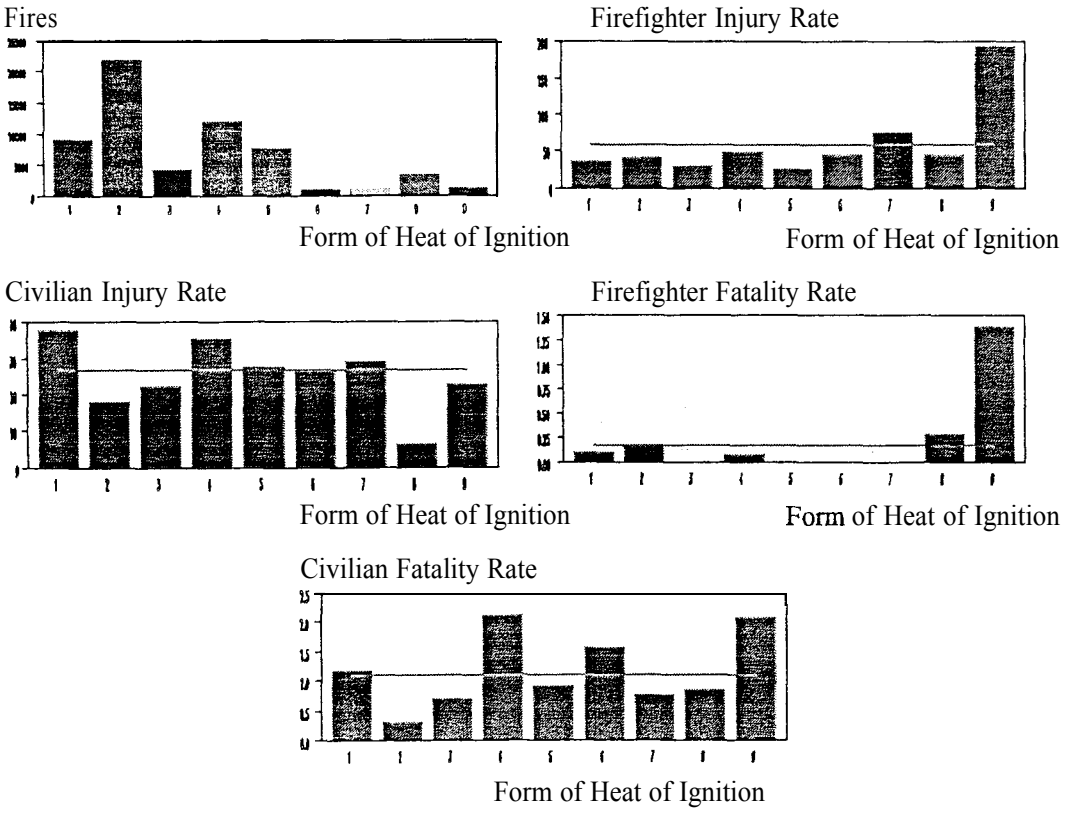


FIGURE *33* FORM OF HEAT OF IGNITION

TABLE *28* FORM OF HEAT OF IGNITION

Form of Heat of Ignition	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
1	9278	338	352	1	11
	(15.1)	(36.4)	(37.9)	(0.1)	(1.2)
2	22069	919	409	4	7
	(35.9)	(41.6)	(18.5)	(0.2)	(0.3)
3	4260	131	97	0	3
	(6.9)	(30.8)	(22.8)	(#)	(0.7)
4	12169	612	436	1	26
	(19.8)	(50.3)	(35.8)	(0.1)	(2.1)
5	7568	200	212	0	7
	(12.3)	(26.4)	(28.0)	(#)	(0.9)
6	1274	59	34	0	2
	(2.1)	(46.3)	(26.7)	(#)	(1.6)
7	1261	97	37	0	1
	(2.1)	(76.9)	(29.3)	(#)	(0.8)
8	3555	163	23	1	3
	(5.8)	(45.9)	(6.5)	(0.3)	(0.8)
9	16562	2061	518	7	27
	(27.0)	(124)	(31.3)	(0.4)	(1.6)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

20 TYPE OF MATERIAL IGNITED

The general classification of type of material ignited is as follows:

TMI 1	Gas
TMI 2	Flammable, combustible liquid
TMI 3	Volatile solid, chemical
TMI 4	Plastic
TMI 5	Natural product (rubber, cork, leather, etc)
TMI 6	Wood, paper
TMI 7	Fabric, textile, fur
TMI 8	Material compounded with oil
TMI 9	Other, unknown, etc

(Note that *TMI* 9 contains the fire with 119 *civilian injuries* and four *civilian fatalities* and *TMI 2* contains the fires with *three and five civilian fatalities.)*

By far the most commonly recorded *type of material ignited* is *wood, paper (40%* of known), but unfortunately *other, unknown, etc* make up the next largest category (Figure 34 and Table 29).

However, the most notable characteristic associated with *type of material ignited* are the extremely high values compared with the overall average of *the civilian injury and fatality rates* associated with *gas; and flammable, combustible liquid.* This association has already been noted for civilian fatalities in another report'.

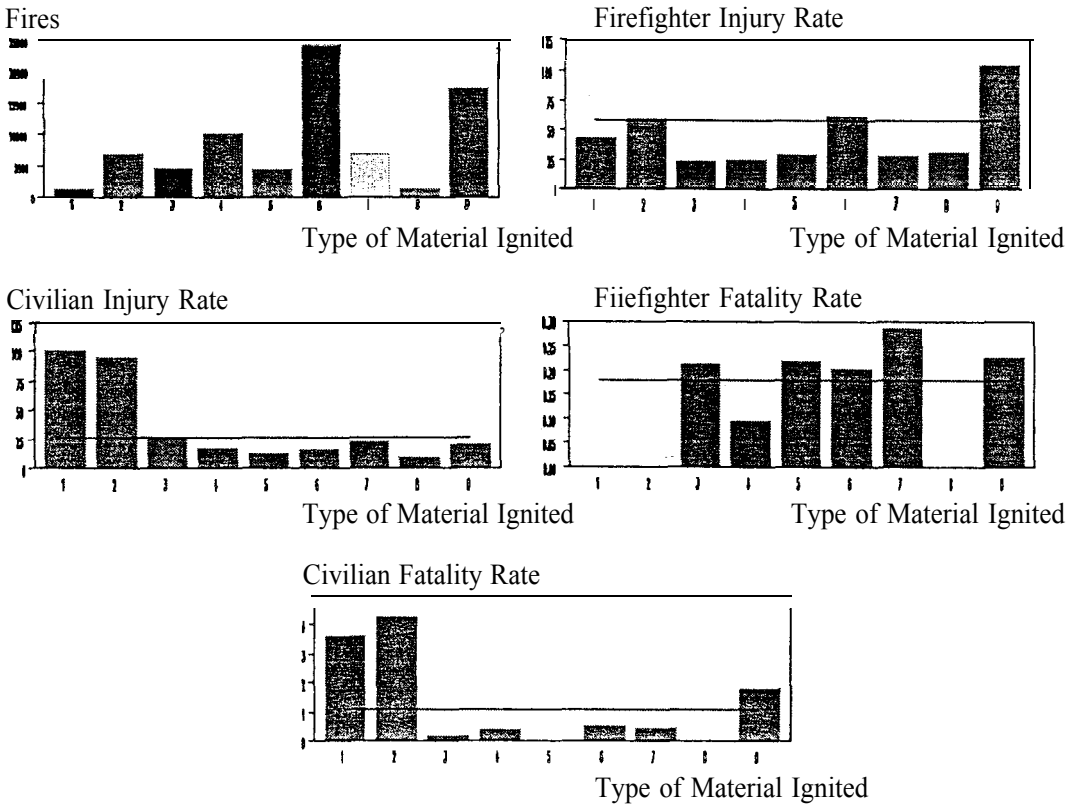


FIGURE 34 TYPE OF

TABLE 29 TYPE OF MATERIAL IGNITED

Type of Material Ignited	*Fires (% of known)*	*Fire-Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire-Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
1	1382	60	140	0	5
	(2.3)	(43.4)	(101)	(#)	(3.6)
2	6806	41%	659	0	29
	(11.2)	(60.4)	(96.8)	(#)	(4.3)
3	4642	110	118	1	1
	(7.7)	(23.7)	(25.4)	(0.2)	(0.2)
4	10341	257	191	1	4
	(17.1)	(24.9)	(18.5)	(0.1)	(0.4)
5	4554	136	59	1	0
	(7.5)	(30.0)	(13.0)	(0.2)	(#)
6	24439	1517	410	5	13
	(40.3)	(62.1)	(16.8)	(0.2)	(0.5)
7	6926	196	161	2	3
	(11.4)	(28.3)	(23.3)	(0.3)	(0.4)
8	1492	48	14	0	0
	(2.5)	(32.2)	(9.4)	(#)	(#)
9	17414	1845	366	4	32
	(28.7)	(106)	(21.0)	(0.2)	(1.8)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

21 FORM OF MATERIAL IGNITED

The general classification of form of material ignited is as follows:

FMI 1	Structural component, finish
FMI 2	Furniture
FMI 3	Soft goods, wearing apparel
FMI 4	Adornment, recreational material
FMI 5	Supplies, stock
FMI 6	Power transfer equipment, fuel
FMI 7	General form
FMI 8	Special form
FMI 9	Other, unknown, etc

(Note that the FMI 9 contains the fire with 119 civilian injuries and four civilian fatalities and FMI 8 and FMI 6 contain the fires with three and five civilian fatalities respectively.)

The three categories with roughly equal numbers of fires are *power transfer equipment, fuel; other, unknown, etc; and structural component, finish* (Figure 35 and Table 30). Notably high *civilian fatality and injury rates are* recorded for *special form* of *material ignited,* again relating to *gas* and *flammable, combustible liquid.*

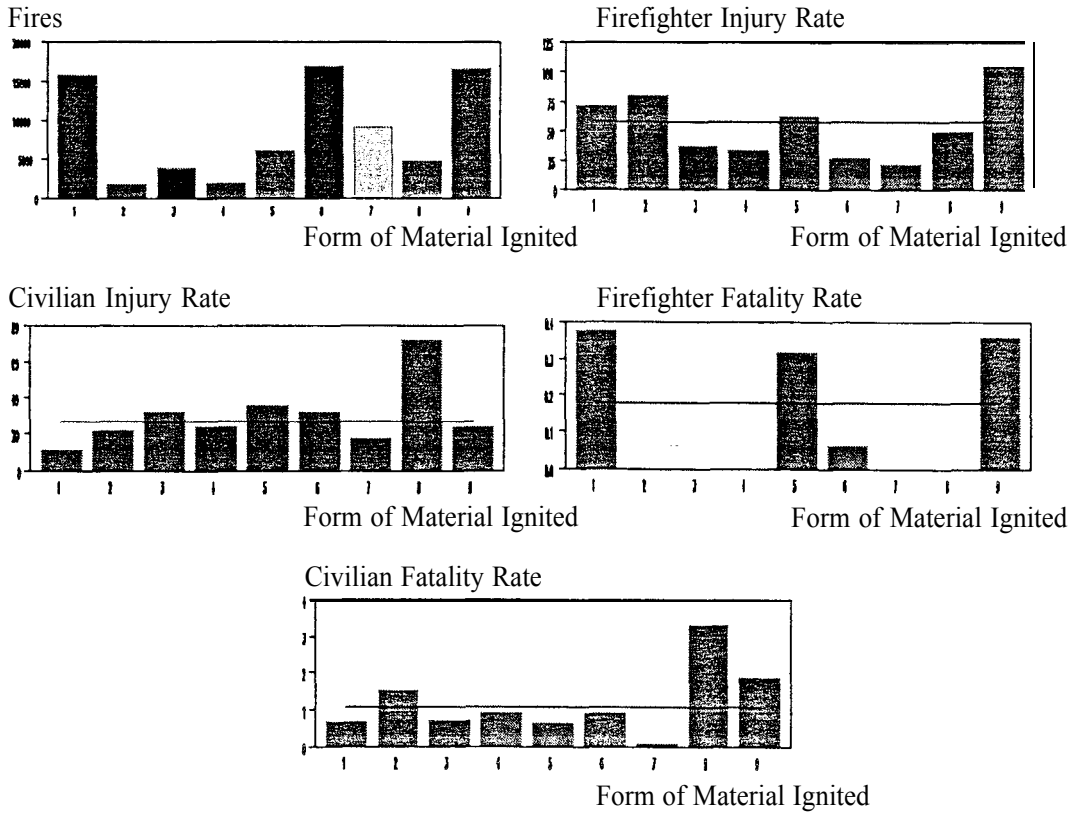


FIGURE 35 FORM OF MATERIAL IGNITED

TABLE 30 FORM OF MATERIAL IGNITED

Form of Material Ignited	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate*)*	*Civilian Fatalities (rate *)*
1	15875	1135	179	6	11
	(25.9)	0	(11.3)	(0.4)	(0.7)
2	1929	156	43	0	3
	(3.1)	0	(22.3)	(#)	(1.6)
3	4056	150	131	0	3
	(6.6)	(37.0)	(32.3)	(#)	(0.7)
4	2092	72	51	0	2
	(3.4)	(34.4)	(24.4)	(#)	(1.0)
5	6193	397	226	2	4
	(10.1)	(64.1)	(36.5)	(0.3)	(0.7)
6	17094	466	562	1	16
	(27.9)	(27.3)	(32.9)	(0.1)	(0.9)
7	9282	198	169	0	1
	(15.1)	(21.3)	(18.2)	(#)	(0.1)
8	4854	248	351	0	16
	(7.9)	(51.1)	(72.3)	(#)	(3.3)
9	16621	1758	406	6	31
	(27.1)	(106)	(24.4)	(0-4)	(1.9)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1 ,000 fires
- Rate per 1000 fires unless noted otherwise

22 IGNITION FACTOR

The general classification of ignition factor is as follows:

IF 1	Incendiary
IF 2	Suspicious
IF 3	Misuse of heat of ignition
IF 4	Misuse of material ignited
IF 5	Mechanical failure, malfunction
IF 6	Design, construction, installation deficiency
IF 7	Operational deficiency
IF 8	Natural condition
IF 9	Other, unknown, etc

(Note that *IF* 9 contains the fire with 119 civilian injuries and three civilian fatalities and *IF* 3 *and IF 1* contain the fires with four and five civilian fatalities respectively.)

The *mechanical failure, malfunction* (with 39% of known) dominates the *ignition factor* breakdown of the number of fires (Figure 36 and Table 31). However, the *casualty rates* for this category are all below the overall averages, particularly the *civilian fatality rate.*

However, several other categories have significant numbers of *fire fighter injuries* and *civilian fatalities and injuries,* and consequently have notably higher than overall average *rates. The civilian fatality rates* for *incendiary; misuse of heat of ignition; misuse of material ignited; and other, unknown, etc* are all substantially above average, *as* is *tie civilian injury rate* for *misuse of material ignited.* The *fire fighter injury rate* is substantially above the overall average for *natural condition; suspicious;* and *other, unknown,etc.*

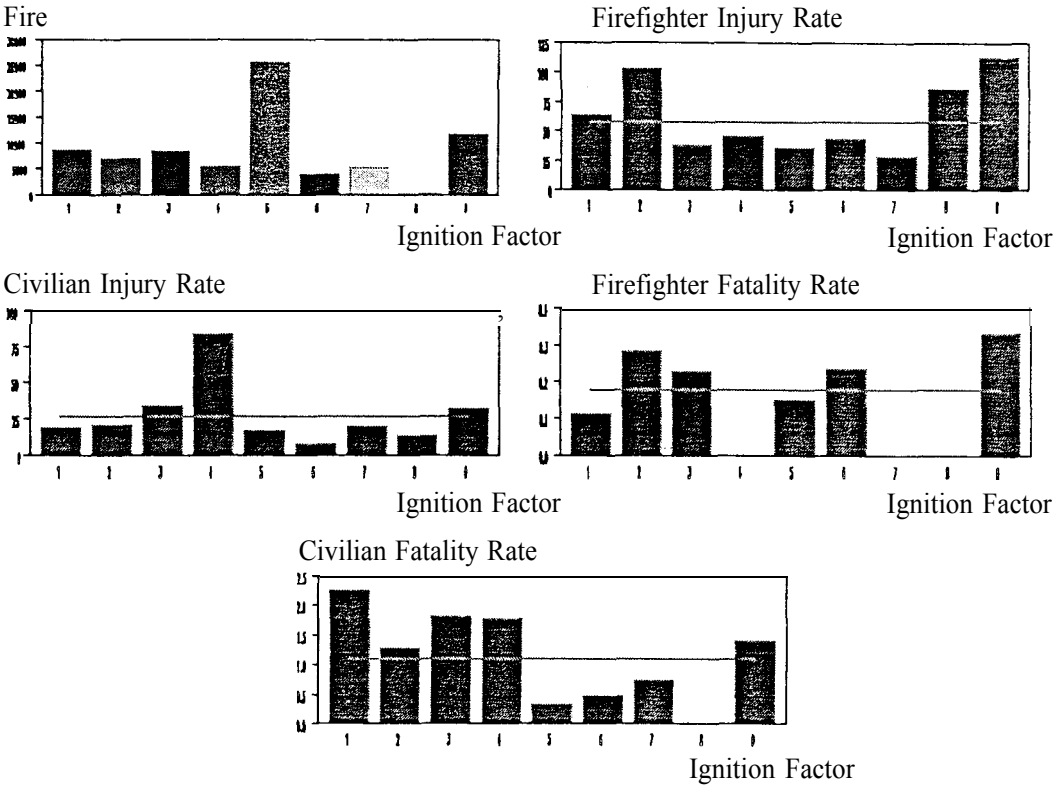


FIGURE 36 IGNITION FACTOR

TABLE 3 **1** IGNITION FACTOR

Ignition Factor	*Fires (% of known)*	*Fire Fighter injuries (rate *)*	*Civilian injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
1	8805	570	179	1	20
	(13.3)	(64.7)	(20.3)	(0.1)	(2.3)
2	6978	730	153	2	9
	(10.6)	(105)	(21.9)	(0.3)	(1.3)
3	8669	33%	305	2	16
	(13.1)	(38.2)	(35.2)	(0.2)	(1.9)
4	5616	259	477	0	10
	(8.5)	(46.1)	(84.9)	(#)	(1.8)
5	25796	945	449	4	9
	(39.1)	(36.6)	(17.4)	(0.2)	(0.4)
6	4242	185	35	1	2
	(6.4)	(43.6)	(8.3)	(0.2)	(0.5)
7	5375	151	112	0	4
	(8.1)	(28.1)	(20.8)	(#)	(0.7)
8	575	50	8	0	0
	(0.9)	(90.0)	(13.9)	(#)	(#)
9	11940	135	400	4	17
	(18.1)	(114)9	(33.5)	(0.3)	(1.4)

Notes: • The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
∘ Rate per 1000 fires unless noted otherwise

23 CONSTRUCTION TYPE

The general classification of construction type is as follows:

CT 1	Fire resistive (BBC Types 1A, 1B; SBC Type I; UBC Type I)
CT 2	Heavy timber (BBC Type 3A; SBC Type III; UBC Type III (HT))
CT 3	Protected non-combustible or limited combustible (BBC Types 2A, 2B; SBC Type II,IV (1 hr); UBC Type II,IV (1 hr))
CT 4	Unprotected non-combustible or limited combustible not qualifying for 3 (BBC Type 2C; SBC Type IV; UBC Type IV (N))
CT 5	Protected ordinary (BBC Type 3B; SBC Type V (1 hr); UBC Type III (1 hr))
CT 6	Unprotected ordinary not qualifying for 5 (BBC Type 3C; SBC Type V; UBC Type III (N))
CT 7	Protected wood frame (BBC Type 4A; SBC Type VI (1 hr); UBC Type V (1 hr))
CT 8	Unprotected wood frame not qualifying for 7 (BBC Types 4B; SBC Type VI; UBC Type V (N))
CT 9	Not classified above, unknown, etc

In the above the classifications in the brackets are USA model building code classifications included in each category. BBC, SBC and UBC designate the Basic Building Code, Standard Building Code and Uniform Building Code respectively. It is understood that in general the categories grade from most fire resistive (CT 1) to least resistive (CT 8).

(Note that CT 6 contains *the* fire with 119 *civilian injuries* and four *civilian fatalities* and CT 9 and CT 5 contain the fires with three and *five civilian fatalities* respectively.)

Unfortunately, the construction type is not recorded for a large proportion of the fires (Figure 37 and Table 32).

The largest numbers of fires by construction type are in *CT 5 (protected ordinary)* and *CT 6 (unprotected ordinary)* with 19% and 24% of known fires respectively.

The largest numbers of *fire fighter injuries* occur in *CT 6 and CT 9 (not classified above, unknown, etc)* but the *fire fighter injury rate* (at nearly 88 injuries per 1000 fires) for *CT* 6 is the highest rate and is well above the overall average. The rate for *CT* 2 *(heavy timber)* is nearly as high but this is based on a much lower number of fires and injuries.

The largest number of *civilian injuries* is for *CT 6* and the *injury rate* for this type (40 injuries per 1000 fires) is also well above the overall average, however the highest rate (52 injuries per 1000 fires) for *CT 4 (unprotected non-combustible or limited combustible not qualifying for CT* 3) is the highest of any *construction type* and is based on a large number of fires.

Caution is required in assessing the *fire fighter fatalities* because there are few of them, but *the fire fighter fatality rate* for *CT 7 (protected wood frame)* is well

above average (0.77 fatalities per 1000 fires) and is based on a reasonably large number of fires.

The largest number of *civilian fatalities (22)* is for *CT 6* and this is nearly the highest rate (1.7 fatalities per 1000 fires), but this is surpassed by the rate for *CT 7* (1.8 fatalities per 1000 fires) but this results from a smaller number of fires and fatalities.

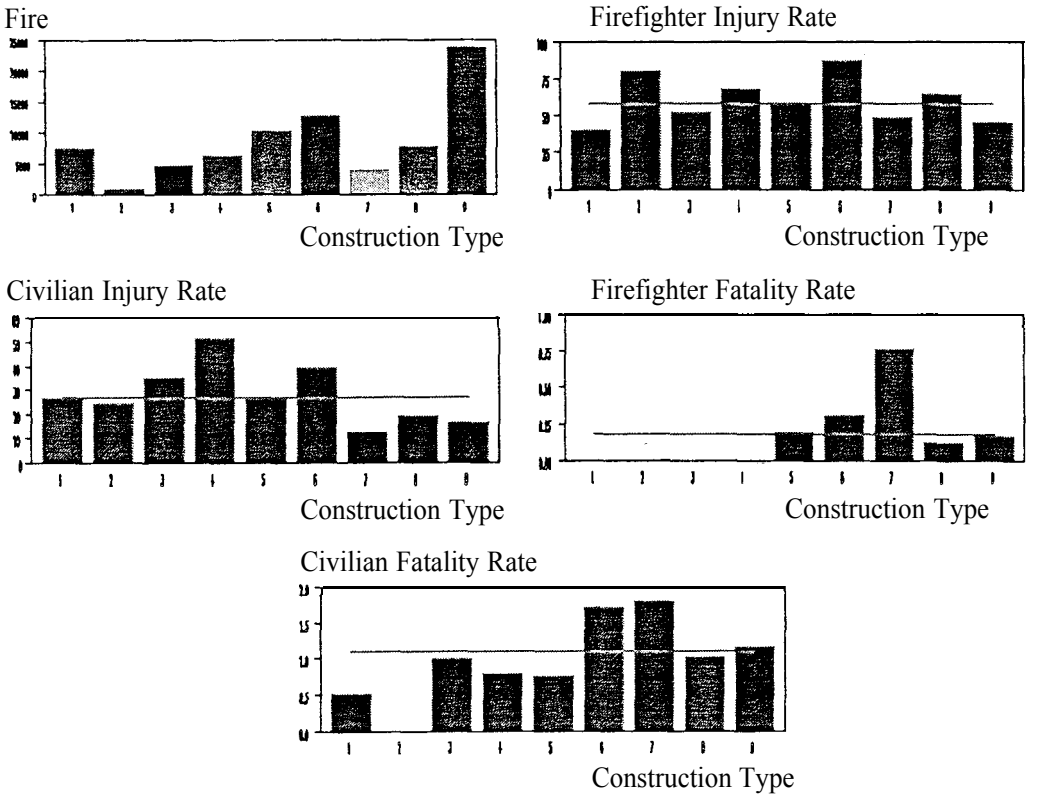


FIGURE 37 CONSTRUCTION TYPE

TABLE 32 CONSTRUCTION TYPE

Construction Type	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
1	7407	303	202	0	4
	(13.7)	(40.9)	(27.3)	(#)	(0.5)
2	965	78	24	0	0
	(1.8)	(80.8)	(24.9)	(#)	(#)
3	4885	259	174	0	5
	(9.0)	(53.0)	(35.6)	(#)	(1.0)
4	6176	422	320	0	5
	(11.4)	(66.3)	(51.8)	(#)	(0.8)
5	10329	606	278	2	8
	(19.1)	(58.7)	(26.9)	(0.2)	(0.8)
6	12813	1123	507	4	22
	(23.7)	(87.7)	(39.6)	(0.3)	(1.7)
7	3885	191	50	3	7
	(7.2)	(49.2)	(12.9)	(0.8)	(1.8)
8	7657	500	152	1	8
	(14.1)	(65 .O)	(19.9)	(0.1)	(1.0)
9	23879	1098	411	4	28
	(44.1)	(46.0)	(17.2)	(0.2)	(1.2)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

In summary:

- construction type is not recorded for a large proportion of the fires
- *24%* of known fires *are* in *unprotected ordinary* and 19% in *protected ordinary*
- *fire fighter injury rate* for *unprotected ordinary* is the highest rate and is well above average
- *the civilian injury rates* for *unprotected non-combustible or limited combustible not qualifying for CT 3* and *unprotected ordinary are* well above average
- the *fire fighter fatality rate* for *protected wood frame* is well above average
- the highest *civilian fatality rates are* for *protected wood frame* and *unprotected ordinary*

24 FORM OF MATERIAL GENERATING MOST SMOKE

The general classification of form of material generating most smoke is as follows:

FMGMS 1	Structural component, finish
FMGMS 2	Furniture
FMGMS 3	Soft goods, wearing apparel
FMGMS 4	Adornment, recreational material
FMGMS 5	Supplies, stock
FMGMS 6	Power transfer equipment, fuel
FMGMS 7	General form
FMGMS 8	Special form
FMGMS 9	Other, unknown, etc

(Note that FMGMS 9 contains the fire with 119 civilian injuries and the fires with three, four and five civilian fatalities respectively.)

As over 80% of fires are recorded as *FMGMS* 9 (Figure 38 and Table 33) the rates for the other categories must be treated with extreme caution. Nevertheless, the *fire fighter fatality rate* for *structural component, finish* (FMGMS 1) is notably higher than the overall average rate.

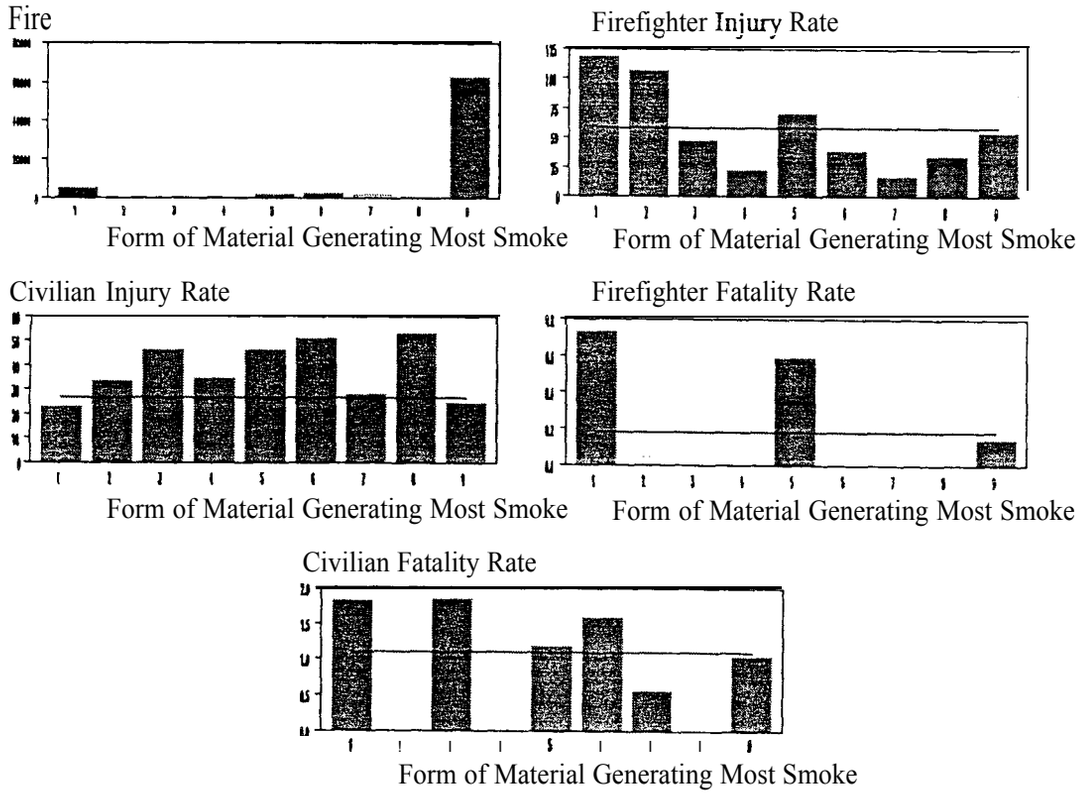


FIGURE *38* FORM OF MATERIAL GENERATING MOST SMOKE

TABLE *33* **FORM** OF MATERIAL GENERATING MOST SMOKE

Form of Material Generating Most Smoke	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter* Fatalities (rate *)	*Civilian* Fatalities (rate *)
1	5495	657	128	4	10
	(36.7)	(120)	(23.3)	(0.7)	(1.8)
2	616	66	21	0	0
	(4.1)	(107)	(34.1)	(#)	(#)
3	1085	51	50	0	2
	(7.3)	(47.0)	(46.1)	(#)	(1.8)
4	572	13	20	0	0
	(3.8)	(22.7)	(35.0)	(#)	(#)
5	1676	120	78	1	2
	(11.2)	(71.6)	(46.5)	(0.6)	(1.2)
6	3135	122	161	0	5
	(20.9)	(38.9)	(5 1.4)	(#)	(1.6)
7	1767	30	51	0	1
	(11.8)	(17.0)	(28.9)	(#)	(0.6)
8	619	21	33	0	0
	(4.1)	(33.9)	(53.3)	(#)	(#)
9	6303 1	3500	1576	9	67
	(421)	(55.5)	(25 .0)	(0.1)	(1.1)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire tighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1 ,000 fires
- Rate per 1000 fires unless noted otherwise

25 TYPE OF MATERIAL GENERATING MOST SMOKE

The general classification of type of material generating most smoke is as follows:

TMGMS 1 Gas
TMGMS 2 Flammable, combustible liquid
TMGMS 3 Volatile solid, chemical
TMGMS 4 Plastic
TMGMS 5 Natural product (rubber, cork, leather, etc)
TMGMS 6 Wood, paper
TMGMS 7 Fabric, textile, fur
TMGMS 8 Material compounded with oil
TMGMS 9 Other, unknown, etc

(Note that TMGMS 9 contains the fires with 119 civilian injuries and three and four civilian fatalities and TMGMS 2 contains the fire with five civilian fatalities.)

As with *form of material generating most* smoke the vast majority (over 70%) of fires are recorded as *TMGMS* 9 (Figure 39 and Table 34) and again, the rates for the other categories must be treated with extreme caution. However, the *fire fighter fatality rate* for *wood, paper* (FMGMS 6) and the *civilian fatality rate* for *flamable, combustible liquid* (FMGMS 1) are both significantly higher than the respective overall average rates and both represent sgnificant numbers of fatalities.

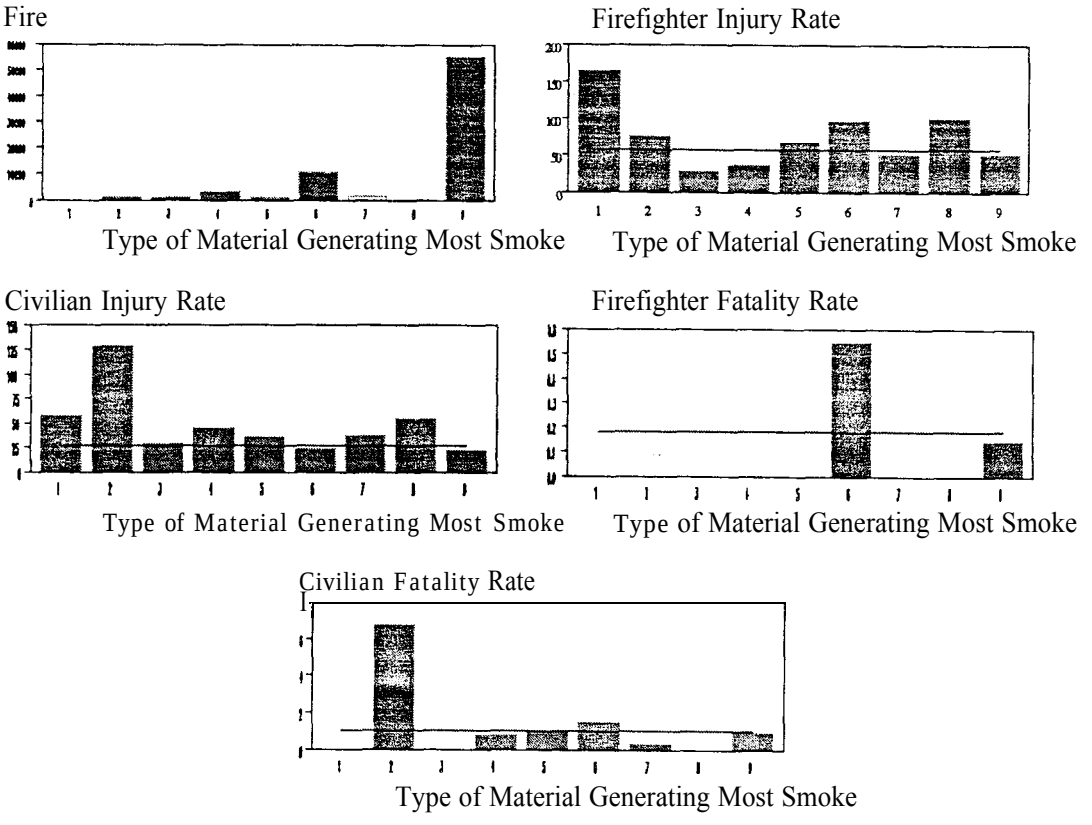


FIGURE 39 TYPE OF MATERIAL GENERATING MOST SMOKE

TABLE 34 TYPE OF MATERIAL GENERATING MOST SMOKE

Type of Material Generating Most Smoke	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities* (rate *)
1	346	58	20	0	0
	(1.6)	(168)	(57.8)	(#)	(#)
2	1329	102	173	0	9
	(6.0)	(76.8)	(130)	(#)	(6.8)
3	1336	38	41	0	0
	(6.0)	(28.4)	(30.7)	(#)	(#)
4	3570	138	165	0	3
	(16.1)	(38.7)	(46.2)	(#)	(0.8)
5	1712	117	62	0	2
	(7.7)	(68.3)	(36.2)	(#)	(1.2)
6	10935	1079	261	6	17
	(49.3)	(98.7)	(23.9)	(0.6)	(1.6)
7	2353	121	87	0	1
	(10.6)	(51.4)	(37.0)	(#)	(0.4)
8	590	60	33	0	0
	(2.7)	(102)	(55.9)	(#)	(#)
9	55825	2867	1276	8	55
	(252)	(51.4)	(22.9)	(0.1)	(1.0)

Notes:
- The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
- Rate per 1000 fires unless noted otherwise

26 AVENUE OF SMOKE TRAVEL

The categories for avenue of smoke travel are:

AST 1	Air handling duct
AST 2	Corridor
AST 3	Elevator shaft
AST 4	Stairwell
AST 5	Opening in construction (included are gaps between slabs and walls, over doors, and the like)
AST 6	Utility opening in wall
AST 7	Utility opening in floor
AST 8	No significant avenue of smoke travel
AST 9	Unknown, etc

(Note that *AST* 9 contains the fire with 119 civilian injuries and three civilian fatalities and *AST 2* and *AST* 8 contain the fires with four and five civilian fatalities respectively.)

The *avenue* of *smoke* travel is *unknown* for the majority of fires and there is no *significant avenue of smoke travel* for the majority of the remaining fires. The numbers of fires in most of the remaining categories are very low and great caution must be exercised in using the *casualty rates.* Nevertheless, the fire *fighter fatality rate* for AST 5 *(opening in construction)* and *civilian fatality rate* for AST 2 *(corridor)* are both notably higher than the respective overall averages and represent significant numbers of fatalities.

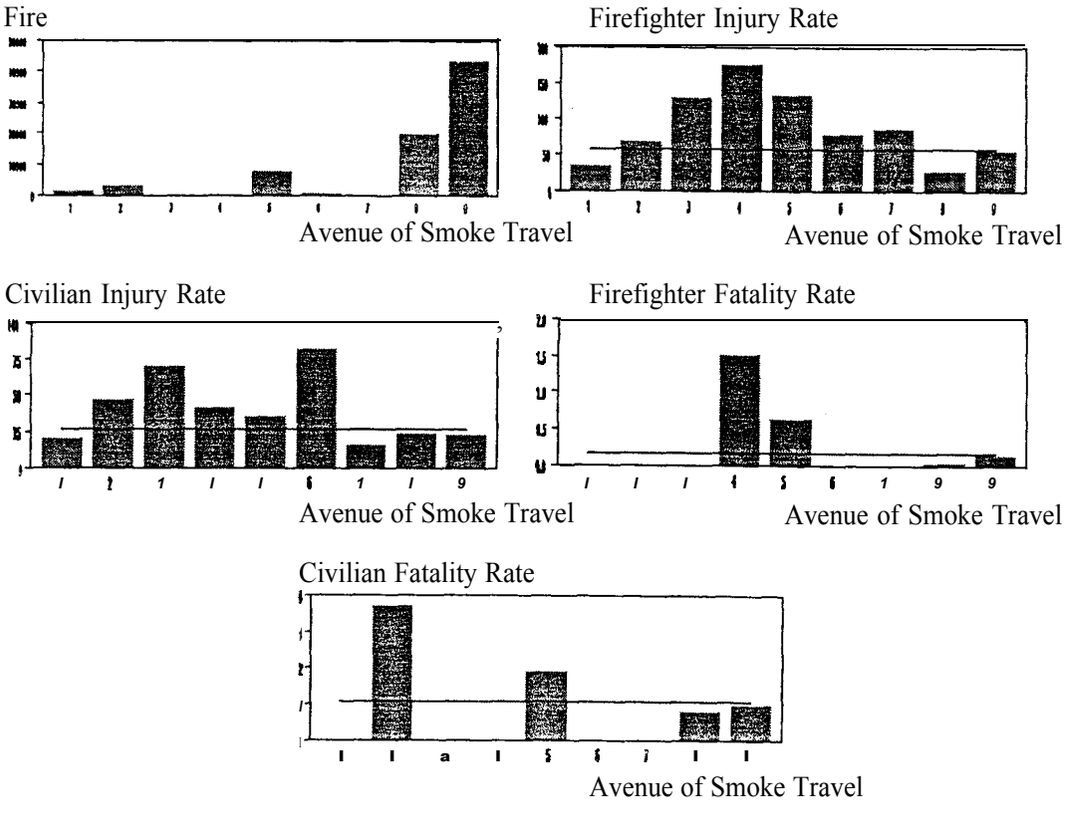


FIGURE *40* AVENUE OF SMOKE **TRAVEL**

TABLE 35 AVENUE OF SMOKE TRAVEL

Avenue of Smoke Travel	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
1	1552	54	32	*0*	*0*
	(4.5)	(34.8)	(20.6)	(#)	(#)
2	3224	222	152	*0*	12
	(9.4)	(68.9)	(47.2)	(#)	(3.7)
3	85	11	6	*0*	0
	(0.2	(129)	(70.6)	(#)	(#)
4	*660*	117	28	1	0
	(1.9)	(177)	(42.4)	(1.5)	(#)
5	7750	1042	278	5	15
	(22.5)	(134)	(35.9)	(0.7)	(1.9)
6	873	70	72	*0*	0
	(2.5)	(80.2)	(82.5)	(#)	(#)
7	298	26	5	*0*	0
	(0.9)	(87.3)	(16.8)	(#)	(#)
8	20006	590	504	1	17
	(58.1)	(29.5)	(25.2)	(0.1)	(0.9)
9	43548	2448	1041	7	43
	(126)	(56.2)	(23.9)	(0.2)	(1.0)

Notes: • The overall average rates are 1.12 civilian and 0.18 fire fighter fatalities and 27.2 civilian and 58.7 firefighter injuries per 1,000 fires
• Rate per 1000 fires unless noted otherwise

27 METHOD OF EXTINGUISHMENT

ME1	Self-extinguished
ME2	Make-shift aids (included are garden hoses, sand, rakes, shovels, baking soda, and the like)
ME3	Portable extinguisher
ME4	Automatic extinguishing system
ME5	Preconnected hose line(s) with water carried in apparatus tanks
ME6	Preconnected hose line(s) with water from hydrant, draft, standpipe (included are preconnected hose lines on standpipe systems)
ME7	Hand-laid hose line(s) with water from standpipe, hydrant, draft
ME8	Master stream device(s) with or without hand line(s)
ME9	Unknown, etc

(Note that ME 7 contains the fire with 119 civilian injuries and types *ME 9, ME 6 and ME* 5 contain the fires with three, four and five civilian fatalities respectively.)

There is some gradation of the method of extinguishment from least to most effective as the category numbers rise (except of course for *ME1* and *ME9).*

A total of 38% of fires are classified as having been extinguished by *unknown* means or means not classified by the other categories (Figure 41 and Table 36). Possibly many of these fires are confined *to the object or area of origin* and are extinguished by the time the fire fighters arrived, otherwise it is difficult to understand why it is difficult to classify the means *of* extinguishment under the categories above.

The *means of extinguishment* of the greatest number of the remaining fires is *preconnected hose line(s) with water carried in apparatus tanks (30%* of known) followed by *portable extinguisher* (21% of known).

It is notable that the *jire fighter injury rate rises* sharply for *MOE 6, MOE 7 and MOE 8 as* does *the civilian fatality rate. The fire fighter fatality rate* is high for *MOE 6 and MOE* 8. The higher *civilian injury rates* are more uniformly spread through the categories.

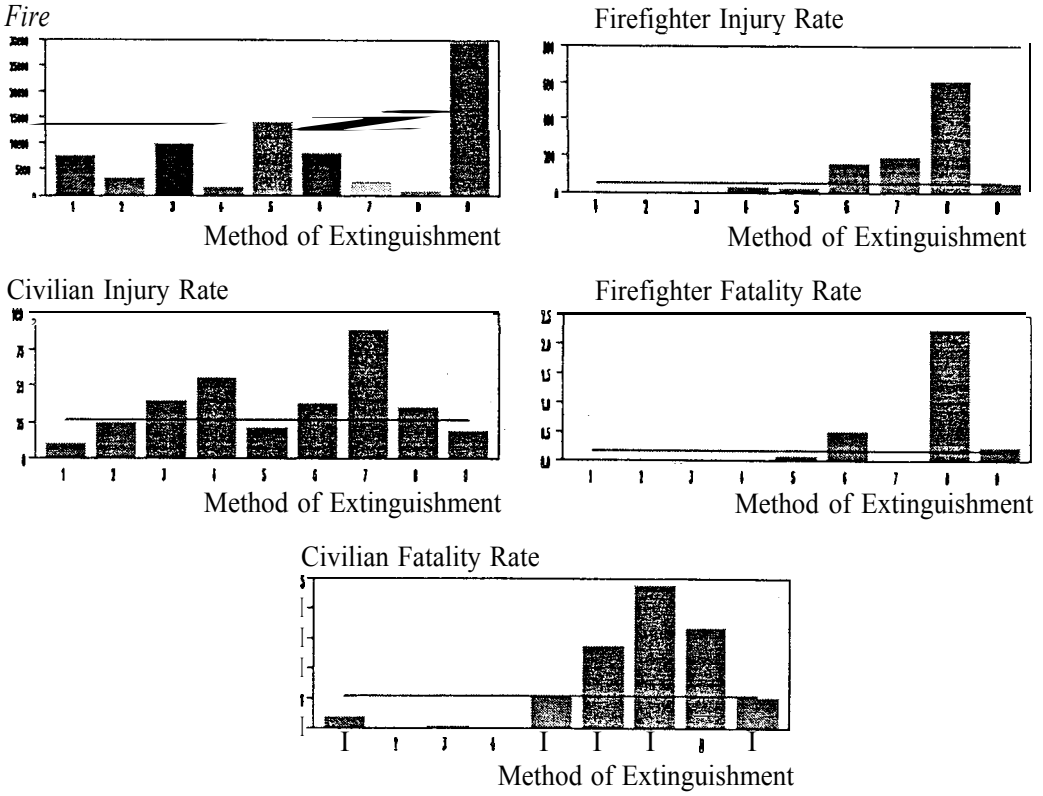


FIGURE 41 METHOD OF EXTINGUISHMENT

TABLE 36 METHOD OF EXTINGUISHMENT

Method of Extinguishment	*Fires (% of known)*	*Fire Fighter Injuries (rate *)*	*Civilian Injuries (rate *)*	*Fire Fighter Fatalities (rate *)*	*Civilian Fatalities (rate *)*
1	7636	37	81	0	3
	(15.8)	(4.9)	(10.6)	(#)	(0.4)
2	3388	15	88	0	0
	(7.0)	(4.4)	(26.0)	(#)	(#)
3	9876	46	403	0	1
	(20.5)	(4.7)	(40.8)	(#)	(0.1)
4	1747	62	98	0	0
	(3.6)	(35.5)	(56.1)	(#)	(#)
5	14233	348	312	1	15
	(29.5)	(24.5)	(21.9)	(0.1)	(1.1)
6	7967	1257	311	4	22
	(16.5)	(158)	(39.0)	(0.5)	(2.8)
7	2506	498	222	0	12
	(5.2)	(199)	(88.6)	(#)	(4.8)
8	891	540	32	2	3
	(1.8)	(606)	(35.9)	(2.2)	(3.4)
9	29752	1777	571	7	31
	(61.7)	(59.7)	(19.2)	(0.2)	(1.0)

Notes: • rates are 1.12 civilian fire 27.2 58.7 firefighter
1,000 fires
• 1000

28 OTHER VARIABLES

In Appendix A there *are* figures, tables and brief analyses for *exposure number, month of incident, day of week, mobile property type, method of alarm and type of action taken.* The following points are noted from these analyses:

- 4.9% of fires are recorded as being ***exposure fires***
- December and January have above average, and September has below average numbers of fires there are also some variations in the *casualty rates* for some months
- there are, on average, fewer fires on Sundays but the *civilian fatality* ***rate*** is highest for Sunday and significantly below the overall average for Tuesday, less so for Wednesday
- there is less variation in the *injury rates* by ***day*** *of the week*
- the overwhelming majority of fires have *unknown, etc mobile property type*
- the majority ***major method*** *of* ***alarm*** is *telephone direct to fire department*
- the majority of ***type*** *of* ***action taken*** is *extinguishment*

29 EFFECT OF TIME OF ALARM AND CONSEQUENTIAL CONSIDERATIONS

In Appendix B there is a more extensive investigation of the effect of the *time of alarm* on *extent of flame damage* (with and without sprinklers present). Several related fields are also examined. The outcomes of this examination are covered briefly in this section.

EXTENT OF FLAME DAMAGE WITH SPRINKLER OPERATION

The number of fires with *extent of flame damage confined to the object of origin* (EFD 1) is much higher during the day and evening than at night for the *sprinklers not present* and *sprinklers present but they did not operate* cases but not for the *sprinklers present and operated* case. The number of fires with *flame damage confined to the object of origin* predominates during the day and evening whether sprinklers are present or not. In the *sprinklers present case* it is clear that this is not significantly due to the operation of the sprinklers.

Sprinklers *operate* at a smaller proportion of the fires at which they are *present* during the hours from about 7 am to about 9 pm:

- from 7 am to 6 pm sprinklers operate in 26.5% of fires where they are present
- from midnight to 4 am sprinklers operate at 48.8% of fires where they are present

It is hypothesised that this difference is largely due to the presence of alert and responsive people in most areas of the building during the day.

METHOD OF EXTINGUISHMENT

Portable extinguishers and *self extinguished* are predominant and represent by far the major variation in the *method of extinguishment* that occurs during the 24 hour period when there are *sprinklers present* whether *they operate* or not. They vary similarly but are not predominant in *the sprinklers not present case. In* this *casepreconnected hose line(s) with water carried in apparatus tanks* is the predominant *method of extinguishment.*

VARIATION OF METHOD OF EXTINGUISHMENT WITH SPRINKLER PERFORMANCE

When *sprinklers are not present the methods of extinguishment* most likely to involve the occupants of the building (self *extinguished, make shift aids* and *portable extinguisher)* represent about 39% of fires and the methods of *extinguishment* expected to involve the fire fighters make up about 60% of fires.

In the *sprinklers present* case (whether they operate or not) the *methods of extinguishment* most likely to involve the occupants of the building *(self extinguished, make shift aids* and *portable extinguisher* represent about 58% of fires, *sprinklers* make up about 18% of fires and the methods of *extinguishment* expected to involve the fire fighters make up about 24% of fires.

The difference between the proportions of fires extinguished using the methods of *extinguishment* most likely to involve the occupants of the building *(self*

extinguished, make shift aids and *portable extinguisher)* is largely due to the different proportions of fires in which *portable extinguishers are* used (17% in the *sprinklers not present* case and 32% in the *sprinklers present case).*

METHOD OF EXTINGUISHMENT OF FLAME DAMAGE

In the ***sprinklers present and operated*** case only 5% of fires have *extent of flame damage confined within the room of origin* (EFD 1, EFD 2 and EFD 3) with *self extinguished, make shift aids* or *portable extinguisher* recorded as the *method of extinguishment.* In this case 54% of fires have *extent of flame damage confined within the room of origin* (EFD 1, EFD 2 and EFD 3) and the *sprinklers* are recorded as *the method of extinguishment.* A further 26% of fires are *confined within the room of origin* (EFD 1, EFD 2 and EFD 3) and *preconnected hose lines with water carried in apparatus tanks* and *preconnected hose lines with water from hydrant, draft, standpipe* recorded *as* the *method of extinguishment.* A total of about 90% of fires are recorded as *confined within the room of origin* (EFD 1, EFD 2 and EFD 3) in this case.

In ***the sprinklers present but did not operate*** case about 96% of fires are recorded as *confined within the room of origin* (EFD 1, EFD 2 and EFD 3). In this case nearly 79% of fires have *extent of flame damage confined within the room of origin* (EFD 1, EFD 2 and EFD 3) with *self extinguished, make shift aids* or *portable extinguisher* recorded *as the method of extinguishment.* A further 16% *of* fires are *confined within the room of origin* (EFD 1, EFD 2 and EFD 3) and *preconnected hose lines with water carried in apparatus tanks* and *preconnected hose lines with water from hydrant, draft, standpipe* recorded *as* the *method of extinguishment.*

In ***the sprinklers not present*** case about 74% of fires are recorded *as confined within the room of origin* (EFD 1, EFD 2 and EFD 3). In this case 37% of fires have *extent of flame damage confined within the room of origin* (EFD 1, EFD 2 and EFD 3) and the *method of extinguishment* is recorded as *self extinguished, make shift aids* or *portable extinguisher.* A further 34% of fires have *extent of flame damage confined within the room of origin* (EFD 1, EFD 2 and EFD 3) and the *method of extinguishment* is recorded *as preconnected hose lines with water carried in apparatus tanks* and *preconnected hose lines with water from hydrant, draft, standpipe* recorded *as the method of extinguishment.* In this case a total of 21% have *extent of flame damage confined to the fire-rated compartment, storey or structure of origin* (EFD 4, EFD 5 or EFD 6) with the *method of extinguishment* recorded *as preconnected hose lines with water carried in apparatus tanks; preconnected hose lines with water from hydrant, draft, standpipe; hand-laid hose line(s) with water from hydrant, draft, standpipe or master stream device(s) with or without hand line(s).*

EFFECT OF SPRINKLERS AND DETECTORS ON EXTENT OF FLAME DAMAGE

Comparing the cases of detectors and/ or sprinklers with no sprinklers:

- *detectors* provide some improvement from 26% of fires with flame *damage* ***not*** *confined to the room of origin* without *detectors* or

sprinklers to 16% of fires with *flame damage not confined to the room of origin* with *detectors*

- *sprinklers* provide greater improvement from 26% of fires with *flame damage* **not** *confined to the room of origin* without *detectors* or *sprinklers* to 6% of fires **not** *confined to the room of origin* with *sprinklers*
- there is little improvement associated with having both *sprinklers* and *detectors*

VARIATION OF VARIOUS FIELDS WITH TIME OF ALARM

In many cases one or more of the categories of the fields in the database stands out from most or all of the other categories for the field. For example, in *the case* of *fixed property use the* category *food, beverage sales* stands out as it correlates least well with the variation in the number of fires with *extent of flame damage confined to the object of origin* with *time of alarm:* it predominates over the other categories throughout the 24 hour period and varies less between day and night than many of the other categories.

The variation of the number of fires for:

- *type of material ignited* category *wood, paper*
- *form of material ignited* category *structural component, finish* (predominates only at night)
- *method of extinguishment* category *preconnected hose line(s) with water carried in apparatus* tanks (predominates only at night)
- *type of action taken* category *extinguishment*

does not correlate well with the number of fires for *extent of flame damage confined to the object of origin* for each *alarm hour* but each predominates over the other categories in their field.

In contrast, the variation of the number of fires for:

- *complex* category *shopping complex*
- *fixed property use* categories *textile, wearing apparel, sales; professional supplies, services; general item stores*
- *form of heat of ignition* categories *heat from electrical equipment arcing, overload; heat from hot object*
- *type of material ignited* categories *volatile solid, chemical; plastic; natural product (rubber, cork, leather, etc); fabric, textile, fur*
- *form of material ignited* categories *soft goods, wearing apparel; power transfer equipment, fuel*
- *ignition factor* categories *misuse of heat of ignition; misuse of material ignited; mechanical failure, malfunction; operational deficiency*
- *construction type* categories *fire resistive; unprotected non-combustible or limited combustible*
- *method of alarm* category *telephone direct to fire department*

- *method of extinguishment* categories *self extinguished; make-shift aids; portable extinguisher*
- *equipment involved in ignition* categories *air conditioning, refrigeration equipment; electrical distribution equipment; appliances, equipment*
- *type of action taken* categories *investigation only; remove hazard*

all correlate highly with the number of tires for *extent of flame damage confined to the object of origin* and consequently the number of fires in each of these categories varies greatly between night and day.

FIELDS WITH AND EXTENT OF FLAME DAMAGE

The variation of the number of fires for many of the fields covered in the previous section with five *extent of flame damage* categories:

- *confined to the object of origin*
- *confined to the area of origin*
- *confined to the room of origin*
- *confined to the fire-rated compartment, storey or structure of origin*
- *beyond the structure of origin*

varies greatly as shown in Figures B23 to B34. This information has been used to develop scenarios that enable comparison of important influences on the fires that occur at *various* times of the day and have *various extents of flame damage.* *See* pages B53 to B82.

30 CIVILIAN FATALITIES

The data for also been analysed specifically in reference to the 87 civilian fatalities.

The following points are noteworthy in this regard:

- there are a broad range of ***victim ages*** among the civilian fatalities but without population-age data little analysis is possible, however very young children seem over-represented
- *males* seem very over-represented in ***tie victim sex*** analysis (52 male out of 67 known; it is understood that in **Australian** shopping centres the overall population is over 60% female, presumable the ratio is similar in the USA)
- most fires involving civilian fatalities are not ***exposure fires***, but three fatalities are recorded in one *exposure fire* with single fatalities in two other *exposure fires*
- 63 of the 87 fatalities are recorded for ***alarm times*** between 7 pm and 7 am
- 40 of the civilian fatalities have known ***familiarity with the building,*** of these only three have *less than one day*, another two have less *than one week,* but 32 have *one year*
- ***59*** have known ***location at time of ignition,*** of these 21 are *intimately involved with ignition,* an additional 11 *in the enclosure of origin,* but two *are outside the building*
- ***49*** have known ***condition before fire,*** of these 31 *are awake, unimpaired,* 18 are *asleep, bedridden, impaired by drugs or alcohol,* or *too young* or *too old* to act
- ***57*** have known ***condition preventing escape,*** of these *25* ***no time to escape,*** 13 have *fire between casualty and exit, 4 locked door,* 10 *no conditions prevented escape or not a factor*
- only ***26*** have known ***activity at time of injury,*** of *these* 11 are *escaping,* seven *unable to act,* 4 noted as *sleeping*
- ***79*** have known ***affiliation,*** of these 78 are civilians, one other emergency personnel (that is, not fire fighter)
- 60 have known or applicable ***cause of injury***, of these *46 are exposed to fire products,* 10 *are caught in,* ***under, between or trapped by***

- 63 have known ***nature of injury,*** of these 33 have *bums and asphyxia/smoke,* 16 *bums only* and 12 *asphyxia/smoke only*
- ***65*** have known ***part of body injured,*** of these 41 have *multiple parts* and 22 *internal (which includes respiratory system and heart)*
- all have known ***fixed property use, 33 are*** in *motor vehicle or boat sales, services* (of these 18 are in *motor vehicle repair, paint shop* and 8 in *service station)* and 22 are in *food, beverage sales* (of these 9 are in *supermarket* and 8 in *market, grocery store)*
- 85 have known ***area of jire origin,*** of these 27 are in *function areas* (of these 16 in *sales, showroom area, 4* in *office*), 19 in *service, equipment areas* (of which 15 *are* in *maintenance shop, area),* 15 *in storage areas* and 13 in *means* ***of egress*** (of which *5* in *hallway, corridor, mall)*
- 63 have known ***form of heat of ignition,*** of these 26 are from *heat from open flame, spark* (of which 13 are from a *match)*
- ***65*** have known ***type of material ignited,*** of these 29 *are flammable, combustible liquid* (of which 19 are *gasoline)* and 13 *wood, paper*
- 69 have known ***form of material ignited,*** of these 16 *are power transfer equipment, fuel* (of which 11 are *fuel)* and 16 are *special form* (of which 13 are gas ***or*** *liquid in or from pipe* ***or*** *container)*
- 71 have known ***ignition factor,*** of these 20 are *incendiary* and 16 *misuse of heat of ignition*

30 CONCLUSION

A total of 87 civilians and 14 fire fighters died as a result of the nearly eighty-thousand fires covered by this analysis. In addition 2118 civilians and 4580 fire fighters are injured and property estimated at over US$ 2 billion is destroyed.

It seems appropriate that information be obtained from the records of the fires with the objective of reducing the number of fires and the scale of destruction in the future. That is the purpose of this report. It is believed this outcome is achieved by the use of the report in the Fire Code Reform Centre project (Project 6 - Investigation of the Fire Safety of Low-rise Sprinklered Shopping Centres) that spawned its production.

The average **rates** of casualties and losses are:

- 1.12 civilian and 0.18 fire fighter. fatalities per 1000 fires
- 27.2 civilian and 58.7 fire fighter injuries per 1000 fires
- US$28,100 average estimated loss per fire

Comparison of these rates with rates based on other *USA and Australian commercial, retail and office* data shows remarkable similarity in *the civilian fatality rates* (range *0.8* to 1.2) and *civilian injury rates* (range 19.5 to 30.4) for *the non-residential* categories. There is more variation *in the fire fighter rates* particularly between *the USA* and *Australian* figures for *the injury rate,* with the USA *injury rates* being substantially higher than the Australian rates.

The civilian casualty rates are substantially lower than for fires in residential buildings in Australia and the USA.

The following are brief summaries of the significant outcomes of analyses of the data. Refer to the body of the report for definitions of the fields and terms.

Complex

- the *fire fighter fatality and injury rates are* largely unaffected by *complex*
- *the civilian fatality rate* is significantly higher than average for *motor vehicle or boat sales, services* - occurring in the no *complex* situation
- *the civilian injury rate* is significantly higher than average for *motor vehicle or boat sales, services than* for all other *fixed property use cases* for all *complex* categories

Fixed Property Use

- *the fire fighter fatality rate* is higher than average for *specialty shops* and *motor vehicle or boat sales, services*
- *the fire fighter injury rate* is unusually high for *household goods sales, repairs*

- *the civilian fatality and injury rates are* both significantly higher than average for *motor vehicle or boat sales, services*

Extent of Flame Damage

- overall, only *22%* of *the* fires with known *extent of flame damage* have *flame damage* **not** *confined to the room of origin*
- of *the fires* that have *flame damage* **not** *confined to the room of origin* the great majority have *the extent of flame* damage classified *as confined to the structure of origin* **or** *extended beyond the structure of origin* (in total 19% of fires with known *extent of flame damage*)
- in general, casualty and property loss rates increase substantially with increasing *extent of flame damage*
- the overall *casualty rates* for the fires with *flame damage confined to the room of origin are* 0.1 and 18.1 for *fire fighter fatalities and injuries* respectively, 0.4 and 24.0 for *civilian fatalities and injuries* and US$8660 average estimated loss
- comparison of these figures with the overall *casualty rates* for fires with *flame damage not confined to the room of origin (0.5* and 224 for *fire fighter fatalities and injuries* respectively, *4.0* and 47 for *civilian fatalities and injuries* and US$107,600 average estimated loss) shows that there are factors of difference between these cases of 5.9 and 12 for *fire fighter fatalities and injuries,* 10 and 2.0 for *civilian fatalities and injuries* and 12 for property losses

Alarm Time

- the peak number of fires per hour (at 6.00 pm) is nearly three times the minimum (at 6.00 am)
- the *fire fighter injury* and *civilian fatality rates are* consistently higher during the night than during the day
- *the civilian injury rate* is consistently lower during the night than during the day
- there is great variation in many of the fields with *alarm time* (see Appendix B)

Variation in Extent of *Flame Damage* with *Alarm Time*

- *the extent of flame damage* .of fires varies substantially with *alarm time*
- the greatest variation takes place in fires with *flame spread confined to the object of origin* - the number of these increases greatly during the day

- the percentage of fires with *extent of flame damage not confined to the room of origin* increases greatly during the night and peaks at 43% at 4 am

Sprinkler Performance

- overall, sprinklers do *not operate* in 69% of fires where they are *present* however in 94% of these cases the fire is judged to be *too small to require operation*
- sprinklers do *not operate* in 73% of fires at which *they are present* from 7 am to 6 pm compared with 51% from 12 midnight to 4 am
- *the fire fighter fatality and injury rates, civilian fatality rate and estimated property loss per fire* is lower for fires with *sprinklers present* than for fires with *sprinklers notpresent*
- *tie civilian injury rate* is higher for fires with *sprinklers present* than for fires with *sprinklers not present*

Effect of *Sprinkler Performance* on *Extent of Flame Damage*

- with *sprinklers present* about 6% of fires have *flame damage not confined to the room of fire origin* compared with about 25% for fires with *sprinklers not present*
- the *civilian injury rate* is higher with *sprinklers present* but all other *casualty and loss rates are* lower with *sprinklers present*
- it is estimated that substantially lower *casualties* (except perhaps for *civilian injuries)* and *property losses* will occur if *sprinklers are present* at all of the fires covered by this data

Effect of *Sprinkler Performance* on *Extent of Smoke Damage*

- with *sprinklers present* about 34% of fires have *smoke damage not confined to the room of fire origin* compared with about 45% for fires with *sprinklers not present*
- *the civilian injury rate* is generally higher with *sprinklers present* but the other *casualty and loss rates* are generally lower with *sprinklers present*
- it is estimated that lower *casualties* (except perhaps for *civilian injuries)* and *property losses* will occur if *sprinklers are present* at all of the fires covered by this data

Area of fire Origin

- there is a wide variation in the proportions of fires from various *areas of fire origin*
- there is substantial variation in the *casualty rates* for fires from various *area-s of fire origin*

Fires by *Area of Fire Origin* by *Alarm Hour*

- there is considerable variation in the total number of fires for each *alarm hour* for many of the *areas of fire origin*
- further study is necessary to properly evaluate this aspect

Time from Alarm to Fire Brigade Arrival

- the *fire brigade arrival time* is between 0 and 9 minutes for 90% of fires
- between 21% and *22%* of fires have *extent of flame damage not confined to the room of origin* for *fire brigade arrival times* between 0 and 9 minutes
- between *35%* and *45%* of fires have *extent of flame damage not confined to the room of origin* for *fire brigade arrival times* between 10 and 19 minutes

Extent of Smoke Damage

- overall, 42% of fires with known *ESD* cause *smoke damage not confined within the room of origin*
- there are factors of difference of 7.5 and 14 for *fire fighter fatalities and injuries* respectively and 11 and *2.7* for *civilian fatalities and injuries* respectively between the overall *casualty rates* for the fires with *smoke damage* **not** *confined* and fires with *smoke damage confined to the room of origin*

Detector Performance

- *detectors* do not operate in more than 50% of fires where they are known to be *present* (in many cases because the fires are too small)
- with *detectors present* about 16% of fires have *flame damage not confined to the room of fire origin* compared with about *25%* for fires with *detectors not present*
- there is a little improvement over *sprinklers alone* with both *sprinklers* and *detectors*
- *the presence of detectors* does not seem to substantially improve the *civilian and fire fighter injury rates* but may improve the *civilian and fire fighter fatality rates*

Number of Storeys

- 77% of buildings with reported storeys are single s torey
- nearly 95% are in one or two storey buildings
- nearly 99% are in one to four storey buildings

Equipment Involved in Ignition

- there is no *equipment involved in ignition* or it is *unknown* in the majority of fires
- *the equipment involved in ignition* in 39% (of known) fires is *electrical distribution equipment* and in 17% (of known) *appliances, equipment*
- the *civilian fatality rate* is particularly high for *service, maintenance equipment*
- *the civilian injury rate* is well above average for *special equipment; processing equipment; and service, maintenance equipment*

Form of Heat of Ignition

- *the form of heat of ignition* is recorded for a remarkably high proportion of fires
- 36% (of known) fires are attributed to *heat from electrical equipment arcing, overload* and 20% (of known) to *heat from open flame, spark*
- *tie civilian fatality rate* for *heat from open flame, spark* is notably above the overall average

Type of Material Ignited

- the most commonly recorded *type of material ignited* is *wood, paper* (40% of known)
- extremely high values (compared with the overall average) of the *civilian injury and fatality rates* for *gas; and-flammable, combustible liquid*

Form of Material Ignited

- three categories, *power transfer equipment, fuel; other, unknown, etc; and structural component, finish* made up the great majority of fires
- high *civilian fatality and injury rates* are recorded for *special form* of *material ignited*

Ignition Factor

- *mechanical failure, malfunction (39%* of known) dominates the fires but its *casualty rates are* below the overall averages, particularly *civilian fatality rate*
- *the civilian fatality rates* for *incendiary; misuse of heat of ignition; misuse of material ignited; and other, unknown, etc* are all substantially above average
- *the civilian injury rate* for *misuse of material ignited* is substantially above average
- *the fire fighter injury rate* is substantially above average for *natural condition; suspicious*

Construction Type

- construction type is not recorded for a large proportion of the fires
- *24%* of known fires are in *unprotected ordinary* and 19% in *protected ordinary*
- *fire fighter injury rate* for *unprotected ordinary* is well above average
- the *civilian injury rates* for *unprotected non-combustible or limited combustible* and *unprotected ordinary* are well above average
- *the fire fighter fatality rate* for *protected wood frame* is well above average
- the highest *civilian fatality rates* are for *protected wood frame* and *unprotected ordinary*

Form of Material Generating Most Smoke

- over 80% of fires are recorded *as unknown, etc*

Type of Material Generating Most Smoke

- the vast majority (over 70%) of fires are recorded as *unknown, etc*

Avenue of Smoke Travel

- *the avenue of smoke travel* is *unknown* for the majority of fires and there is *no significant avenue of smoke travel* for the majority of the remaining fires

Method of Extinguishment

- the greatest number of fires with *method of extinguishment* known is for *preconnected hose line(s) with water carried in apparatus tanks (30%* of known) followed by *portable extinguisher* (21% of known)
- *portable extinguishers, self extinguished* and the *sprinklers* themselves are the predominant *methods of extinguishment* with *sprinklers present,* whereas with *sprinklers not present* the predominant *methods of extinguishment are preconnected hose line(s), self extinguished and portable extinguisher*
- the *fire fighter injury rate rises* sharply for *preconnected hose lines with water from hydrant, draft, standpipe; hand laid hose lines with water from hydrant, standpipe, draft; and master stream devices with or without hand lines as* does the *civilian fatality rate*
- *the fire fighter fatality rate* is high for *preconnected hose lines with water from hydrant, draft, standpipe; and master stream devices with or without hand lines*

- high *civilian injury rates* are more uniformly spread through the categories

The extent of damage resulting from the ignition of a fire in retail premises appears to be primarily dependent on the presence of people:

- particularly during the day and evening when awake, able and alert people are in these buildings in considerable numbers the extent of damage and casualties is likely to be much less than at other times presumably because they deal with many of the fires quickly and effectively
- presumably the presence of detectors can help by warning the occupants and fire department earlier than would otherwise occur in cases where there are no people in the immediate vicinity of the fire, but before sprinklers are activated
- if present and the fire is not dealt with beforehand, sprinklers are likely to extinguish or limit the growth of a fire
- finally, when they arrive and if the fire has not already been dealt with, fire fighters influence the final extent of destruction resulting from a fire

It is quite clear from these summaries that design and management of retail buildings to minimise the number of fire starts and to minimise the extent of smoke and fire spread is likely to reduce the human casualties and property losses due to such fires. The use of alert people, detectors, and automatic sprinklers appear the most effective means of achieving such reductions.

31 SIGNATURE PAGE

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32 REFERENCES,

1 National Fire Incident Reporting System, Federal Emergency Management Agency, USA

2 Bennetts, I D, Poh, K W, Thomas I R, Lee A C, Beever P F, "Case Studies of Fires in Retail Buildings", BHP Research Report No SM/R/056, October 1996

3 Fire Code Reform Centre, Project 3 Fire Resistance and Non-combustibility, Part 1 Objectives and Performance Levels for Fire resistance, October 1996

4 Thomas, I R, Bennetts, ID, Poon, S L, Sims, J A, "The Effect of Fire on the Building at 140 William Street A Risk Assessment, BHP Research Melbourne Laboratories Rep No. BHP Research/ENG/R/92/044/SG2C, February 1992

5 Thomas, I R, "Analysis of NSW Retail Fires 1986 to1992", BHP Research Report, to be published.

6 Thomas, I R, "Analysis of Australian Retail Fires 1986 to 1992", BHP Research Report, to be published

APPENDIX A

TABLE A1 FIRES WITH CIVILIAN INJURIES

Civilian Injuries per Fire	Fires
0	76535
1	1172
2	188
3	54
4	19
5	8
6	7
7	1
8	3
9	2
10	2
11	1
13	1
15	1
23	1
119	1

TABLE A2 FIRES WITH FJRE FIGHTER INJURIES

Fire Fighter Injuries per Fire	Fires
0	7551s
1	1619
2	431
3	190
4	97
5	37
6	38
7	21
8	14
9	4
10	6
11	4
12	5
13	4
14	1
15	1
16	2
19	3
21	1
23	1
25	1
30	1

TABLE A3 TOP TWENTY $ LOSS VALUES BY NUMBER OF FIRES

Estimated $ Loss	Fires
0	15662
500	6092
50	4768
100	473 1
200	3431
1000	3397
5000	2914
300	1956
2000	1787
10000	1349
3000	1071
1500	1052
150	904
25	852
20000	838
250	836
400	771
15000	741
100000	727
50000	714

TABLE A4 TOP TWENTY FIRES BY $ LOSS VALUE

Estimated $ Loss	Fires
80000000	1
40000000	1
35000000	1
15000000	1
12000000	1
9433284	1
6000000	1
5550000	1
5000000	4
4500000	1
4000000	3
3800000	1
3500000	2
3423494	1
3371000	1
3250000	1
3225000	1
3096000	1
3000000	9
2750000	1

EXPOSURENUMBER

Of the 77,996 fires a total of 3,811 are recorded as *exposure fires,* that is fires in a building or structure resulting from a fire that started in another building or structure or somewhere external to the building. However, note that there are possible discrepancies in the record as can be seen in the Table A5 - there are some discrepancies in the exposures above ten (but the missing exposure fires could be in another *fixed property* use category and thus there may be no anomalies at all).

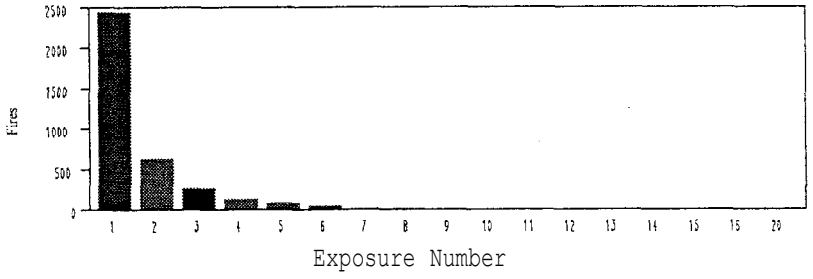


FIGURE Al EXPOSURE NUMBER

Table A5 Exposure Number

	Fires	Fire Fighter Injuries	Fire-fighter Injury Rate*	Civilian Injuries	Civilian Injury Rate*	Fire Fighter Fatalities	Fire-fighter Fatality Rate*	Civilian Fatalities	Civilian Fatality Rate*
0	74184	4499	60.7	2106	28.4	13	0.18	82	1.11
1	2461	63	25.6	7	2.8	1	0.41	4	1.63
2	642	8	12.5	0	0.0	0	0.00	0	0.00
3	280	6	21.4	5	17.9	0	0.00	1	3.57
4	153	2	13.1	0	0.0	0	0.00	0	0.00
5	86	0	0.00	0	0.0	0	0.00	0	0.00
6	68	2	29.4	0	0.0	0	0.00	0	0.00
7	34	0	0.0	0	0.0	0	0.00	0	0.00
8	27	0	0.0	0	0.0	0	0.00	0	0.00
9	1.5	0	0.0	0	0.0	0	0.00	0	0.00
10	8	0	0.0	0	0.0	0	0.00	0	0.00
11	9	0	0.0	0	0.0	0	0.00	0	0.00
12	5	0	0.0	0	0.0	0	0.00	0	0.00
13	5	0	0.0	0	0.0	0	0.00	0	0.00
14	7	0	0.0	0	0.0	0	0.00	0	0.00
15	6	0	0.0	0	0.0	0	0.00	0	0.00
16	4	0	0.0	0	0.0	0	0.00	0	0.00
20	1	0	0.0	0	0.0	0	0.00	0	0.00
96	1	0	0.0	0	0.0	0	0.00	0	0.00
Notes:		**rates**		0.18			27.2		58.7 firefighter
		1,000 fires.							
		1000							

Thus 4.9% of the recorded fires (one in 20) are *exposure fires* and the rate of civilian fatalities in these fires (1.31 fatalities per 1,000 fires overall) is slightly higher than the average over all fires. However, the total is due to three fatalities in one fire and one fatality in another fire. Thus the rate is boosted by the occurrence of a triple fatality. There is insufficient data to determine whether there is a greater than normal propensity for multiple civilian fatalities in *exposure*

fires, consequently the significance or otherwise of the higher rate of civilian fatalities in *exposure fires* remains undetermined.

The firefighter fatality rate is not noticeably different from the overall average, but both the civilian and firefighter injury rates appear to be slightly below the overall averages.

The rate of exposure fires (4.9% of all retail fires) seems anomalous compared with the percentage of fires recorded as having an **extent of flame spread** *beyond the structure* of *origin* (see Section 5).

MONTH OF INCIDENT

The number of fires for each month is shown in Figure A2 and Table A6. In Figure A2 the vertical axis is the number of fires during the period represented by the data and the horizontal line within the graph is the average number of fires per month over this period. January (1) and December (12) have significantly above and September (9) below average numbers of fires. Even discounting these months the variation in the numbers of fires for the other months is almost certainly too great to simply be the result of random variations.

Also shown in Table A6 is the number of fire fighter and civilian injuries and fatalities for each month and the rate per 1000 fires of these casualties on a monthly basis.

Note that August (month 8) has the fire with 119 civilian casualties and this explains the exceptionally high civilian injury rate for this month. Similarly, July is the month with the single fire that resulted in five civilian fatalities, November the fire with four and December the fire with three civilian fatalities, each of these occurrences has significantly influenced the number of fatalities in the month and the fatality rate per 1000 fires for those months.

There are variations in the monthly numbers of fatalities and injuries and the injury and fatality rates in both categories but the fatality variations may not be more than the result of random variations considering the small numbers involved. This is unlikely to be the case for the injury variations.

That said, October and November appear to have above average civilian fatality rates but the two preceding months, August and September to have below average rates. No explanation of these departures from the average are proposed at present. There are significant variations in the civilian and firefighter injury rates (the August civilian injury rate is clearly above the average and the October firefighter rate is clearly below the average). Again, no proposed explanations for these departures from the average are offered.

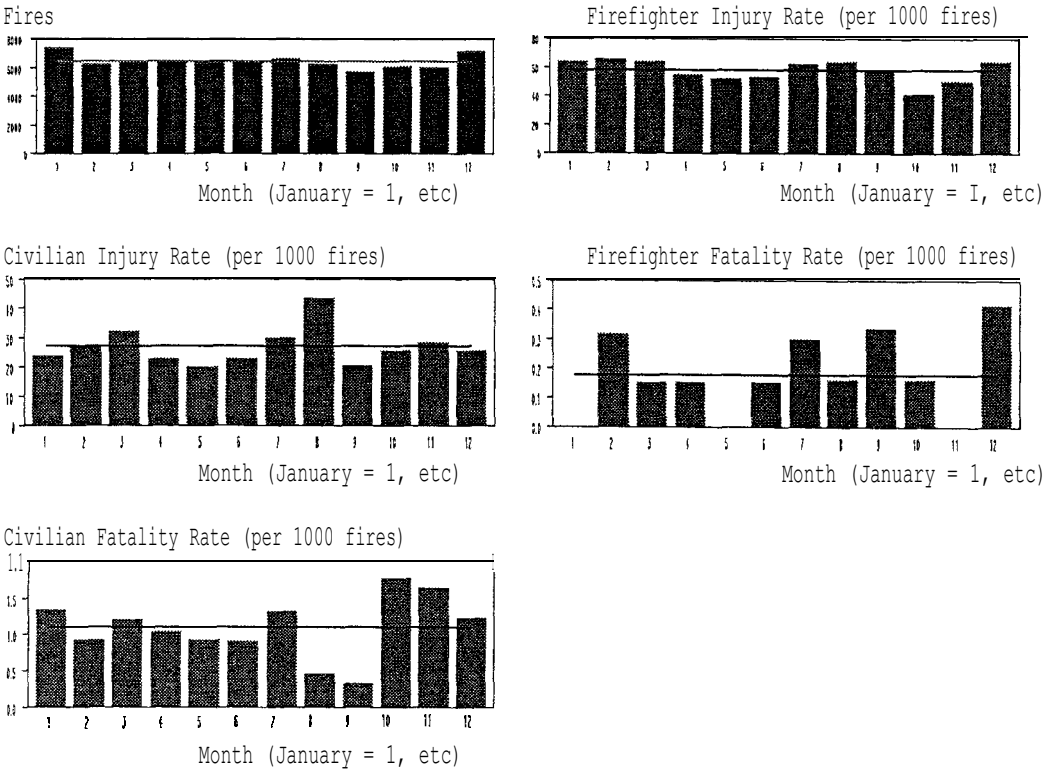


FIGURE A2 MONTH OF INCIDENT

TABLE A6 MONTH OF INCIDENT

Month	Fires	Fire Fighter Injuries	Fire Fighter Injury Rate*	Civilian Injuries	Civilian Injury Rate*	Fire Fighter Fatalities	Fire Fighter Fatality Rate*	Civilian Fatalities	Civilian Fatality Rate*
1	7432	480	64.6	179	24.1	0	0.00	10	1.35
2	6334	418	66.0	170	26.8	2	0.32	6	0.95
3	6575	426	64.8	215	32.7	1	0.15	8	1.22
4	6579	368	55.9	153	23.3	1	0.15	7	1.06
5	6365	336	52.8	129	20.3	0	0.00	6	0.94
6	6477	349	53.9	151	23.3	1	0.15	6	0.93
7	6697	422	63.0	202	30.2	2	0.30	9	1.34
8	6322	411	65.0	277	43.8	1	0.16	3	0.47
9	5813	335	57.6	122	21.0	2	0.34	2	0.34
10	6141	259	42.2	160	26.1	I	0.16	11	1.79
11	6073	311	51.2	174	28.7	0	0.00	10	1.65
12	7188	465	64.7	186	25.9	3	0.42	9	1.25

Notes: rates are 1.12 civilian and 0.18 27.2 58.7 firefighter
1,000 fires.
1000

DAY OF WEEK

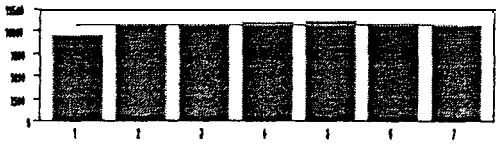
The number of incidents per day of the week varies slightly but only Sunday (1) seems to be markedly different from the average which is represented by the horizontal line within the graph (Figure A3, see also Table A7). There are 2,630 fires with day of the week not entered and not include in the table, graph or average.

Note that the fire that resulted in 119 civilian injuries occur on a Sunday.

There are variations in the civilian fatality rate with the figure for Tuesday being well below the average and Sunday being well above, but due to the small numbers of fatalities these may be due only to random fluctuations. Note that Sunday (day 1) does not have any of the fires with three, four or five civilian fatalities, these occur on Monday, Friday and Saturday respectively. No explanation of the variations is proposed.

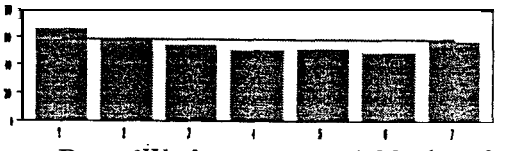
The civilian and firefighter injury numbers and rates vary significantly, not entirely in a corresponding manner and not in a manner that corresponds with the observed variations in fatality numbers and rates. The lowest injury rate for firefighters is for Friday and the highest Sunday, but the lowest injury rate for civilians is for Thursday and the highest Friday. No explanation for these variations is offered.

Fires



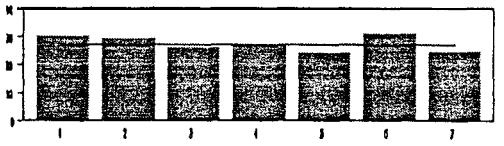
Day of Week (Sunday = 1, Monday = 2, etc)

Firefighter Injury Rate (per 1000 fires)



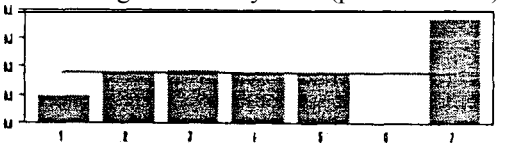
Day of Week (Sunday = 1, Monday = 2, etc)

Civilian Injury Rate (per 1000 fires)



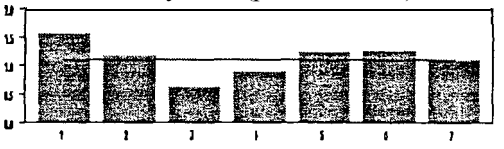
Day of Week (Sunday = 1, Monday = 2, etc)

Firefighter Fatality Rate (per 1000 fires)



Day of Week (Sunday = 1, Monday = 2, etc)

Civilian Fatality Rate (per 1000 fires)



Day of Week (Sunday = 1, Monday = 2, etc)

FIGURE **A3** DAY OF WEEK

TABLE A7 DAY OF WEEK

Day of Week	Fires	Fire Fighter Injuries	Fire Fighter Injury Rate*	Civilian Injuries	Civilian Injury Rate*	Fire Fighter Fatalities	Fire Fighter Fatality Rate*	Civilian Fatalities	Civilian Fatality Rate*
Sun (1)	9645	634	65.7	294	30.5	1	0.10	15	1.56
Mon (2)	10908	635	58.2	320	29.3	2	0.18	13	1.19
Tue (3)	10765	589	54.7	281	26.1	2	0.19	7	0.65
Wed (4)	11117	572	51.5	302	27.2	2	0.18	10	0.90
Thu (5)	11216	581	51.8	270	24.1	2	0.18	14	1.25
Fri (6)	10997	536	48.7	342	31.1	0	0.00	14	1.27
Sat (7)	10718	622	58.0	267	24.9	4	0.37	12	1.12

Notes: rates are 1.12 civilian and 58.7 firefighter
1,000 fires.
*Rate noted otherwise.

MOBILE PROPERTY TYPE

The mobile property type categories are:

MPT 1 Passenger road transport vehicles
MPT2 Freight road transport vehicles
MPT3 Rail transport vehicles
MPT4 Water transport vehicles
MPT5 Air transport vehicles
MPT6 Heavy equipment
MPT7 Special vehicles, containers
MPT9 Unknown, other, etc

(Note that *unknown, etc* (MPT 9) contains the fire with 119 civilian injuries and the fires with three, four and five civilian fatalities.)

The overwhelming majority if fires have no relevant mobile *property type* (Figure A4 and Table AS).

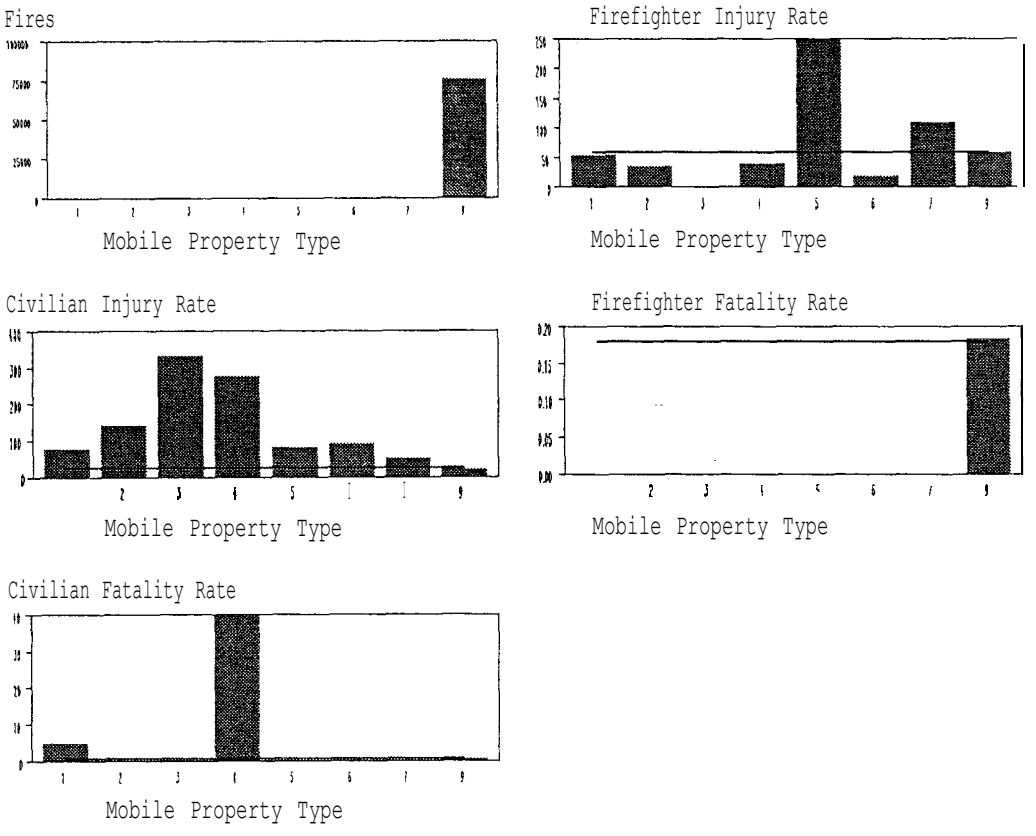


FIGURE A4 MOBILE PROPERTY TYPE

TABLE A8 MOBILE PROPERTY TYPE

Mobile Property Type	Fires	Fire-fighter Injuries	Fire Fighter Injury Rate*	Civilian Injuries	Civilian Injury Rate*	Fire Fighter Fatalities	Fire-fighter Fatality Rate*	Civilian Fatalities	Civilian Fatality Rate*
1	1219	68	55.8	98	80.4	0	0.00	6	4.92
2	214	8	37.4	31	144	0	0.00	0	0.00
3	3	0	0.0	1	333	0	0.00	0	0.00
4	25	1	40.0	7	280	0	0.00	1	40.00
5	12	3	250	1	83.3	0	0.00	0	0.00
6	53	1	18.9	5	94.3	0	0.00	0	0.00
7	90	10	111	5	55.6	0	0.00	0	0.00
9	76380	4489	58.8	1970	25.8	14	0.18	80	1.05

Notes: rates are 1.12 0.18 27.2 58.7 firefighter
1,000 fires.
1000

METHOD OF ALARM

This categorisation of the data and those that follow relate to the response to the fire.

MOA 1	Telephone direct to fire department
MOA 2	Coded signal municipal fire alarm systems
MOA 3	Private fire alarm system
MOA 4	Radio
MOA 5	Direct report to station
MOA 6	No alarm received - no response
MOA 7	Telephone tie-line to fire department
MOA 8	Voice signal municipal fire alarm systems
MOA 9	NCA, undetermined or unreported

(Note that MOA 4 contains the fire with 119 civilian injuries and MOA 9, MOA 6 and MOA 1 contain the fires with three, four and five civilian fatalities respectively.)

The *method of alarm* is predominantly by *telephone directly to the fire department* (MOA 1) with the great majority of the remainder by tie line calls (MOA 7). Calls to 911 can be in either of these categories depending on the arrangements, but it appears the majority of them is in MOA 7.

The numbers of fires in the other categories are so low that comparison of the injury and death rates for them is hardly meaningful (Figure A5 and Table A9).

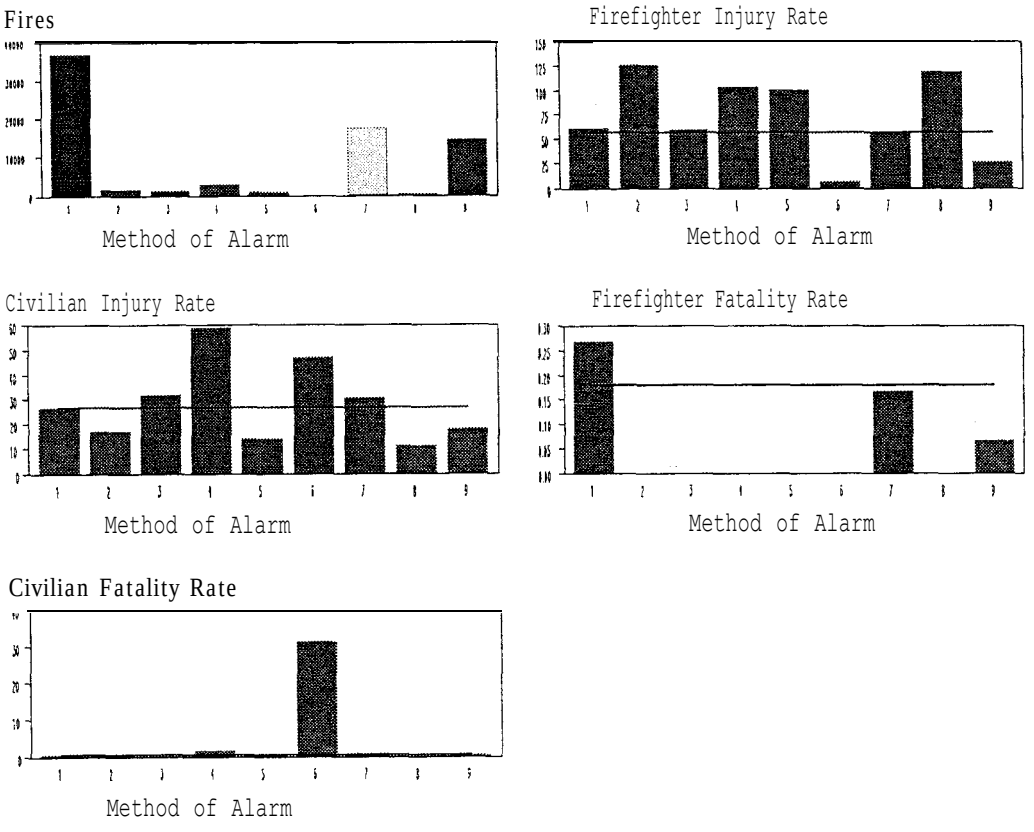


FIGURE A5 METHOD OF ALARM

TABLE A9 METHOD OF ALARM

Method of Alarm	Fires	Fire Fighter Injuries	Fire Fighter Injury Rate*	Civilian Injuries	Civilian Injury Rate*	Fire Fighter Fatalities	Fire Fighter Fatality Rate*	Civilian Fatalities	Civilian Fatality Rate*
1	36908	2317	62.8	998	27.0	10	0.27	38	1.03
2	1684	214	127	29	17.2	0	0.00	1	0.59
3	1424	86	60.4	46	32.3	0	0.00	0	0.00
4	3194	335	105	189	59.2	0	0.00	6	1.88
5	1334	136	102	19	14.2	0	0.00	1	0.75
6	126	1	7.94	6	47.6	0	0.00	4	31.8
7	17779	1018	57.3	549	30.9	3	0.17	21	1.18
8	600	72	120	7	11.7	0	0.00	0	0.00
9	14947	401	26.8	275	18.4	1	0.07	16	1.07

Notes: rates are 1.12 0.18 27.2 58.7 firefighter
1,000 fires.
1000

TYPE OF ACTION TAKEN

The categories here are:

TAT 1 *Extinguishment*
TAT 2 Rescue only
TAT *3 Investigation only*
TAT 4 Remove hazard
TAT 5 Standby
TAT 6 Salvage
TAT 7 Ambulance service
TAT 8 Fill in, move up, transfer
TAT 9 Unknown, other, etc

(Note that TAT 1 contains the fire with 119 civilian injuries and TAT 1 and TAT 9 contain the fires with three and five, and four civilian fatalities respectively.)

The known cases fall overwhelmingly into the *extinguishment* and *investigation only* categories (Figure A6 and Table A10).

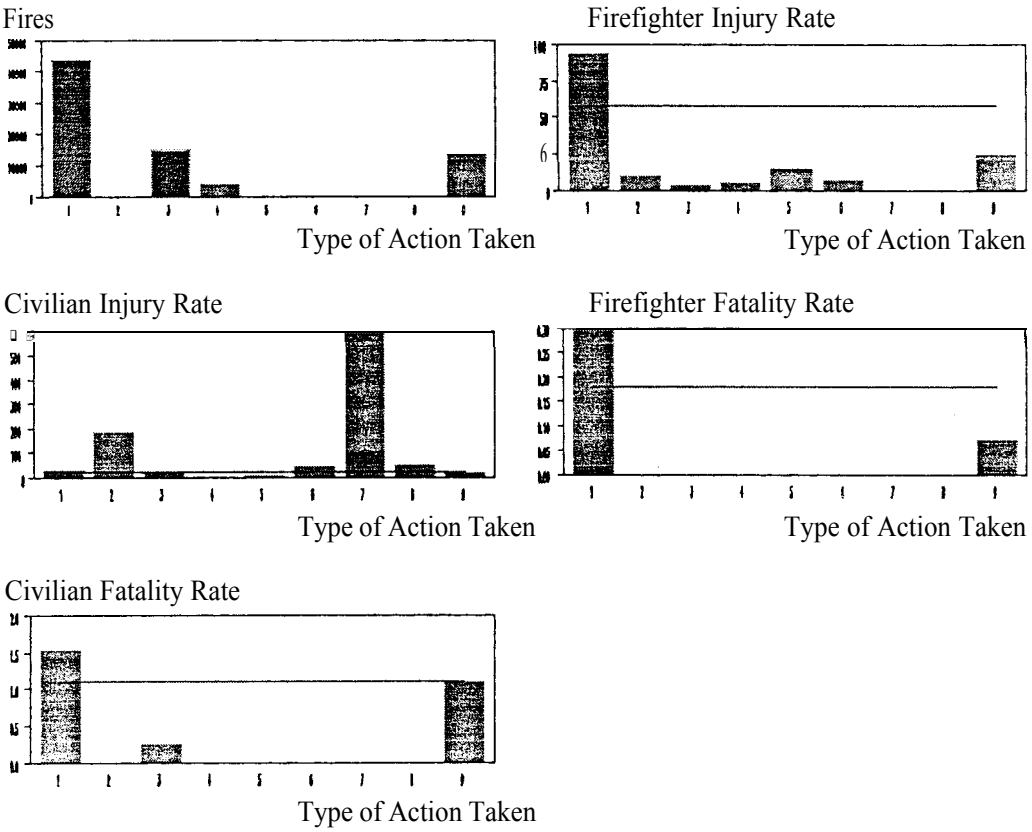


FIGURE A6 TYPE OF ACTION TAKEN

TABLE **A10** TYPE OF **ACTION TAKEN**

Type of Action Taken	Fires	Fire Fighter Injuries	Fire Fighter Injury Rate*	Civilian Injuries	Civilian Injury Rate*	Fire Fighter Fatalities	Fire Fighter Fatality Rate*	Civilian Fatalities	Civilian Fatality Rate*
1	44122	4142	93.88	1430	32.41	13	0.29	68	1.54
2	107	1	9.35	20	**186.92**	**0**	**0.00**	**0**	**0.00**
3	15077	64	4.24	321	21.29	0	0.00	4	0.27
4	4326	25	5.78	47	10.86	0	0.00	0	0.00
5	257	4	15.56	4	15.56	0	0.00	0	0.00
6	506	4	7.91	23	45.45	0	0.00	0	0.00
7	27	0	0.00	16	592.59	0	0.00	0	0.00
8	18	0	0.00	1	55.56	0	0.00	0	0.00
9	13556	340	25.08	256	18.88	1	0.07	15	1.11

Notes: rates are 1.12 civilian and 58.7 firefighter
fires.
1000 fires unless

EFFECT OF CONSTRUCTION TYPE

The effect of construction *type* is expected to be most clear in fires with *sprinklers not present.* Figures A7 to Al4 present summaries of *the extent of flame spread* and casualty data for Construction Types 1 to 8 for fires with *sprinklers not present.*

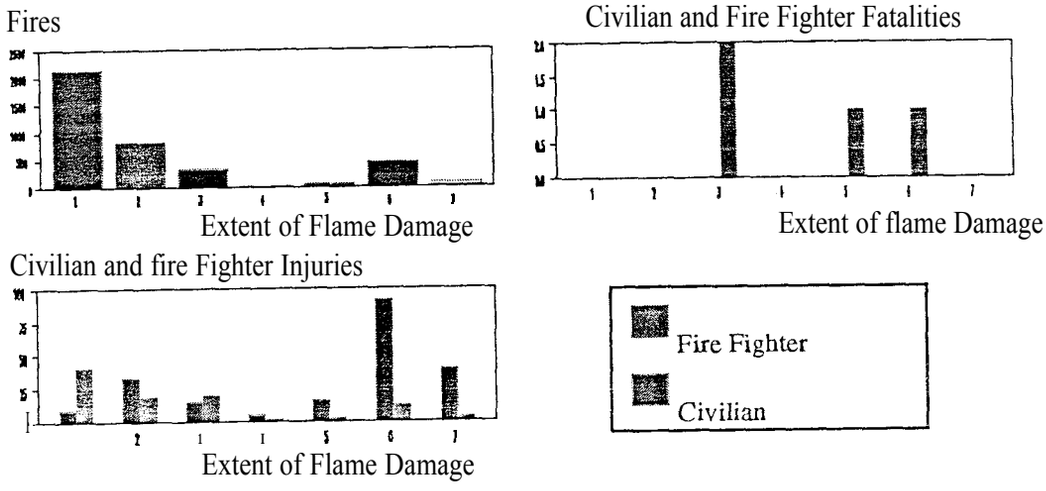


FIGURE A7 SPRINKLERS NOT PRESENT, CONSTRUCTION TYPE 1

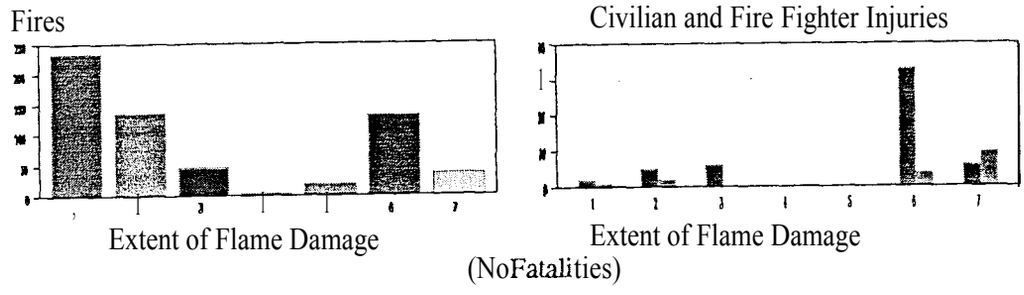


FIGURE A8 SPRINKLERS NOT PRESENT, CONSTRUCTION TYPE 2

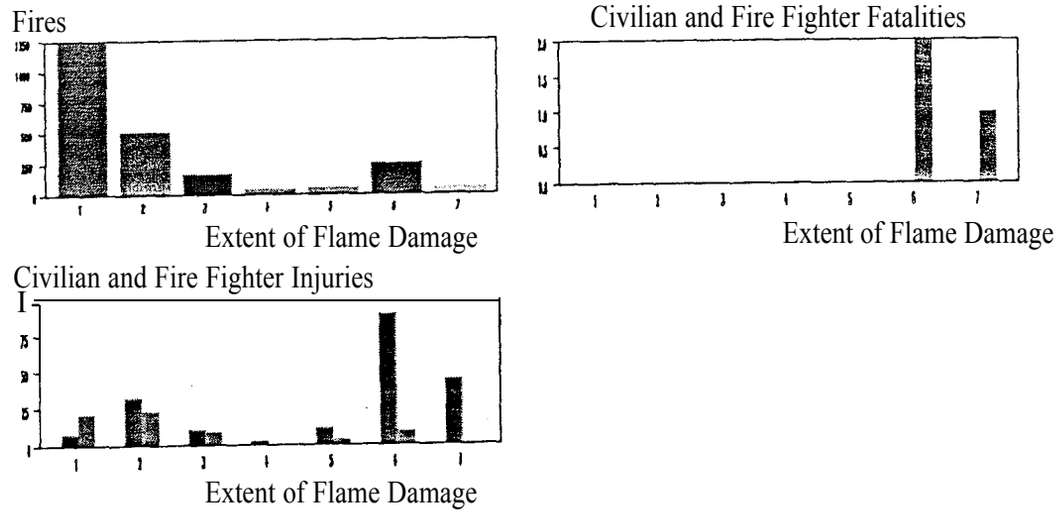


FIGURE A9 SPRINKLERS NOT PRESENT, CONSTRUCTION TYPE 3

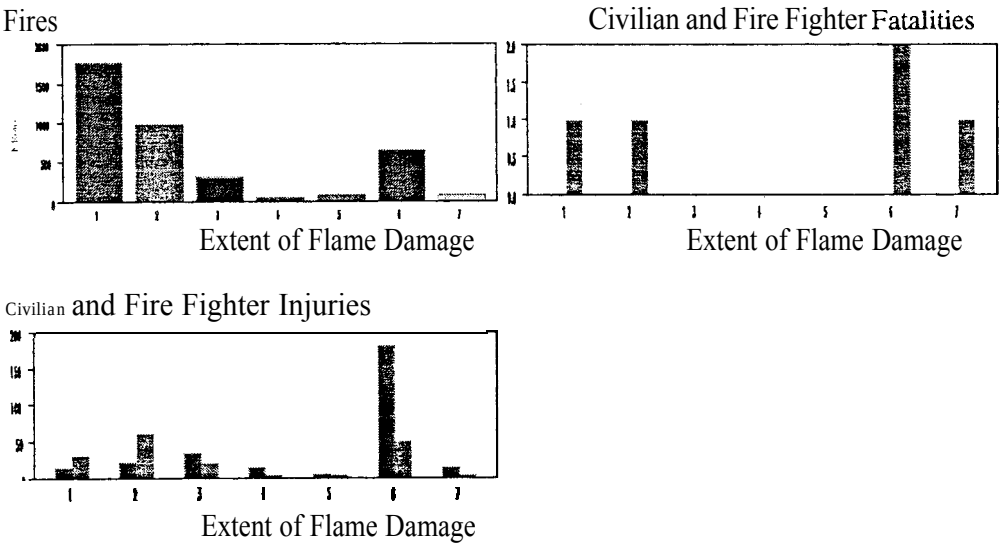


FIGURE A 10 SPRINKLERS NOT PRESENT, CONSTRUCTION TYPE **4**

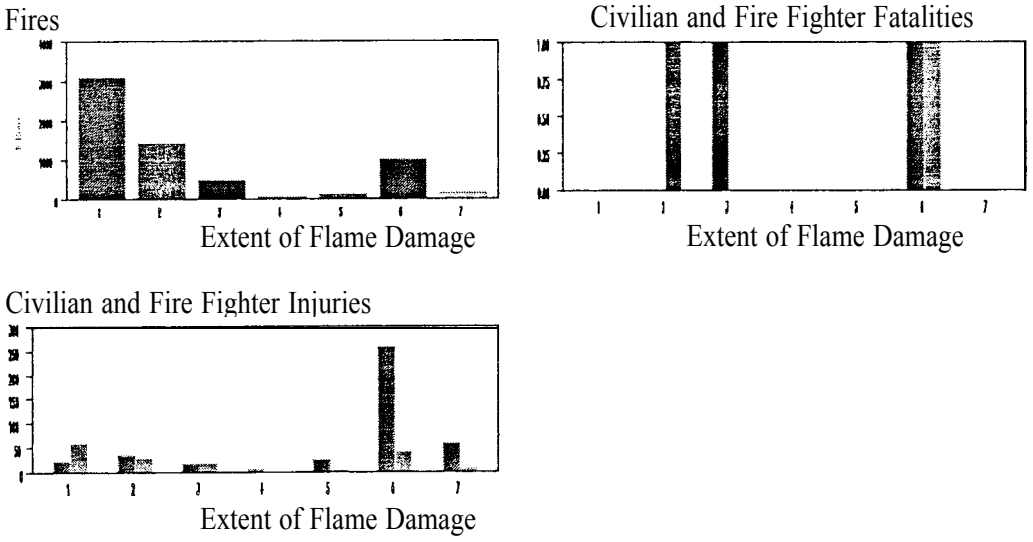


FIGURE A 11 SPRINKLERS NOT PRESENT, CONSTRUCTION TYPE 5

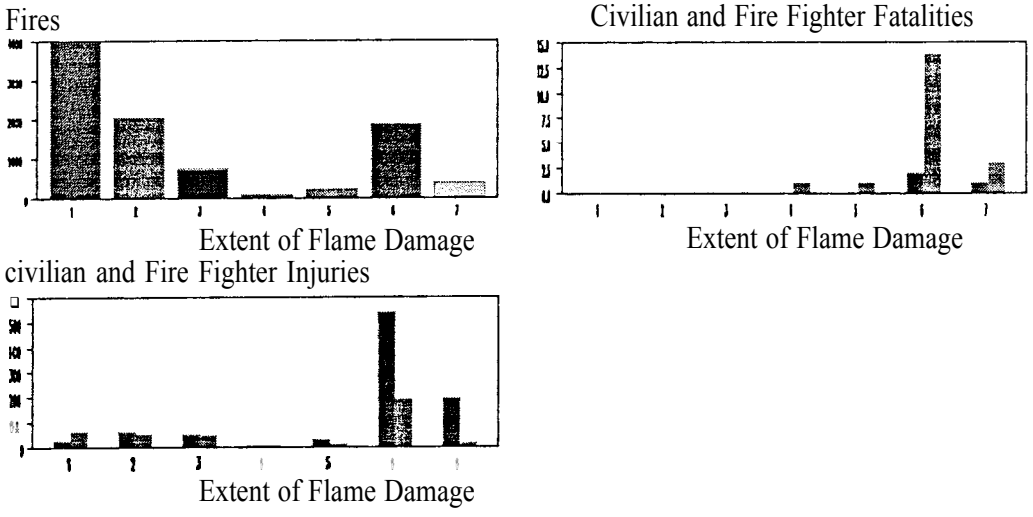


FIGURE A 12 SPRINKLERS **NOT PRESENT,** CONSTRUCTION TYPE 6

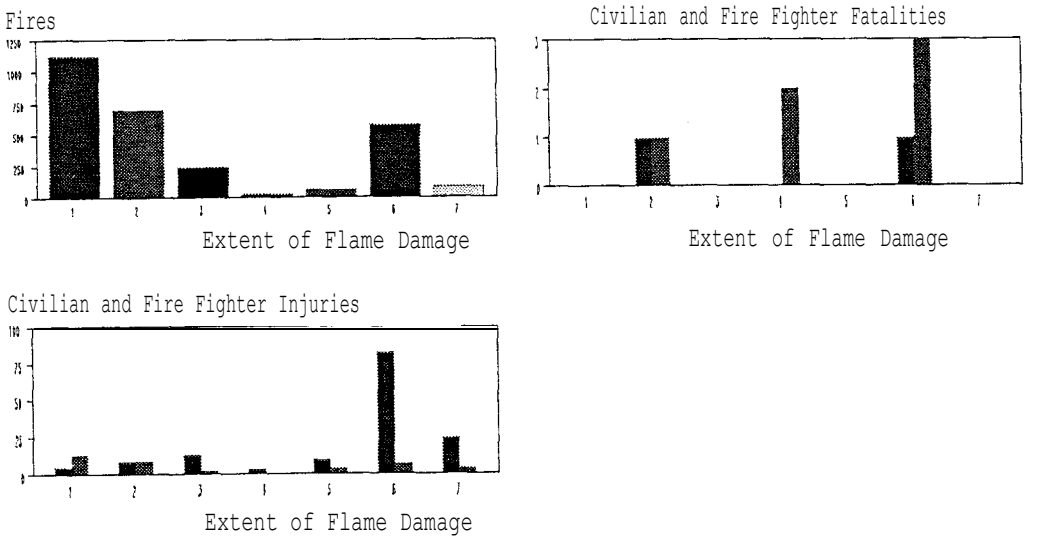


FIGURE A13 SPRINKLERS NOT PRESENT, CONSTRUCTION TYPE 7

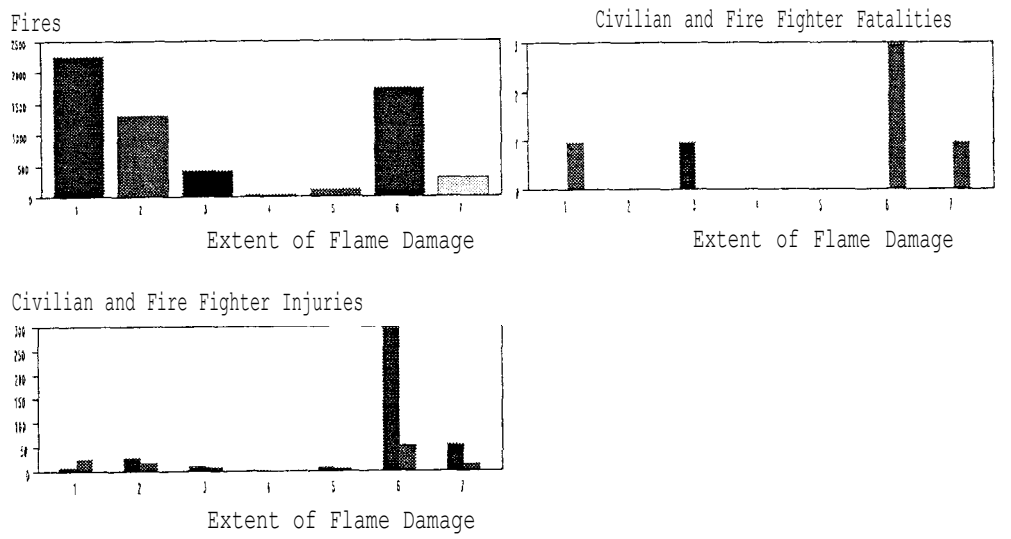


FIGURE A14 SPRINKLERS NOT PRESENT, CONSTRUCTION TYPE 8

APPENDIX B

E F F E C T OF ALARM TIME AND CONSEQUENTIAL CONSIDERATIONS

In Sections 6 and 7 it is noted that the number of fires per hour and their extent of *flame damage* vary widely with *alarm time.* In this appendix the variation of the *extent of flame damage* with *alarm time* is examined for each of the sprinkler presence and operation cases along with the variation with *time of alarm* of several other fields. Considerations arising as a consequence are also covered.

EXTENT OF FLAME DAMAGE WITH SPRINKLER OPERATION

The *extent of flame damage* is examined and the categories defined in Section 5. The variation in the *extent of flame damage* with *time of alarm* is examined for all fires as one group in Section 7. In this section the variation of *extent of flame damage* with *time of alarm* is examined in three groups:

- *fires* with *sprinklers notpresent* (SP 8)
- fires with *sprinklers present but they did not operate* (SP 2 and SP 3)
- fires with *sprinklers present and operated* (SP1)

Not all of *the* fires in *the* database have the *sprinkler presence and operation, extent of flame damage* and *time of alarm* known. A total of 49,653 fires do have this information and are included in this analysis.

The variation in the *extent of flame damage* with *time of alarm* for the fires recorded as having *sprinklers not present* (SP 8) is shown in Figures B1 and B2. In these figures and those following only *extent of flame damage confined to the object of origin* (EFD 1), *confined to the area or part of room of origin* (EFD 2), *confined to the room of origin* (EFD 3) and *confined to the structure of origin* (EFD 6) are shown, as it is clear from Sections 5 and 7 that the proportions of fires with *confined to the fire rated compartment of origin* (EFD 4), *confined to the storey of origin* (EFD 5) and *beyond the structure of origin* (EFD 7) are very small.

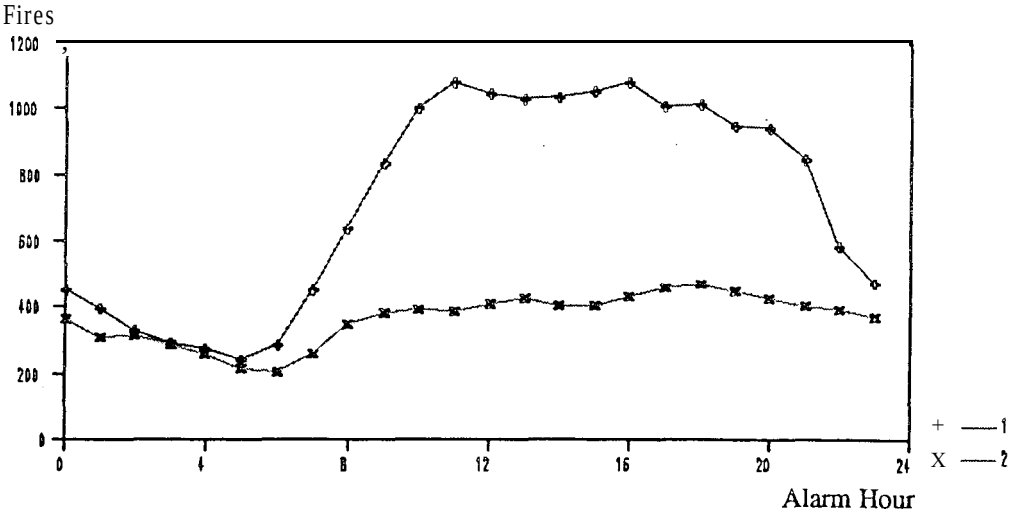


FIGURE B 1 VARIATION OF EFD 1 AND EDF 2 WITH ALARM HOUR FOR SPRINKLERS NOT PRESENT

It is clear in Figure B 1 that the number of fires with flame damage *confined to the object of origin* (EFD 1) rises sharply from 6 am to 11 am, it is then steady to 4 pm when it begins to fall slowly to 8 pm, fast from then to 11 pm and slowly again from then to 5 am. The minimum is 245 at 5 am and the maximum 1084 at 11 am and 1083 at 4 pm, a more than fourfold increase. However, for fires with flame damage *confined to the area of origin* (EFD 2) the number of fires generally rises from 6 am until 6 pm when it begins to fall slowly. The minimum is 208 at 6 am and the maximum 472 at 6 pm.

These variations contrast with those in Figure B2, particularly for *confined to the structure of origin* (EFD 6).

The number of fires with *flame* damage *confined to the room of origin* (EFD 3) rises slowly from 6 am until 6 pm when it begins to fall slowly. The minimum is 77 at 5 am and the maximum 184 at 6 pm.

The number of fires *confined to the structure of origin* (EFD 6) is reasonably constant from midnight to 4 am, then falls sharply until 6 am, is fairly constant again until 10 am and then rises slowly until midnight. The minimum is 167 at 10 am and the maximum 520 at 2 am, a more than threefold change. This variation is quite different to that for EFD 1 *to* EFD 3.

(The fires confined to the *fire rated compartment of origin* (EFD 4) is a minimum of 10 at 2 am and 5 am and a maximum 32 at 8 pm and *confined to the floor of origin* (EFD 5) is a minimum of 17 at 8 am and a maximum of 58 at 11 pm.)

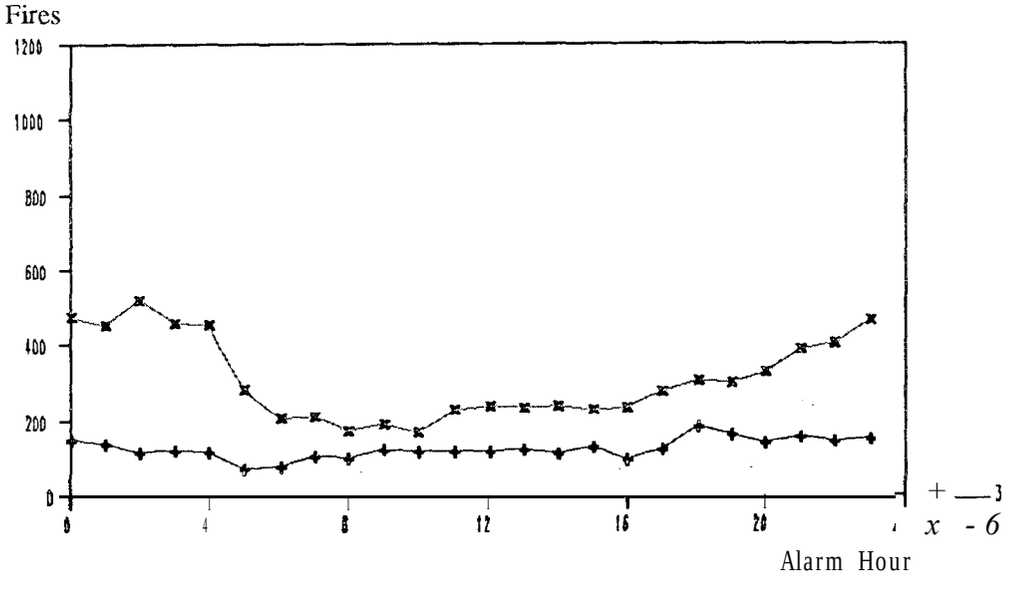


FIGURE B2 VARIATION OF EFD 3 AND EDF 6 WITH ALARM HOUR FOR SPRINKLERS NOT PRESENT

The variation *in the extent of flame damage* with *time of alarm* for fires recorded as having *sprinklers present but did not operate* (SP 2 and SP 3) is shown in Figures B3 and B4. (Note that Figures B1 and B2 have the same vertical scale and that Figures B3 to B6 have the same vertical scale (but different from Figures B 1 and B2).)

In Figure B3 the number of *fiies confined to the object of origin* (EFD 1) rises sharply from 6 am to 11 am, then progresses unsteadily to a maximum at 6 pm when it begins to fall slowly to 9 pm, fast from then to 1 am and then is

reasonably steady until 6 am. The minimum is 66 at 4 am and the maximum 348 at 6 pm, over a fivefold increase. Overall, the shape of this curve is very similar to the variation in the number of fires with *time of alarm* for extent of flame damage *confined to the object of origin* for the *sprinkler not present case* (Figure B1).

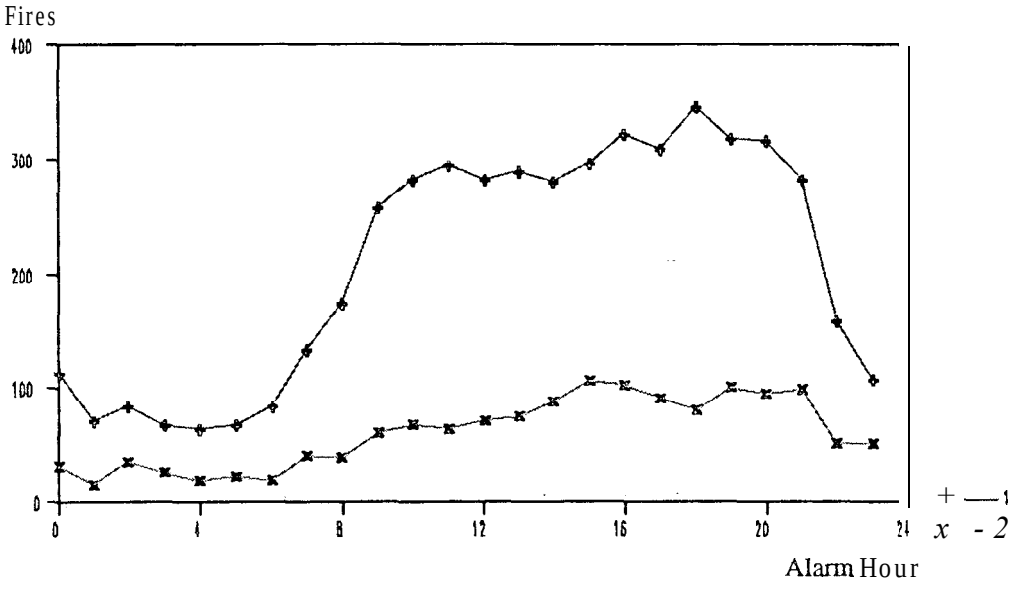


FIGURE B3 VARIATION OF EFD 1 AND EDF 2 WITH ALARM HOUR FOR SPRINKLERS PRESENT BUT DID NOT OPERATE

The number of fires *confined to the area of origin* (EFD 2) rises slowly from 6 am until 3 pm, is reasonably steady until 9 pm, then falls until 1 am and then is reasonably steady until 6 am. The minimum is 16 at 1 am and the maximum 108 at 3 pm, a nearly sevenfold increase. However, again this is quite similar to the variation for fires *confined to the area of origin* for *the sprinkler not present case.*

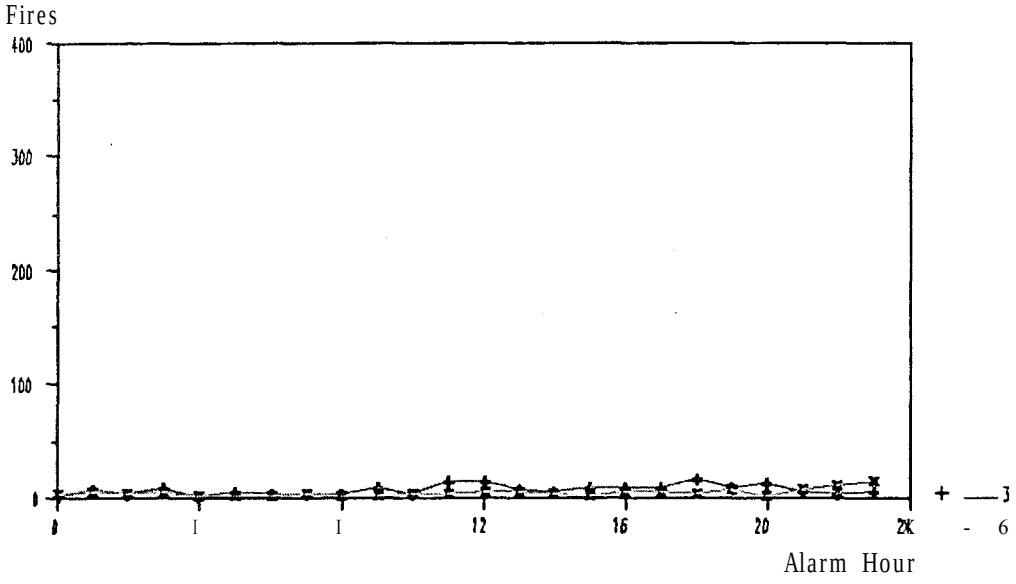


FIGURE B4 VARIATION OF EFD 3 AND EDF 6 WITH ALARM HOUR FOR SPRINKLERS PRESENT BUT DID NOT OPERATE

In Figure B4 it can be seen that the number of fires *confined to the room of origin* (EFD 3) is very low throughout the day The minimum is 2 at 4 am and the maximum 19 at noon.

The number of fires *confined to the structure of origin* (EFD 6) is also very low. It rises very slowly from 6 am until midnight. The minimum is 2 at 6 am and 9 am and the maximum 15 at 11 pm. The variation is markedly different to the *sprinklers not present case.*

These cases contrast sharply with the variation in the *extent of flame damage* with *time of alarm* for fires recorded as having *sprinklers present and operated* (SP 1), shown in Figures B5 and B6.

In Figure B5 the number of fires *confined to the object of origin* (EFD 1) rises from 6 am to 11 am, then progresses unsteadily to a maximum at 7 pm when it begins to fall until 1 am, rises to another peak at 3 am, falls sharply to 4 am and then is steady until 6 am. The minimum is 23 at 6 am and the maximum 71 at 7 pm. This is quite different to *the sprinklers present but did not operate case* (SP 2 + SP 3).

The number of fires *confined to the area of origin* (EFD 2) is almost always greater than the number *confined to the object of origin* (EFD 1). It rises slowly and somewhat unsteadily from 6 am until 4 pm, rises more sharply but unsteadily until 8 pm, then falls until 2 am, there is a sharp peak at 3 am and then is reasonably steady from 4 am until 6 am. The minimum is 42 at 6 am and the maximum 99 at 4 pm. Again, this is in sharp contrast to the variation that occurs in the cases above.

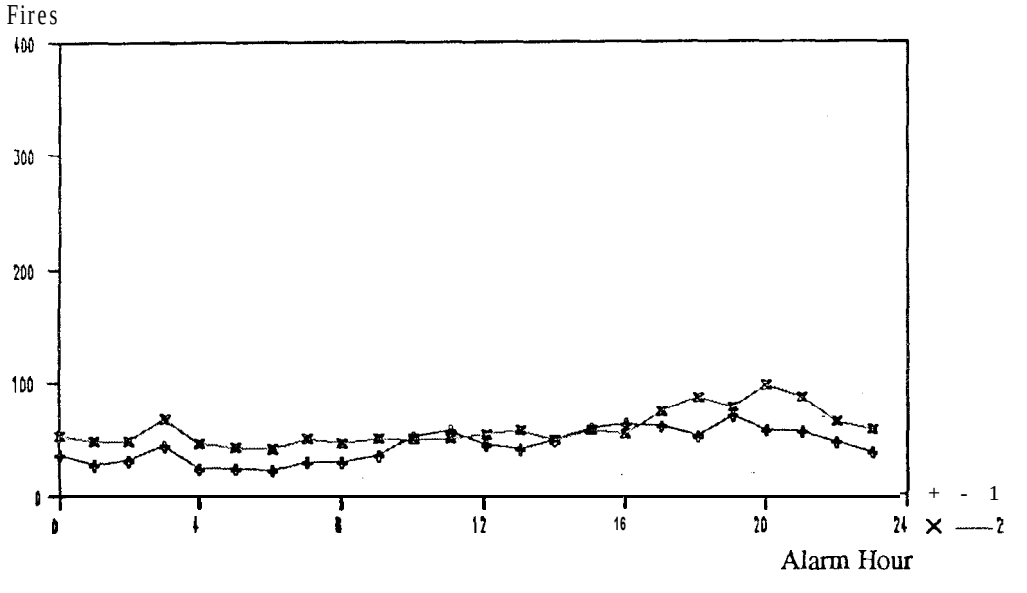


FIGURE B5 VARIATION OF EFD 1 AND EDF 2 WITH ALARM HOUR FOR SPRINKLERS PRESENT AND OPERATED

In Figure B6 the number of fires *confined to the room of origin* (EFD 3) can be seen to rise slowly and unsteadily from 6 am until 9 pm, then falls initially rapidly until 6 am. The minimum is 9 at 10 am and the maximum 38 at 9 pm.

The number of fires *confined to the structure of origin* (EFD 6) is very low throughout the day. This variation is markedly different to the *sprinklers not present* case. The minimum is 1 at 7 am and the maximum 19 at midnight.

Fires with flame damage *confined to the object* of *origin* make up a minimum of 25% of the fires at 3 am and 4 am and a maximum of 59% at 10 am and 11 am. Fires with *flame* damage *confined to the urea* of *origin* range only between 18% and 21% while fires with flame damage *confined to the room of origin vary* slightly more, from 10 % during the day to 16% at 1 am. Fires with flame damage *confined to the fire-rated compartment, storey and structure of origin* together range from 10% of the fires at 10 am to 34% of the fires at 2 am to 4 am. Finally, fires that have *flame damage* that *extends beyond the structure of origin* are a minimum of 2% from 7 am to 7 pm and a maximum of 8% at 4 am.

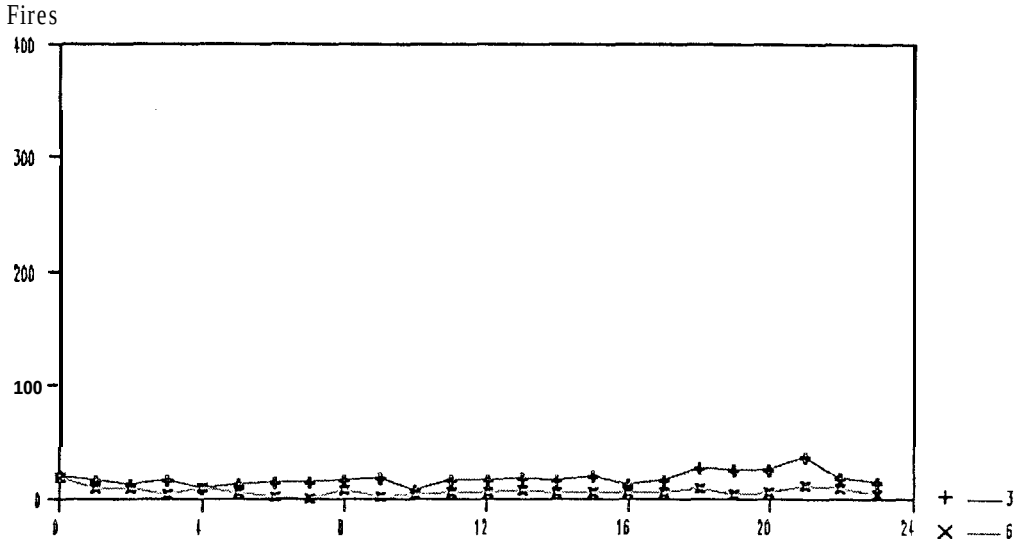
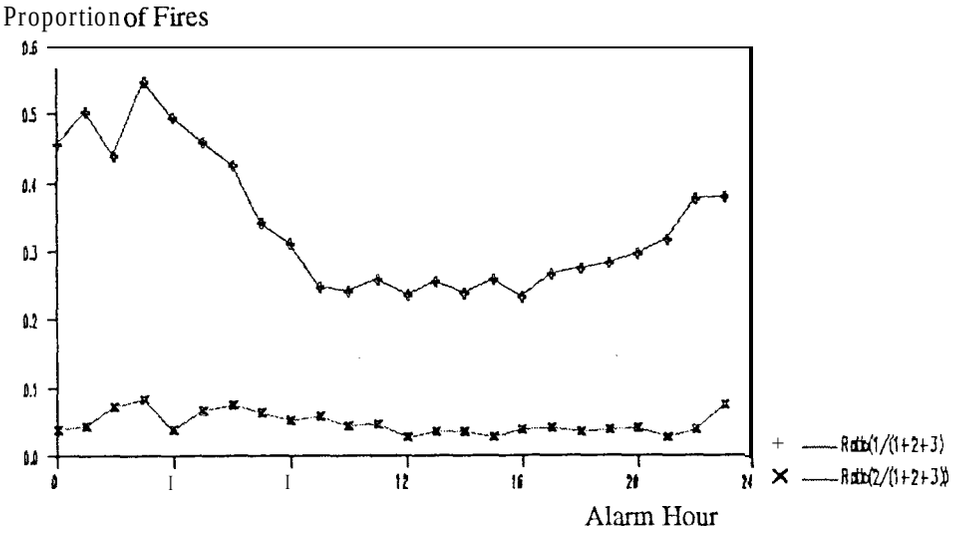


FIGURE B6 VARIATION OF EFD 3 AND EDF 6 WITH ALARM HOUR FOR SPRINKLERS PRESENT AND OPERATED

Thus overall, it is apparent that the proportion of fires with flame damage *confined to the object of origin* whether sprinklers are present or not increases greatly during the hours from about 7 am to about 9 pm. However, in the *sprinklers present* case and contrary to what might be expected, this increase is **not** significantly due to the operation of the sprinklers as the increase in flame *damage confined to the object of origin* in the *sprinklers present and operated* category is comparatively small.

It is also interesting to note that sprinklers operate at a smaller proportion of the fires at which they are present during the hours from about 7 am to about 9 pm (Figure B7).



IN PROPORTION OF SPRINKLER OPERATION CATEGORIES WITH ALARM HOUR

The upper plotted line in Figure B7 is the ratio of the number of fires in which the *sprinklers operated* compared with the number of fires in which *they* were *present* (SP 1 / (SP 1 + SP 2 + while the lower plotted line is the ratio of the number of fires where they did not operate but the reporting fire fighter decided they should have operated (SP 2 / (SP 1 + SP 2 + SP 3)). This second (lower) ratio has a mean of 4.9%, a range of 2.8% to 8.3% and, in comparison with the variation of the other ratio, is relatively constant. (Note again that the distinction between SP 2 and SP 3 is based on the judgement of the reporting fire fighter.)

The ratio SP 1 / (SP 1 + SP 2 + SP 3) is clearly greater during the night than during the day. The maximum is 55% at 3 am and the minimum 23% at 4 pm, but from 9 am until 4 pm only varies between 23% and 26%. It increases slowly until 9 pm and then more rapidly (but unsteadily) until 3 am. It then decreases rapidly until 9 am. The mean is 26.5% from 7 am until 6 pm and 41.7% from 7 pm until 6 am, but 48.8% from midnight to 4 am.

Thus during the day *the sprinklers operate* in 37% fewer fires at which they are present than at night and in 46% fewer fires at which they are present than in the four hours after midnight.

It is hypothesised that this difference is largely due to the presence of alert and responsive people in most areas of the building during the day.

It should be noted that the existence of fires classified *as sprinkler did not operate* (SP 2 and SP 3) requires that the fire has been noticed, the fire brigade notified (whether by people or through some form of detector other than sprinklers), travelled to the fire and entered the building. (It may also be assumed that in a proportion of the cases when the *sprinklers **do** operate* (EFD 1) the fire is first noticed and the fire brigade notified by an agency other than the sprinklers.) Thus, a significant time must have elapsed between the fire being noticed and the arrival at the fire scene of the fire brigade, with the sprinklers still not having operated. An estimated range of total elapse times of 5 to 15 minutes seems reasonable based on fire brigade arrival times in Section 12 and estimates of the other components using the Australian Fire Brigade model.

It is presumed that the range of circumstances in which this may occur is covered by the following:

- the fires are inherently too small to trigger the operation of the sprinklers
- the fires are capable of growing such that the sprinklers would eventually be triggered, but are controlled while small by some other means (including in some cases by the fire brigade)
- the sprinklers simply do not operate

Some information on this aspect is available through the *method of extinguishment* field.

METHOD OF EXTINGUISHMENT

The *method of extinguishment* is examined and the categories defined in Section *20.*

The variation in the *method of extinguishment* with *time of alarm* is shown for the various *sprinkler presence and operation* cases in Figures B8 to B 11. Note that the scale of the vertical axis of Figures B8 to B10 are identical to enable comparison of the *sprinkler present* cases.

In Figure B8 the case of *sprinklers present and operated* is examined.

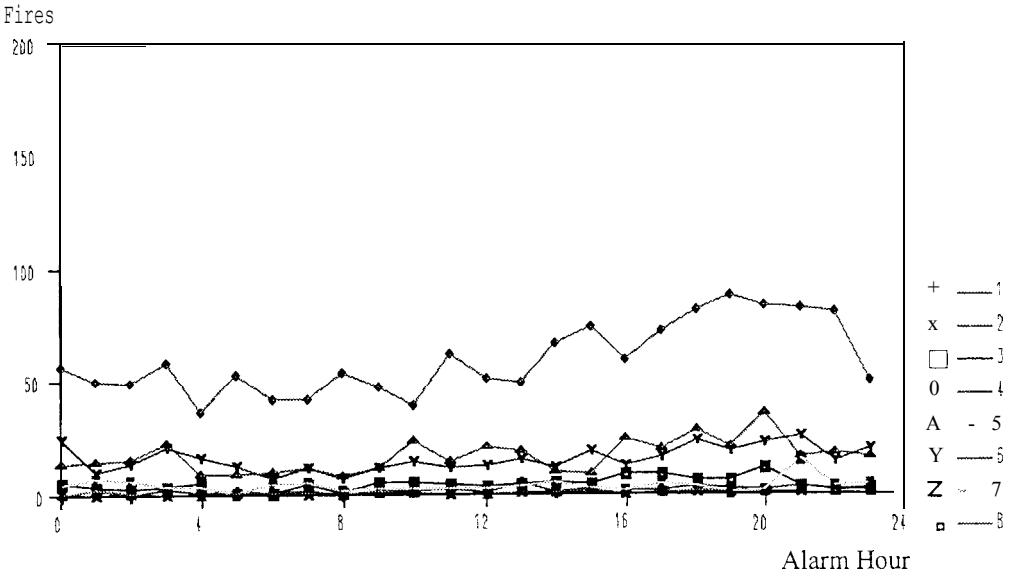


FIGURE B8 VARIATION OF METHOD OF EXTINGUISHMENT WITH ALARM HOUR FOR SPRINKLERS PRESENT AND OPERATED

The number and proportion of fires with MEO 4 *(sprinklers)* rises slowly and unsteadily from midnight to 10 pm (minimum 37 at 4 am, maximum 89 at 7 pm), the other method of extinguishment categories are comparatively low with relatively little variation. MEO 5 *@reconnected hose lines with water carried in apparatus tanks)* is next highest with minimum of 23 at 3 am and maximum of 36 at 8 pm).

Figure B9 shows the case of *sprinklers present but did not operate* and judged by fire fighter that *they should have* (SP 2).

In this case all of the *method of extinguishment* categories are very low compared with other the other sprinkler categories (Figures B8 and B10) and thus on this scale relatively little variation is apparent.

In Figure B 10 the case for *sprinklers present and did not operate* but judged by fire fighter that the *fire was too small* (SP 3) is examined.

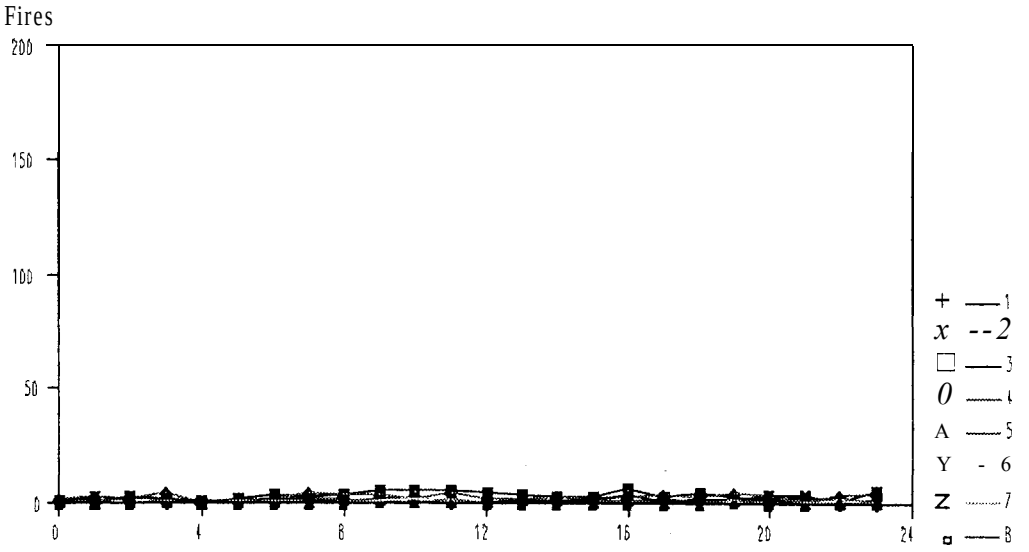


FIGURE B9 VARIATION OF METHOD OF EXTINGUISHMENT WITH ALARM HOUR FOR SPRINKLERS PRESENT AND DID NOT OPERATE BUT JUDGED BY FIRE FIGHTER THAT THEY SHOULD HAVE

The largest numbers and greatest variation occur in MEO 3 (*portable extinguishers,* minimum of 30 at 5 am, maximum of 183 at 6 pm) and then in MEO 1 (self *extinguished,* minimum of 14 at 6 am and maximum of 100 at 4 pm and 7 pm), MEO 2 *(makeshift aids,* minimum of 3 at 6 am and maximum of 54 at 8 pm) and MEO 5 (*preconnected hose lines with water carried in apparatus tanks,* minimum of 14 from 4 am to 6 am and at 8 am, and maximum of 53 at 9 pm).

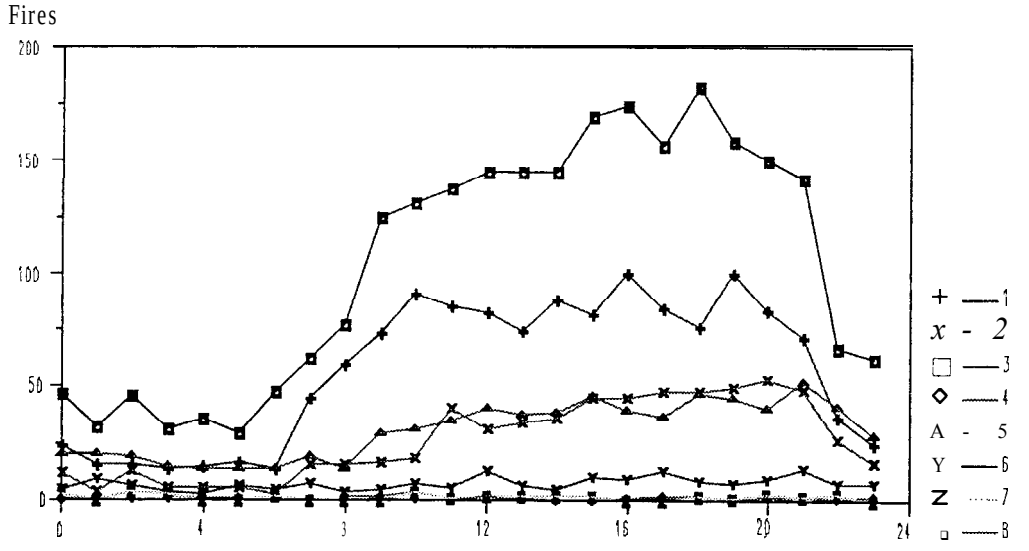


FIGURE B 10 VARIATION OF METHOD OF EXTINGUISHMENT WITH ALARM HOUR FOR SPRINKLERS PRESENT AND DID NOT OPERATE BUT JUDGED BY FIRE FIGHTER THAT THEY SHOULD NOT HAVE

Thus the first two of these *(portable extinguishers and self extinguished)* represent by far the major variation that occurs when there *are sprinklers present* whether they operate (Figure B8) or not (Figures B9 and B 10).

Note that the numbers of fires for each hourly period for both *portable extinguishers* and *self extinguished* (MEO 1 and MEO 3) correlate well with number of fires for *sprinklers present but did not operate* (fire judged too small, SP 3) and *extent of flame damage confined to the object* of *origin* (EFD 1) with r^2 of 0.94 and 0.98 respectively. The numbers of fires for MEO 2 and MEO 5 also correlate reasonably well (r^2 of 0.84 and 0.75) but the other *method of extinguishment* cases do so very poorly.

Figure B 11 examines the case for *sprinklers not present* (SP 8).

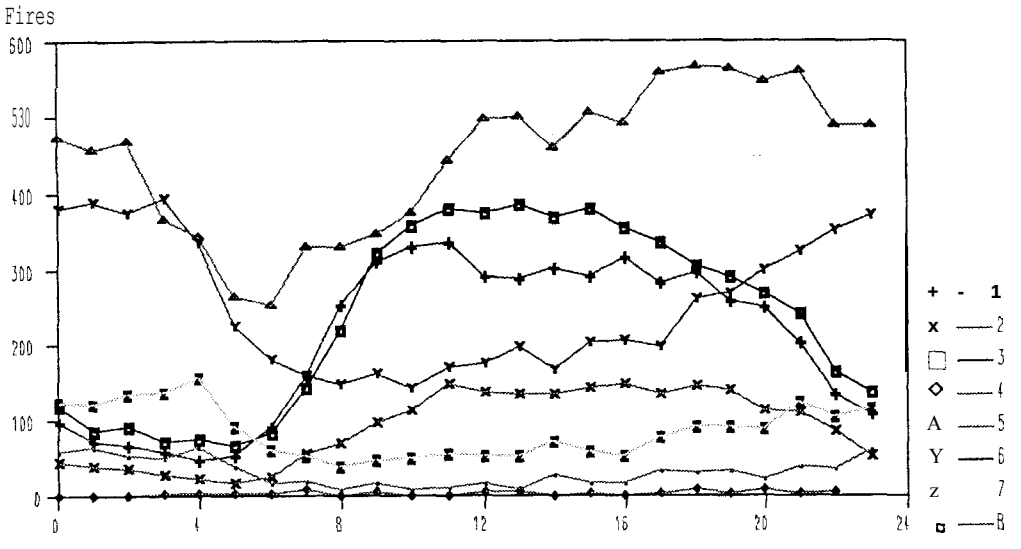


FIGURE B 11 VARIATION OF METHOD OF EXTINGUISHMENT WITH ALARM HOUR FOR SPRINKLERS NOT PRESENT

The largest numbers and greatest variation occur in MEO 5 *@reconnected hose lines with water carried in apparatus tanks,* minimum of 256 at 6 am, maximum of 568 at 6 pm) and then in MEO *6* (*preconnected hose lines with water from hydrant, draft, standpipe,* minimum of 144 at 10 am and maximum of 395 at 3 am), MEO 3 *(portable extinguisher,* minimum of 67 at 5 am and maximum of 386 at 1 pm) and MEO 1 *(self-extinguished,* minimum of 47 at 4 am and maximum of 338 at 11 am).

In some respects the variation in the proportions of each *method of extinguishment* with *time of alarm* is of more interest than the absolute numbers. Thus:

- MOE 1 is a minimum of 3.6% of fires at 4 am and a maximum of 18.5% of fires at 8 am
- MOE 2 is a minimum of 1.7% of fires at 4 am and a maximum of 7.5% of fires at 11 am
- MOE 3 is a minimum of 5.2% of fires at 3 am and a maximum of 19.4% of fires at 10 am
- MOE 4 is very low throughout
- MOE 5 is a minimum of 20.4% of fires at 10 am and a maximum of 3 1.6% of fires at 2 am

- MOE 6 is a minimum of 7.8% of fires at 10 am and a maximum of 28.8% of fires at 3 am
- MOE 7 is a minimum of 2.7% of fires at midnight, 1 am and 4 pm, and a maximum of 11.9% of fires at 4 am
- MOE 8 is a minimum of 0.5% of fires at 1 pm and a maximum of 4.9% of fires at 4 am

It can be seen that the maximum percentages are generally from 2 am to 4 am for the means of *extinguishment* that are most likely to involve fire fighters (MOE 5 to MOE 8) and from 8 am to 11 am for those more likely to involve the building occupants (MOE 1 to MOE 3).

Note that the numbers of fires for MEO 1 and MEO 3 correlate well with number of fires with *sprinklers not present* and extent of flame damage *confined to the object of origin* (r^2 of 0.97 and 0.94 respectively) and MEO 2 *(makeshift aids)* correlates reasonably well (r^2 of 0.83) but the other *method of extinguishment* cases correlate poorly.

Thus the variation of *method of extinguishment* throughout the twenty-four hour period is quite different for *sprinklers present and operated* (Figure BS) compared with *sprinklers present and did not operate* (Figures B9 and B10) and also with *sprinklers not present* (Figure B 11). It is clear that the number of fires with MOE 1 and MOE 3, and to a lesser extent MOE 2, correlate well with the number of fires with extent of flame damage *confined to the object of origin* for *sprinklers present and did not operate* and *sprinklers not present* cases.

VARIATION OF METHOD OF EXTINGUISHMENT WITH SPRINKLER PERFORMANCE

The variation in the recorded *method of extinguishment* with sprinkler presence and performance is summarised in Table B 1.

It can be seen from the figures in the table that for the *sprinklers not present* (SP 8) case *the methods* of *extinguishment* most likely to involve the occupants of the building *(self extinguished, make shift aids* and *portable extinguisher,* MOE 1 to MOE 3) represent about 39% of fires and the methods of *extinguishment* expected to involve the fire fighters (MOE 5 to MOE 8) make up about 60% of fires.

TABLE B1 VARIATION OF METHOD OF EXTINGUISHMENT WITH SPRINKLER PRESENCE AND PERFORMANCE

Method of Extinguishment	% of known fires				
	SP 1	SP 2	SP 3	SP 8	SP 1 + SP 2 +SP 3
MOE 1	2.0	6.1	24.9	15.1	17.3
MOE 2	0.6	3.4	11.6	6.8	8.0
MOE 3	4.8	31.2	45.3	17.3	32.4
MOE 4	56.4	8.4	0.5	0.3	17.9
MOE 5	16.4	27.8	13.5	32.9	14.8
MOE 6	15.2	15.2	3.4	18.8	7.4
MOE 7	4.1	3.4	0.6	6.4	1.8
MOE 8	0.6	4.6	0.1	2.1	0.4

In contrast, when *sprinklers are present and operate* (SP 1) only about 7% of fires are recorded as extinguished by MOE 1 to MOE 3. However, when *sprinklers are present but do not operate* this rises to about 40% for SP 2 *(should have)* and *80%* for **SP 3** (*fire too small*).

In aggregate, when *sprinklers are present* about 58% of *fires* are extinguished by the methods of *extinguishment* most likely to involve the occupants of the building (MOE 1 to MOE 3). The bulk of the difference between this percentage and that for the *sprinklers not present* (SP 8) case is made up of fires with *sprinklers present* but where the *sprinklers do not operate* (SP 3) and the fire is extinguished using a *portable extinguisher* (MEO 3).

With *sprinklers present* MEO 5 and MEO 6 together make up 31.6%, 43.0% and 16.9 % for SP1, SP 2 and SP3 respectively, and MEO 7 and MEO 8 together make up 4.7%, 8.0% and 0.7 % for the same sprinkler cases.

Thus, when *the sprinklers operate* (SP 1) it is predominantly reported that the sprinklers *are the means of extinguishment* and, if not them, that MOE 5 and MOE 6 are *the means of extinguishment.*

However, if the *sprinklers do not operate* and the reporting fire fighter judges that the fire was too small to require their operation (SP 2), then the *means of extinguishment* is reported as **MOE** 1, **MOE 2** or **MOE 3. In** contrast, if the

sprinklers do ***not*** *operate* and the reporting fire fighter judges that they should have (SP 3), then the *means of extinguishment* reported is MOE 3, MOE 5 or MOE 6.

Based on this information it appears to be likely that *portable extinguishers are* more likely to be present (and thus be used) when sprinklers are present than when they are not.

VARIATION OF METHOD OF EXTINGUISHMENT WITH EXTENT OF FLAME DAMAGE

In Tables B2 to B4 the variation of the recorded *method of extinguishment* with *extent of flame damage* is shown for all of the fires where this information is available. The values in these tables are the percentages of relevant fires with known *method of extinguishment* (MOE) and *extent of flame damage* (EFD) for each combination of these fields. Table B2 is for the *sprinklers present and operated* case (SP 1), Table B3 for the *sprinklers present but did nut operate* case (SP 2) and Table B4 for the *sprinklers not present* case (SP 3). In these tables the cells with greater than 5.0% are shaded to highlight the MOE / EFD combinations with the highest proportions of fires.

TABLE B2 VARIATION OF METHOD OF EXTINGUISHMENTWITH EXTENT OF FLAME DAMAGE WITH SPRINKLERS PRESENT AND OPERATED

	% of known fires for SP 1							
MOE	EFD 1	EFD 2	EFD 3	EFD4	EFD 5	EFD 6	EFD 7	All EFD
1	1.5	0.2	0.2	0.0	0.0	0.0	0.0	1.9
2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.6
3	1.9	2.2	0.5	0.0	0.0	0.1	0.0	4.7
4	18.0	28.0	8.2	0.6	0.8	0.8	0.1	56.5
5	5.4	7.3'	2.0	0.1	0.4	0.8	0.2	16.3
6	2.0	6.4	2.6	0.5	0.7	2.6	0.3	15.2
7	0.4	1.4	0.7	0.1	0.2	1.2	0.2	4.2
8	0.0	0.1	0.0	0.0	0.1	0.3	0.1	0.6
All MOE	29.6	45.8	14.3	1.3	2.3	5.8	0.9	100.0

In the *sprinklers operated* case (Table B2) the highest percentage is for MOE 4 *(sprinklers)* and EFD 2 *(confined to the area* of *origin)* and the second highest MOE 4 and EFD 1 *(confined to the object of origin).*

TABLE B3 VARIATION OF METHOD OF EXTINGUISHMENT WITH EXTENT OF FLAME DAMAGE WITH SPRINKLERS PRESENT BUT DID NOT OPERATE

	% of known fires for SP 2 and SP3							
MOE	EFD 1	EFD 2	EFD 3	EFD4	EFD 5	EFD 6	EFD 7	All EFD
1	20.6	2.1	0.2	0.1	0.0	0.1	0.1	23.2
2	8.9	1.7	0.4	0.0	0.0	0.1	0.0	11.1
3	32.5	10.8	1.4	0.2	0.2	0.2	0.0	45.3
4	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.8
5	7.7	5.1	0.6	0.1	0.1	0.8	0.1	14.5
6	1.3	1.4	0.4	0.1	0.1	0.6	0.2	4.0
7	0.3	0.2	0.1	0.0	0.0	0.1	0.0	0.8
8	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.4
All MOE	71.9	21.5	3.1	0.5	0.6	2.0	0.4	100.0

In Table B2 the other values greater than 5.0% (in fact greater than 2.6%) are all in the range MOE 4 to MOE 6 and EFD 1 to EFD 3.

In the *sprinklers did not operate* case (Table B3) the highest percentage is for MOE 3 *(portable extinguisher)* and EFD 1 and the second highest MOE 1 (self *extinguished)* and EFD 1. The other values greater than 5.0% (in fact greater than 2.1%) are all in the range MOE 1 to MOE 5 (excluding MOE 4) and EFD 1 and EFD 2.

In the *sprinklers not present* case (Table B4) the highest percentages are for MOE 1, MOE 3 and MOE 5 and EFD 1, closely followed by MOE 5 and EFD 2. The other values greater than 5.0% are for MOE 5 and MOE 6 and EFD 6.

TABLE B4 VARIATION OF METHOD OF EXTINGUISHMENT WITH EXTENT OF FLAME DAMAGE WITH SPRINKLERS NOT PRESENT

	% of known fires for SP 8							
MOE	EFD 1	EFD 2	EFD 3	EFD4	EFD5	EFD 6	EFD7	All EFD
1	12.3	1.4	0.4	0.0	0.0	0.3	0.0	14.4
2	4.7	1.5	0.2	0.0	0.0	0.2	0.0	6.6
3	12.0	4.3	0.6	0.1	0.1	0.3	0.1	17.4
4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.3
5	11.9	10.6	3.5	0.3	0.6	5.6	0.8	33.2
6	1.7	3.6	2.7	0.5	1.1	8.3	1.4	19.1
7	0.6	0.9	0.7	0.1	0.3	3.2	0.7	6.5
8	0.1	0.1	0.0	0.0	0.0	1.4	0.7	2.4
All MOE	43.3	22.5	8.1	1.1	2.2	19.2	3.7	100.0

EFFECT OF SPRINKLERS AND DETECTORS ON EXTENT OF FLAME DAMAGE

Table B5 shows the percentages of fires with known sprinkler and detector presence and operation and known extent of flame damage.

TABLE B5 EFFECT OF SPRINKLERS AND DETECTORS ON EXTENT OF FLAME DAMAGE

		% of known fires							
SP	DP	EFD 1	EFD 2	EFD 3	EFD 4	EFD 5	EFD 6	EFD 7	Fires
1	1	41.6	37.1	12.5	0.9	1.7	5.6	0.5	983
2+3	1	75.9	17.4	2.8	1.0	1.2	1.5	0.3	688
8	1	49.3	22.0	8.6	1.7	2.4	13.6	2.5	2690
1	3+5	49.4	34.5	9.2	1.1	1.1	4.6	0.0	87
		79.1	16.1	2.5	0.3	0.4	1.4	0.2	1678
8	3+5	71.6	16.1	3.5	0.9	1.1	5.4	1.4	1016
1	2	29.9	41.9	14.4	0.6	2.4	7.8	3.0	167
2+3	2	68.0	22.5	2.8	2.1	1.4	2.8	0.4	284
8	2	44.0	23.3	10.1	1.6	3.1	13.7	4.0	940
1	4	26.5	49.0	19.6	2.0	2.0	1.0	0.0	102
2+3	4	67.9	27.9	2.0	0.2	0.2	1.6	0.2	498
8	4	51.8	28.2	6.8	0.7	1.5	9.7	1.2	1187
1	8	27.4	47.8	14.3	1.7	2.8	5.1	0.8	1433
2+3	8	69.1	23.8	3.3	0.5	0.5	2.1	0.6	2843
8	8	43.1	22.6	8.1	1.0	2.3	19.5	3.4	30361

From the figures in this Table B5:

- with *sprinklers not present* and *detectors not present* (either *in room of origin* or *not in room of origin)* nearly 7470 of fires had flame damage *confined to the room of origin*
- with *sprinklers present* in the *room of origin* between 9470 of fires (with *detectors not present* at all) and just over 9570 of fires (with *detectors in the room of origin* also) had flame damage *confined to the room of origin*
- with *sprinklers not present* and with *detectors present* between nearly 83% (with *detectors not in the room of origin)* and nearly 85% (with *detectors in the room of origin)* had fires with flame damage *confined to the room of origin*

Thus, in summary:

- detectors provide some improvement (from 26% of fires with *flame damage not confined to the room of origin* to 16% of fires with *flame*

damage not confined to the room of *origin,* an improvement factor of 1.6)

- but sprinklers provide greater improvement (from 26% of fires with *flame damage not confined to the room of origin* to 6% of fires with *flame damage not confined to the room of origin,* an improvement factor of 4.3)
- there is little further improvement (over sprinklers alone) associated with having both sprinklers and detectors

VARIATION OF VARIOUS FIELDS WITH ALARM HOUR

In Figures B12 to B22 the variation in the number of fires in the various categories of several of the fields in the database with alarm hour may be observed. In these figures all of the fires where the required information is known are included in the data on which the figures are based.

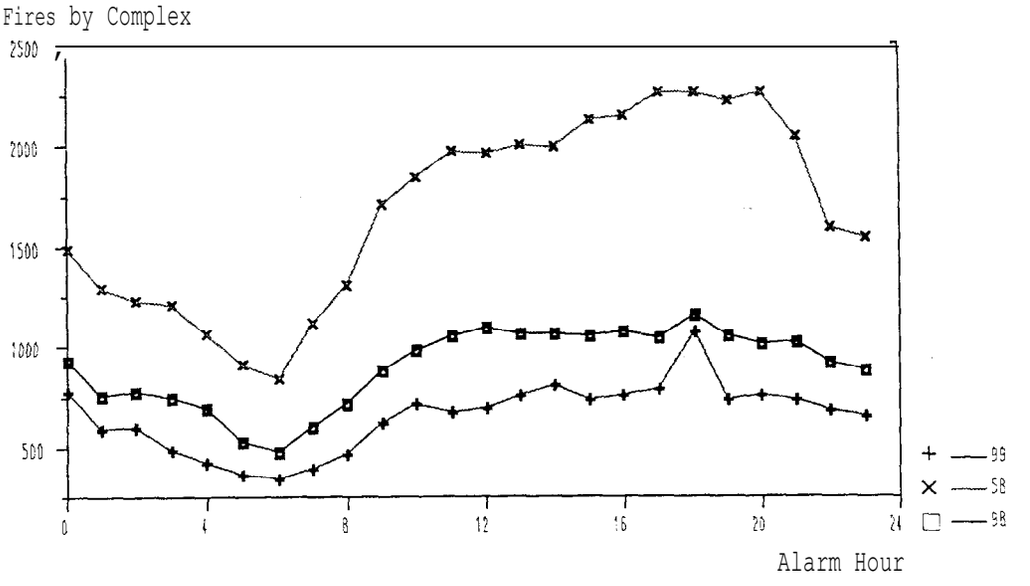


FIGURE B 12 VARIATION OF NUMBER OF FIRES BY COMPLEX WITH ALARM HOUR

The variation of CON 58 *(shopping complex)* with time of alarm appears to be very similar to that of EFD 1 in Figure B1. Their quite close correlation is confirmed by an r^2 of 0.89. The correlation with EFD 1 of COM 98 (no *complex,* r^2 of 0.79) is not quite so good and COM 99 *(unknown complex,* etc, r^2 of 0.58) is much worse.

The sharp peak at 6 pm (alarm hour 18) is due to the fires that accompanied the Los Angeles riots of 29 April 1992, and similar peaks are be seen in some categories for some fields in Figures B 13 to B22.

In Figure B 13 it can be seen that the variation of most of the *fixed property use* categories is quite similar with FPU 52, FPU 53, FPU 54 and FPU 55 quite tightly bunched at a relatively low level through the 24 hours. FPU 51 (*food, beverage* sales) has the greatest number of fires all through the 24 hour period but varies quite differently compared with the other categories.

Because of the number of *fixed property* use categories in Figure B 13 it is difficult to visually assess the correlation of any one of them with EFD 1. Checking the correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour shows that for FPU 56 is very high (r^2 of 0.98) and FPU 52 and FPU 58 are also high (r^2 of 0.91 and 0.93 respectively), but FPU 54 and FPU 57 are only moderate (r^2 of 0.88 and 0.80 respectively), FPU 53 and **FPU** *55* low (r^2 of 0.67 and 0.79 respectively) and very low for FPU 5 1 (r^2 of 0.08).

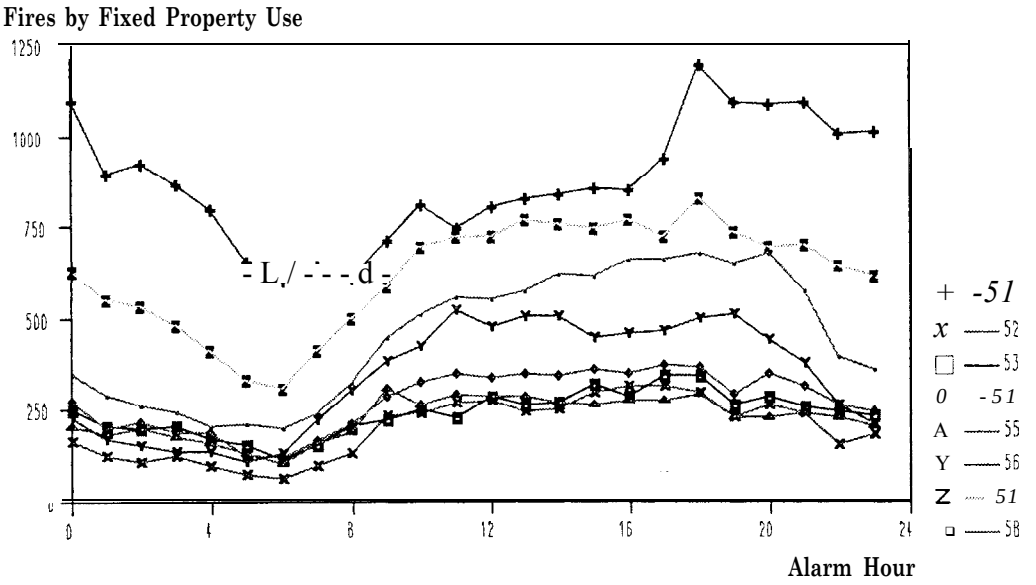


FIGURE B 13 VARIATION OF NUMBER OF FIRES BY FIXED PROPERTY USE WITH ALARM HOUR

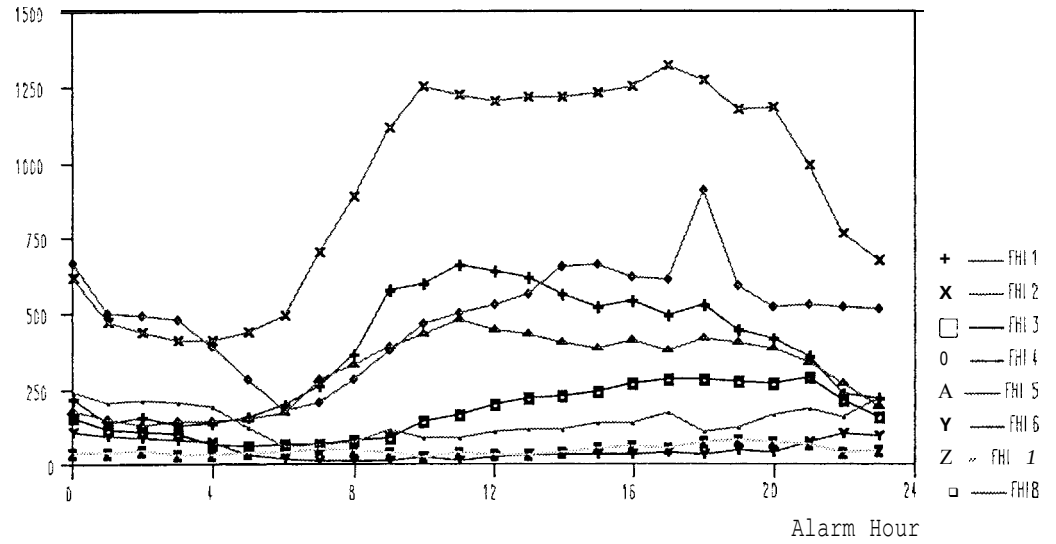


FIGURE B 14 VARIATION OF NUMBER OF FIRES BY FORM OF HEAT OF IGNITION WITH ALARM HOUR

FHI 2 *(heatfrom electrical equipment arcing, overload)* stands out from the other categories through most of the 24 hour period, but particularly during the period from 6 am to 10 pm and clearly has a shape similar to EFD 1 (Figure Bl). The category FHI 4 *(heatfrom open flame, spark)* has the peak associated with the Los Angeles riots mentioned above.

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for FHI 2 is very high (r^2 of 0.98), FHI 5 is high (r^2 of 0.92), FHI 1 is moderate (r^2 of 0.87), but is low or very low for FHI 3, FHI 4 and FHI 6, FHI 7 and FHI 8 (r^2 of 0.63, 0.36, 0.24, 0.11 and 0.11 respectively).

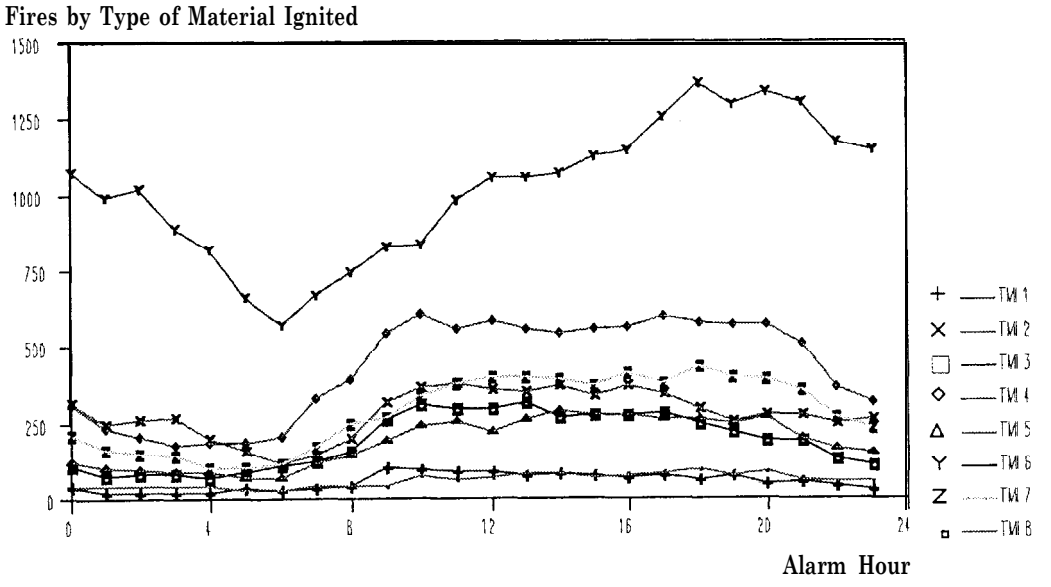


FIGURE B 15 VARIATION OF NUMBER OF FIRES BY TYPE OF MATERIAL IGNITED WITH ALARM HOUR

TMI 6 (wood, paper) stands out from the other categories in Figure B 15 both for its high magnitude and because it varies differently during the 24 hours. Its prominence and the way it varies appears to have much in common with FPU 51 (Figure B 13). TMI 4 (*plastic*)is the next most prominent category and its variation appears to be much more similar to EFD 1 (Figure B 1).

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for TMI 4, TMI 5 and TMI 7 are very high (r^2 of 0.97, 0.96 and 0.96 respectively), TMI 3 is high (r^2 of 0.90), TMI 1, TMI 2 and TMI 8 are moderate (r^2 of 0.73, 0.62 and 0.78 respectively), but is low for TMI 6 (r^2 of 0.36).

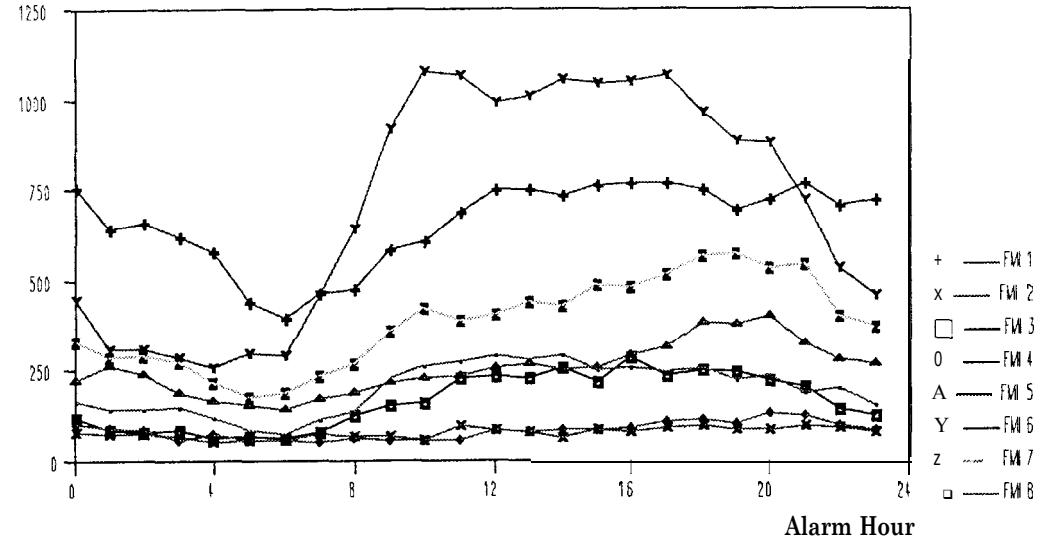


FIGURE B 16 VARIATION OF NUMBER OF FIRES BY FORM OF MATERIAL IGNITED WITH ALARM HOUR

In Figure B 16, FMI 6 (power transfer equipment, *fuel*) through much of the day and appears the most like EFD 1. FMI 1 (structural component, *finish)* is also prominent, particularly from 10 pm to 6 am, but the variation is quite different to that of EFD 1 and FMI 6.

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for FMI 6 is very high (r^2 of 0.97), FMI 3 is high (r^2 of 0.91), FMI 8 is moderate (r^2 of 0.88), but is low or very low for FMI 1, FMI 2, FMI 4, FMI 5 and FMI 7 (r^2 of 0.42, 0.32, 0.15, 0.42 and 0.74 respectively).

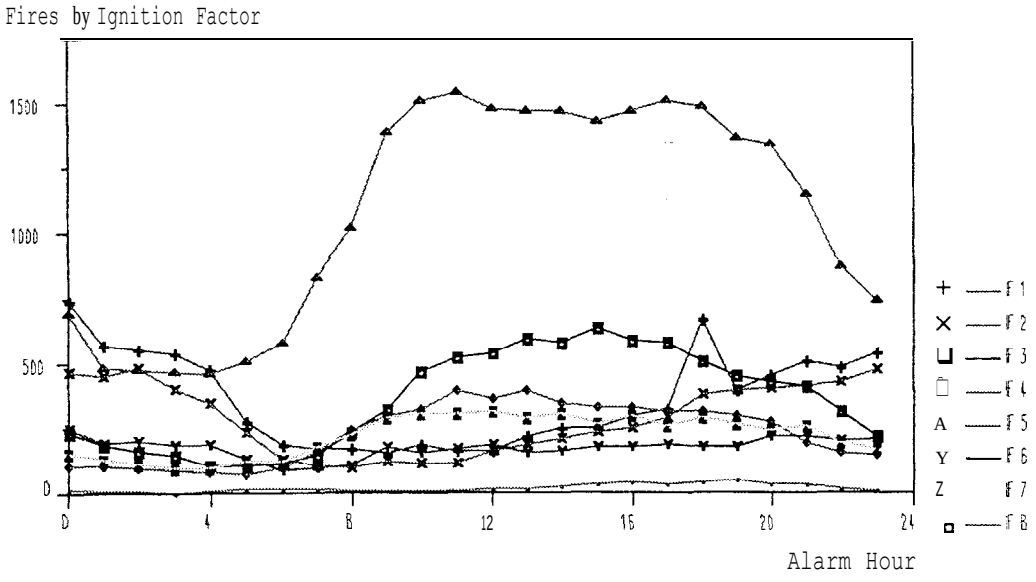


FIGURE B17 VARIATION OF NUMBER OF FIRES BY IGNITION FACTOR WITH ALARM HOUR

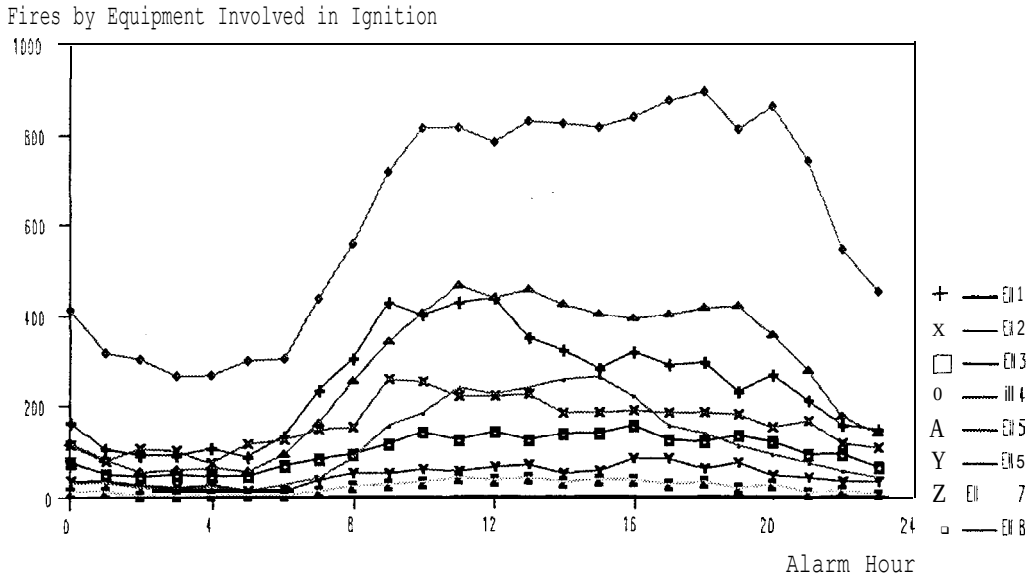


FIGURE B18 VARIATION OF NUMBER OF FIRES BY EQUIPMENT INVOLVED IN IGNITION WITH ALARM HOUR

IF 5 *(mechanical failure,* malfunction) predominates over the other categories in Figure B17 and appears to vary similarly to EFD 1. IF1 *(incendiary)* shows the peak associated with the Los Angeles riots.

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for IF 3, IF 4, IF 5 and IF 7 is very high or high (r^2 of 0.0.94, 0.91, 0.97 and 0.93 respectively), but is low or very low for IF 1, IF 2, IF 4, and IF 8 (r^2 of 0.11, 0.08, 0.02 and 0.38 respectively).

In many fires there is no equipment involved in the ignition of the fire or, if there is, it is unknown. Of the 77,996 fires in the database 27,428 had no equipment involved (EII 98) and a further 12,571 were unknown, *etc.* The following information relates to the remaining 37,997 fires for which an *equipment involved in ignition* category was entered. For these, the predominant category of *equipment involved in ignition* through the 24 hours (Figure B 18) is EII 4 *(electrical distribution equipment)* for which the variation in the number of fires through the 24 hour period appears to be very similar to that for EFD 1.

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for EII 3, EII 4 and EII 5 is high or very high (r^2 of 0.91, 0.98 and 0.96 respectively), EII 6, EII 7 and EII 8 is moderate (r^2 of 0.79, 0.82 and 0.78), but is low for the remaining categories (0.69 for both).

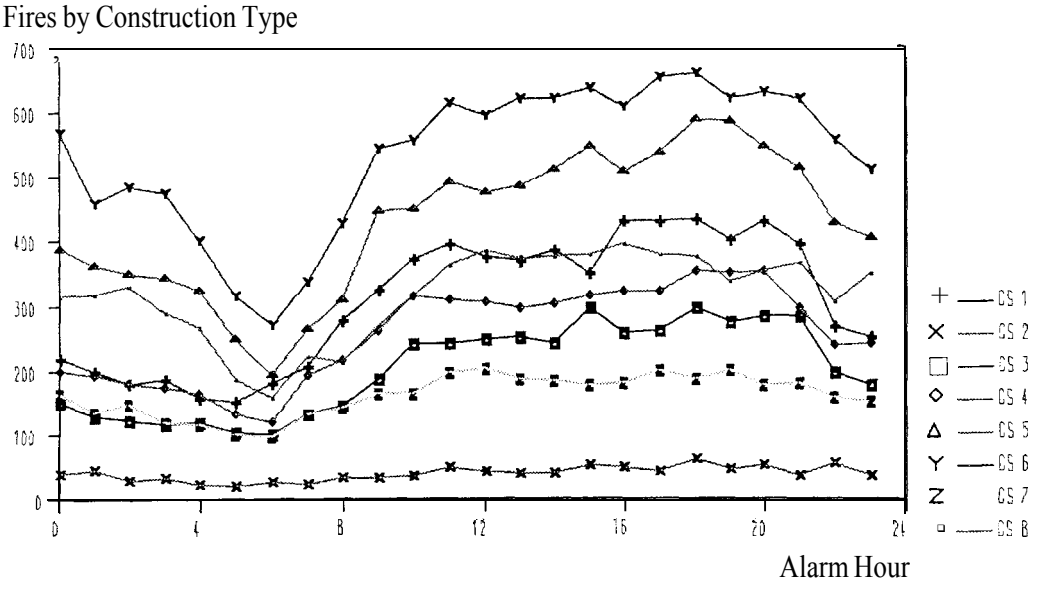


FIGURE B 19 **VARIATION** OF NUMBER OF FIRES BY CONSTRUCTION TYPE WITH ALARM HOUR

In Figure B19 the variation of most of the categories appears to be fairly similar with only CS 2 (heavy *timber)* standing out, both for low magnitude and because it is relatively constant through the 24 hours.

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for CS 1 and CS 4 is high (r^2 of 0.94 and 0.91 respectively), CS 3, CS 5, CS 6 and CS 8 is moderate (r^2 of 0.89, 0.78, 0.73 and 0.81 respectively), but is low for CS 2 and CS 8 (r^2 of 0.46 and 0.54 respectively).

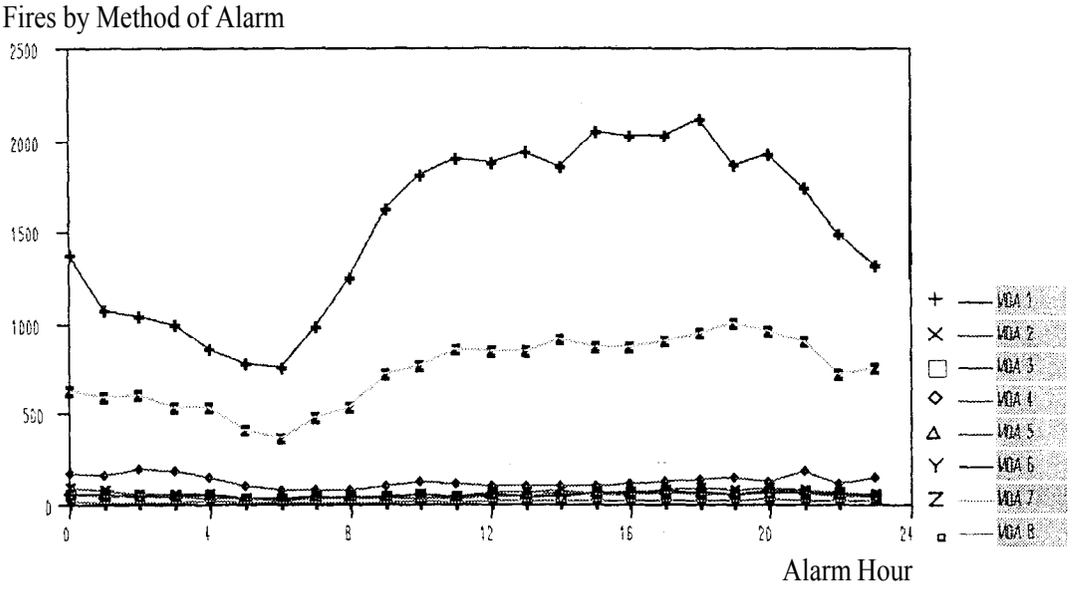


FIGURE B20 VARIATION OF NUMBER OF FIRES BY METHOD OF ALARM WITH ALARM **HOUR**

MOA 1 *(telephone direct to fire department)* predominates through the day with MOA 7 *(telephone tie-line to fire department)* being the only other significant method of alarm category (Figure B20).

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour is very high only for MOA 1 (r^2 of 0.95), is moderate for MOA 7 (r^2 of 0.80)and is very low for the remaining categories.

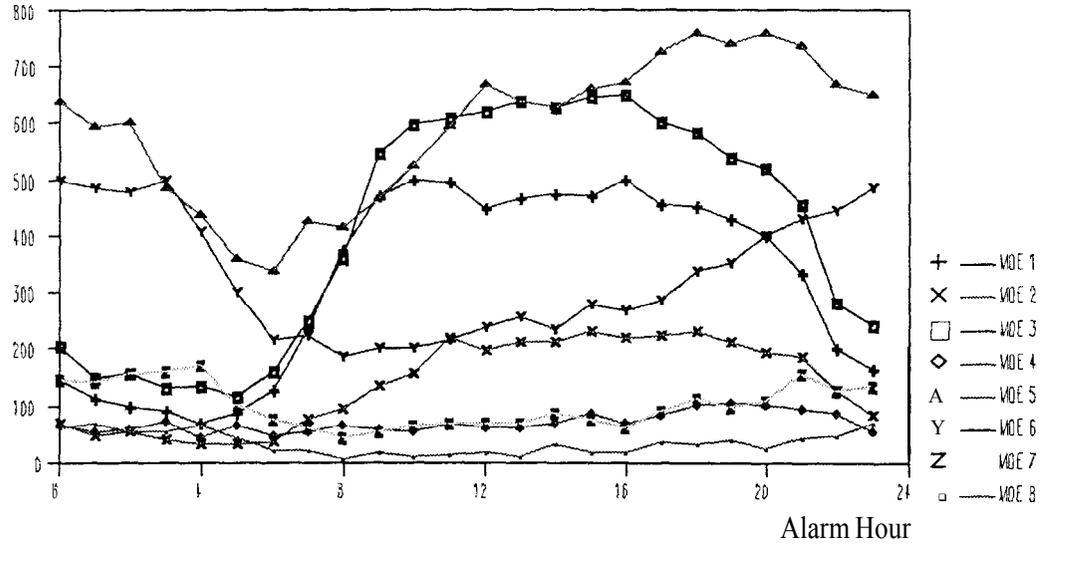


FIGURE B2 1 VARIATION OF NUMBER OF FIRES BY METHOD OF EXTINGUISHMENT WITH ALARM HOUR

In Figure B21 MOE *5 (preconnected hose line(s) with water carried in apparatus tanks)* predominates during the night and varies quite differently to MOE 1 (self *extinguished)* and MOE 3 *(portable extinguisher)* which appear to be the categories that vary most similarly to EFD 1. The variation of EFD 6 *@reconnected hose line(s) with waterfrom hydrant, draft, standpipe)* is markedly

different to these three categories. The variation of MOE 5 appears quite similar to that of FPU 5 1 and TMI 6.

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for MOE 1, MOE 2 and MOE 3 is very high or high (r^2 of 0.93, 0.97 and 0.98) but is low or very low for MOE 4, MOE 5, MOE 6, MOE 7 and MOE 8 (r^2 of 0.3 1, 0.43, 0.22, 0.27 and 0.37 respectively).

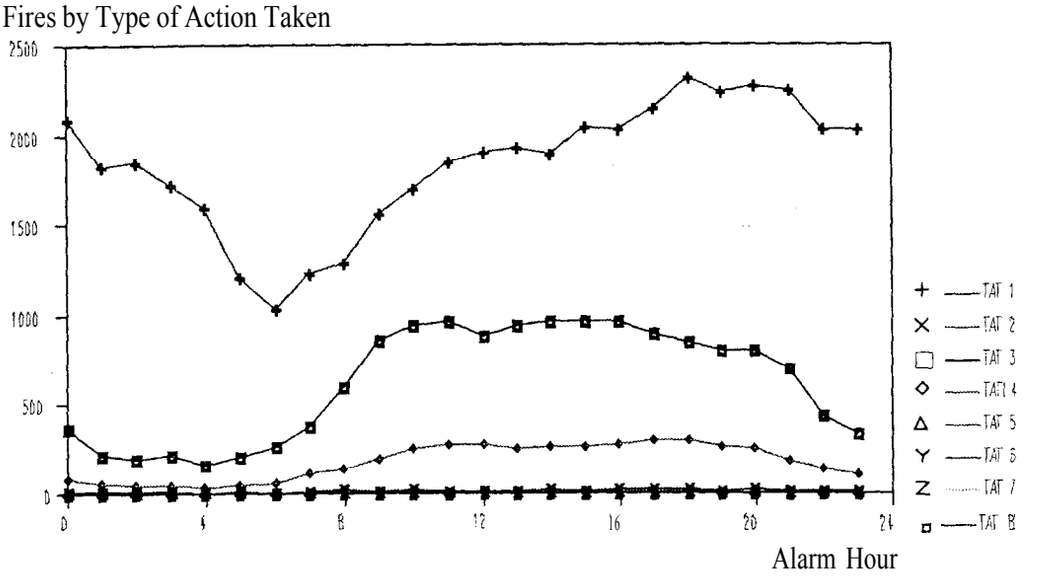


FIGURE B22 VARIATION OF NUMBER OF FIRES BY TYPE OF ACTION TAKEN WITH ALARM HOUR

Although TAT 1 (*extinguishment*) predominates the category of type of action taken that varies most like EFD 1 is TAT 3 TAT 4 (remove *hazard)* is the only other category with a magnitude noticeably above zero, The variation of TAT 1 appears similar to FPU 5 1, TMI 6 and MOE 5.

Correlation of number of fires for EFD 1 for each alarm hour and the number of fires for each alarm hour for TAT 3 and TAT 4 is very high (r^2 of 0.97 and 0.98 respectively), but is very low for the remaining categories.

In summary:

- the variation of the number of fires for COM 58, FPU 52, FPU 56, FPU 58, FHI 2, FHI 5, TMI 3, TMI 4, TMI 5, TMI 7, FMI 3, FMI 6, IF 3, IF *4,* IF *5, IF 7,* CS 1, CS 4, MOA 1, MOE 1, MOE 2, MOE 3, EII 3, EII 4, EII 5, TAT 3 and TAT 4 all correlate highly with the number of fires for EFD 1 for each alarm hour
- the variation of the number of fires for FPU 51, TMI 6, FMI 1 (predominates only at night) and MOE 5 (predominates only at night) and TAT 1 does not correlate well with the number of fires for EFD 1 for each alarm hour but each predominates over the other categories in their field.

VARIATION OF VARIOUS FIELDS. WITH ALARM HOUR AND EXTENT OF FLAME DAMAGE

Figures B23 to B34 present similar information to Figures B12 to B22, but rather than presenting the overall situation each graph within the figures present information for a specific range of *extent of flame damage.* The *extent of flame damage* categories represented by the graphs are:

- *confined to the object of origin* (EFD 1)
- *confined to the area* of *origin* (EFD 2)
- *confined to the room of origin* (EFD 3)
- *confined to the fire rated compartment, storey or structure of origin* (EFD 4 + EFD 5+EFD 6)
- *beyond the structure of origin* (EFD 7)

Rather than commenting in detail on each graph, these graphs have been used to develop scenarios that indicate the most common categories of each of the fields for the *extent of flame damage* and time period represented by the scenario. The scenarios, numbered 1 to 30 follow Figure B34.

Each scenario represents a four hour time period: midnight to 4 am, 4 am to 8 am, 8 am to 12 midday, midday to 4 pm, 4 pm to 8 pm and 8 pm to midnight and an *extent of flame damage* as indicated above for the data represented by the graphs in Figures B23 to 34.

Perusal of the graphs shows that the fires that occur during the twenty-four hour period vary considerably, even within an *extent of flame damage* category. The scenarios are intended to summarise the most probable fire situations for the four hour periods nominated. The periods used are quite arbitrary.

In the scenarios the percentage given is the average percentage over the time period. The percentages are generally only given for categories with percentages greater than 10%, although lower percentages are given if they are considered to be of particular interest.

Comparison of the graphs and scenarios enables an understanding to be developed of the likely differences between fires of different *extent of flame* damage and occurring at different periods of the day. For example, comparison of Scenarios 1 and 4 (both for the time period 12 midnight to 4 am) show that significant differences appear to exist between fires *confined to the object of origin* and those *confined to the fire rated compartment, storey or structure of origin* at these times in a range of factors including:

- *ignition factor* is classified as *mechanical failure, malfunction* for 3 1 % of fires in Scenario 1 but only 18% in Scenario 4 and 34% are classified as *incendiary* or *suspicious* in Scenario 1 but 60% in Scenario 4
- the *method of extinguishment* is classified as *preconnected hose line(s) with waterfrom hydrant, draft, standpipe* for 48% of fires in Scenario 4 but is less than 10% (by its non-appearance) in Scenario 1 and *portable*

extinguisher for 23% of fires in Scenario 1 but less than 10% in Scenario 4

A further example: comparison of Scenario 1 (midnight to 4 am, confined *to object* of *origin)* with Scenario 16 (12 midday to 4 pm, confined *to object of* origin) show such differences as:

- *fixed property use* is classified as *food and beverage sales* in 42% of fires in Scenario 1 but only 24% in Scenario 16
- *ignition factor* is classified as *mechanical failure, malfunction* for 3 1 % of fires in Scenario 1 but 52% in Scenario 16 and 34% are classified as *incendiary* or *suspicious* in Scenario 1 but both of these are less than 10% in Scenario 16
- the *method of extinguishment* is classified as *preconnected hose Line(s) with waterfrom apparatus tanks* for 36% of fires in Scenario 1 but 21% of fires in Scenario 16 and *portable extinguisher* for 23% of fires in Scenario 1 but 33% of fires in Scenario 16

Thus, these scenarios aid in comparison of fires at different times and of differing severity (as measured by *extent of flame damage).*

In comparing the graphs and scenarios it becomes apparent that the great variation in *extent of flame damage* that occurs during the 24 hour period is not solely due to the greatly increased number of fires that occur during the day and early evening. It is also due to reductions in the *extent of flame spread* during the day and early evening for some of the categories that vary differently to EFD 1 or that predominate, particularly during the night.

Thus fires for *form of heat of ignition* category *heat from open flame, spark* (FHI *4)* have *extent of flame damage* extending *beyond the room of origin* for about 33% of fires during the period 12 midnight to 4 am and a minimum of about 13 % during the period 12 midday to 4 pm. Similarly:

- *form of heat of ignition heat from another hostile fire (exposure)* (FHI 8) has *extent of flame damage* extending *beyond the room of origin* for about 3 1% of fires during the period 12 midnight to 4 am and a minimum of about 23% during the day.
- *type of material ignited* category *wood paper* (TMI 6) has *extent of flame damage* extending *beyond the room of origin* for about 3 1% of fires during the period 12 midnight to 4 am and a minimum of about 14% during the day.
- *type of material ignited* category *flammable, combustible liquid* (TMI 2) has *extent of flame damage* extending *beyond the room of origin* for about 35% of fires during the period 12 midnight to 4 am and a minimum of about 18% during the day.
- *form of material ignited* category *structural component, finish* (FMI 2) has *extent of flame damage* extending *beyond the room of origin* for about 36% of fires during the period 12 midnight to 4 am and a minimum of about 18% during the day.

- *ignition factor* categories *incendiary and suspicious* (IF 1 and 2) has *extent of flame damage* extending *beyond the room of origin* for about 37% of fires during the period 12 midnight to 4 am and a minimum of about 14% during the day.

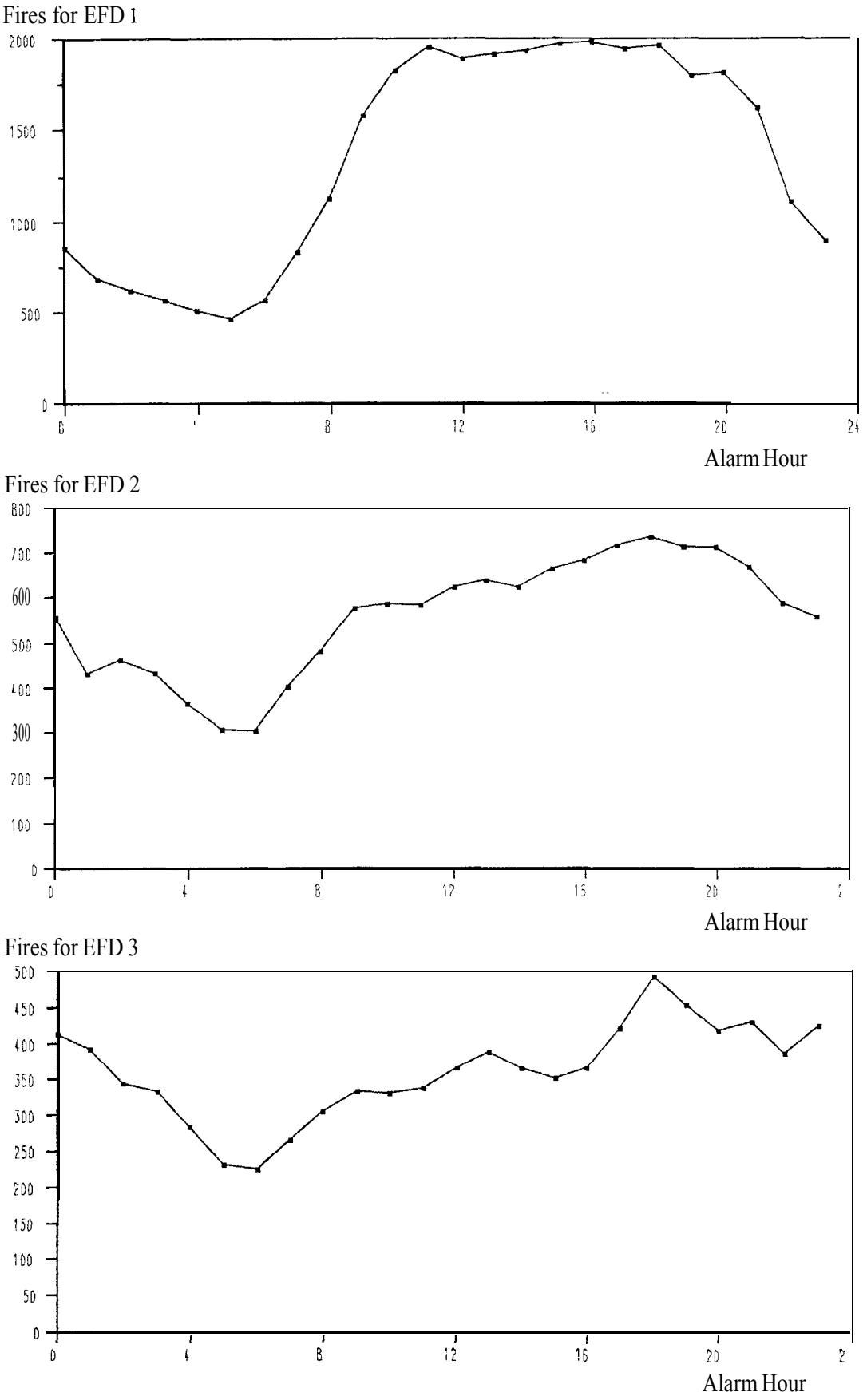


FIGURE B23 VARIATION OF NUMBER OF **FIRES** BY EXTENT OF **FLAME DAMAGE** **WITH** ALARM **HOUR**

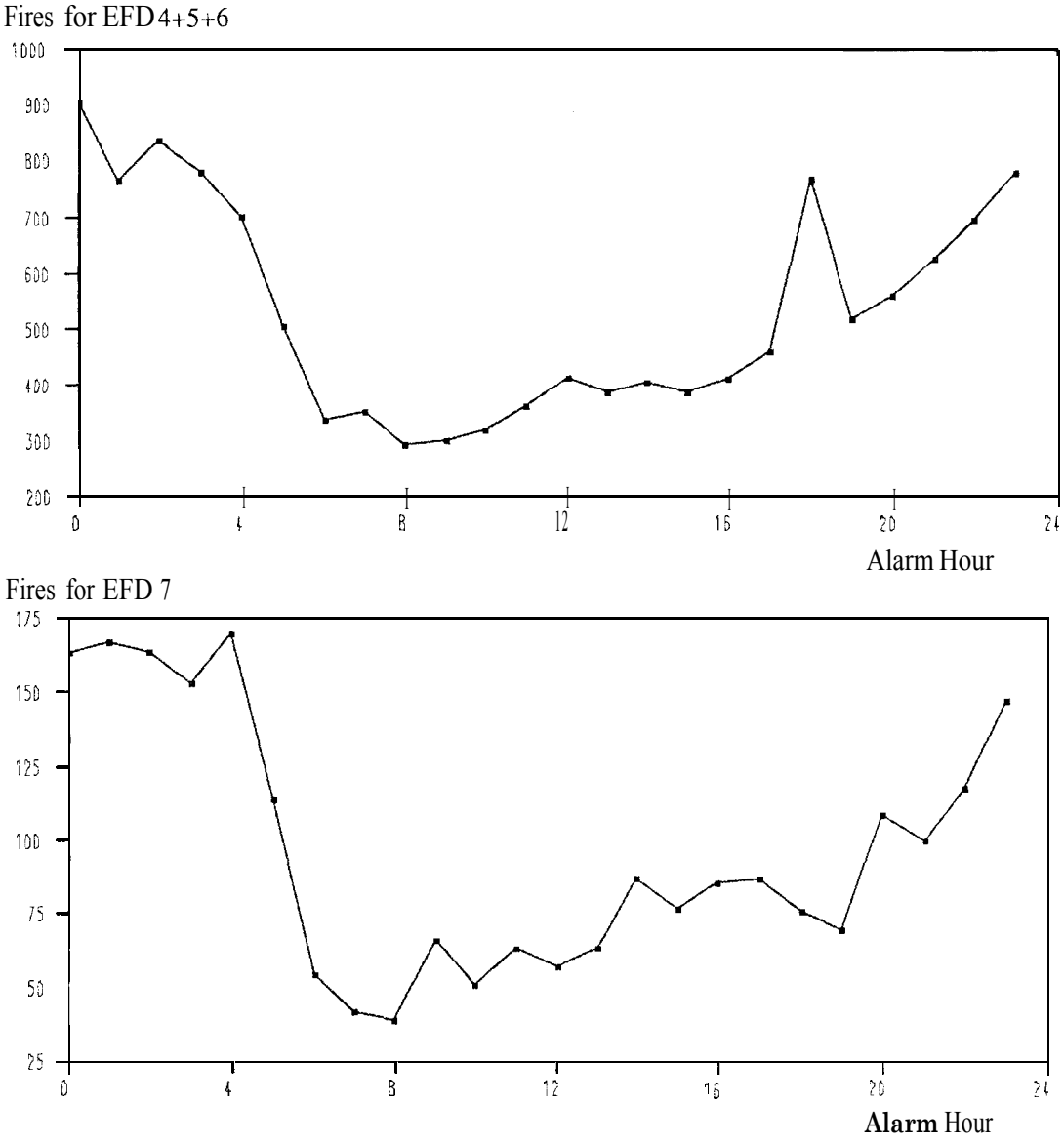


FIGURE B23 VARIATION OF NUMBER OF FIRES BY EXTENT OF FLAME DAMAGE **WITH** ALARM HOUR (CONTINUED)

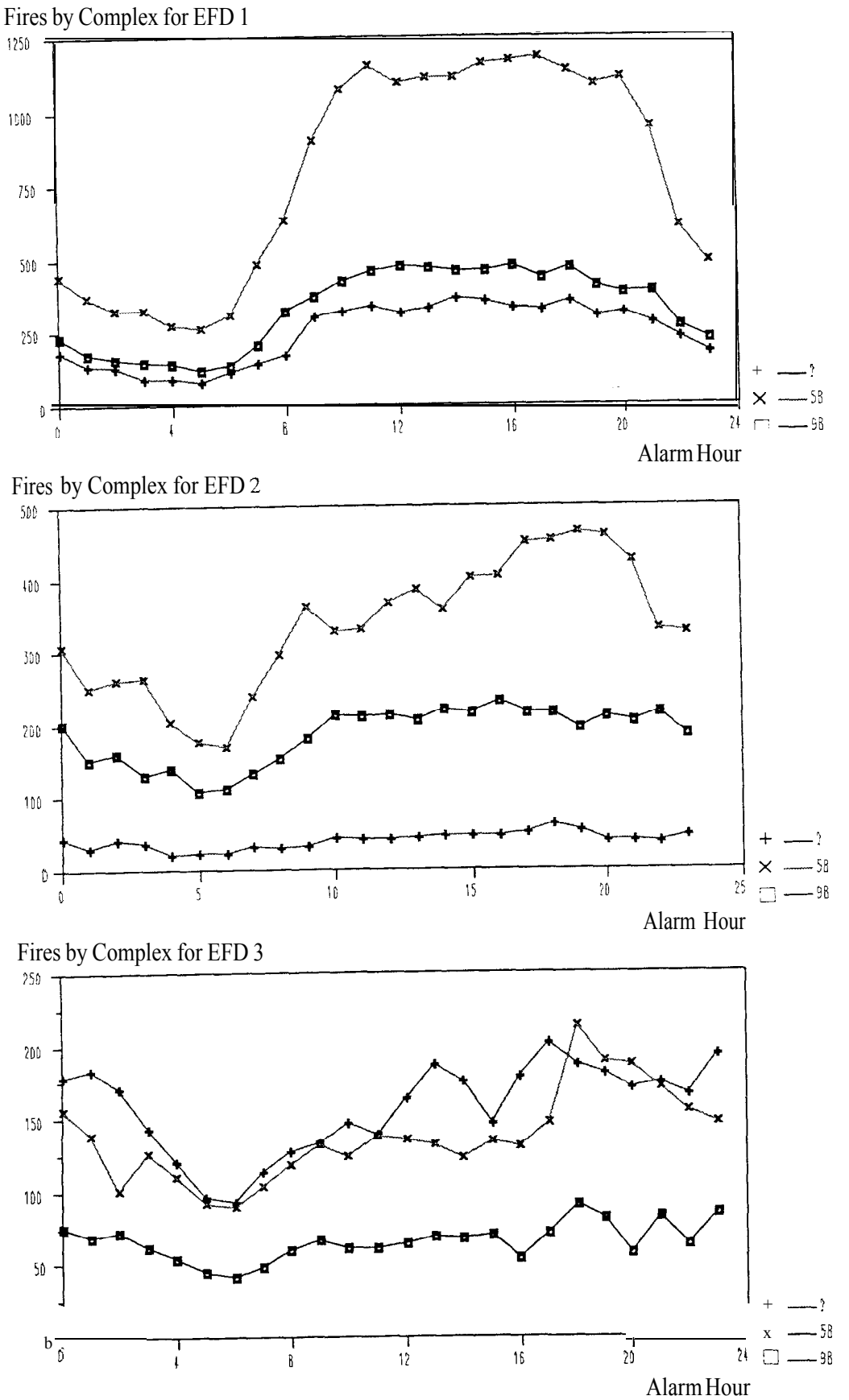
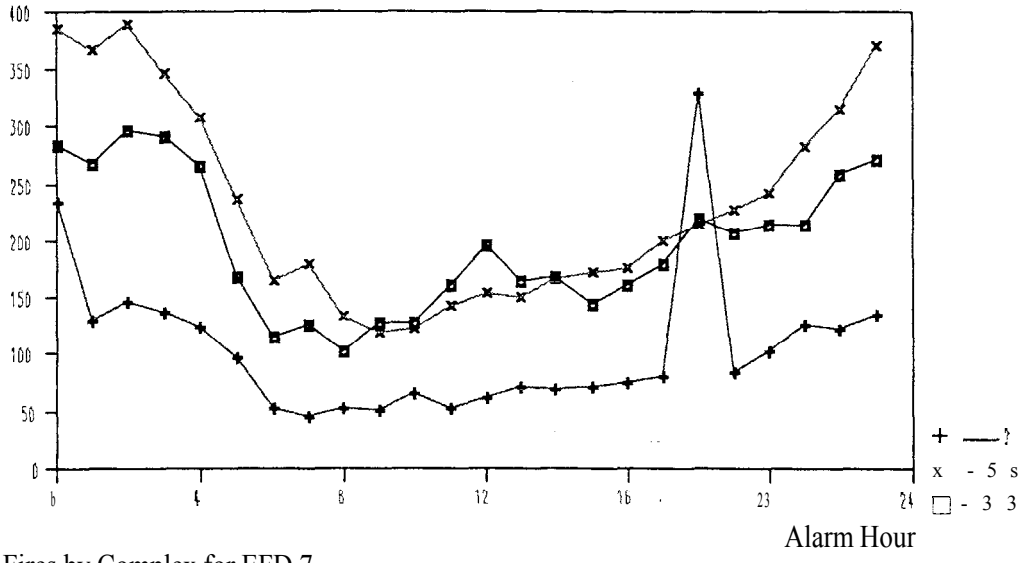


FIGURE B24 VARIATION OF NUMBER OF FIRES BY COMPLEX AND EXTENT OF FLAME **DAMAGE** WITH **ALARM HOUR**

Fires by Complex for EFD 4+5+6



Fires by Complex for EFD 7

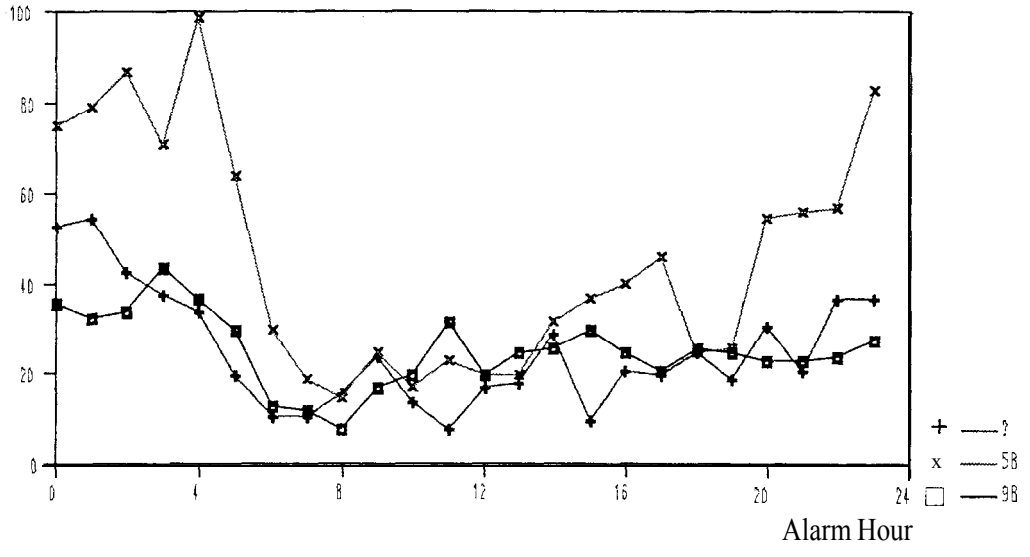


FIGURE B24 VARIATION OF NUMBER OF FIRES BY COMPLEX AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR (CONTINUED)

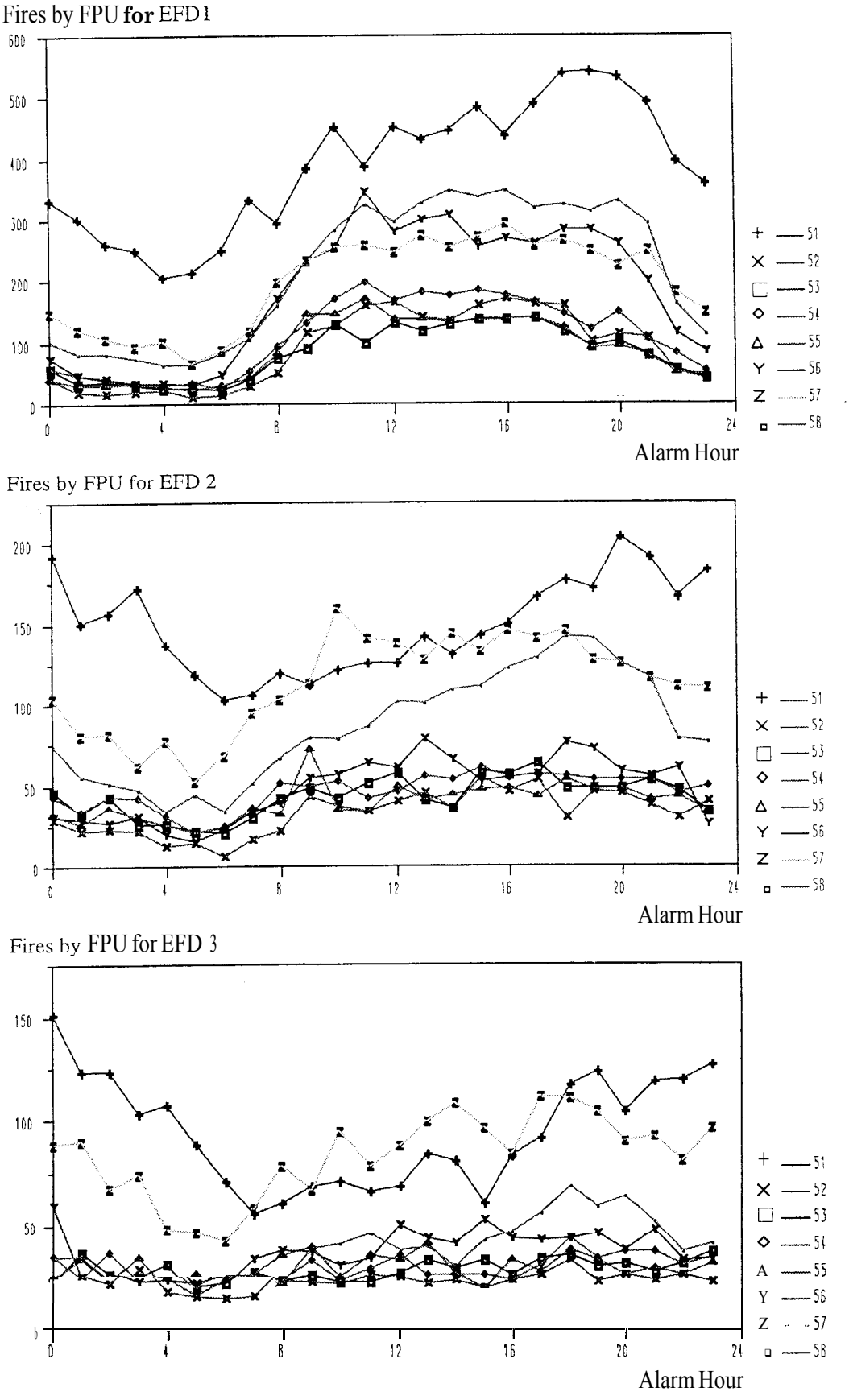


FIGURE B25 VARIATION OF NUMBER OF FIRES BY FIXED PROPERTY USE AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR

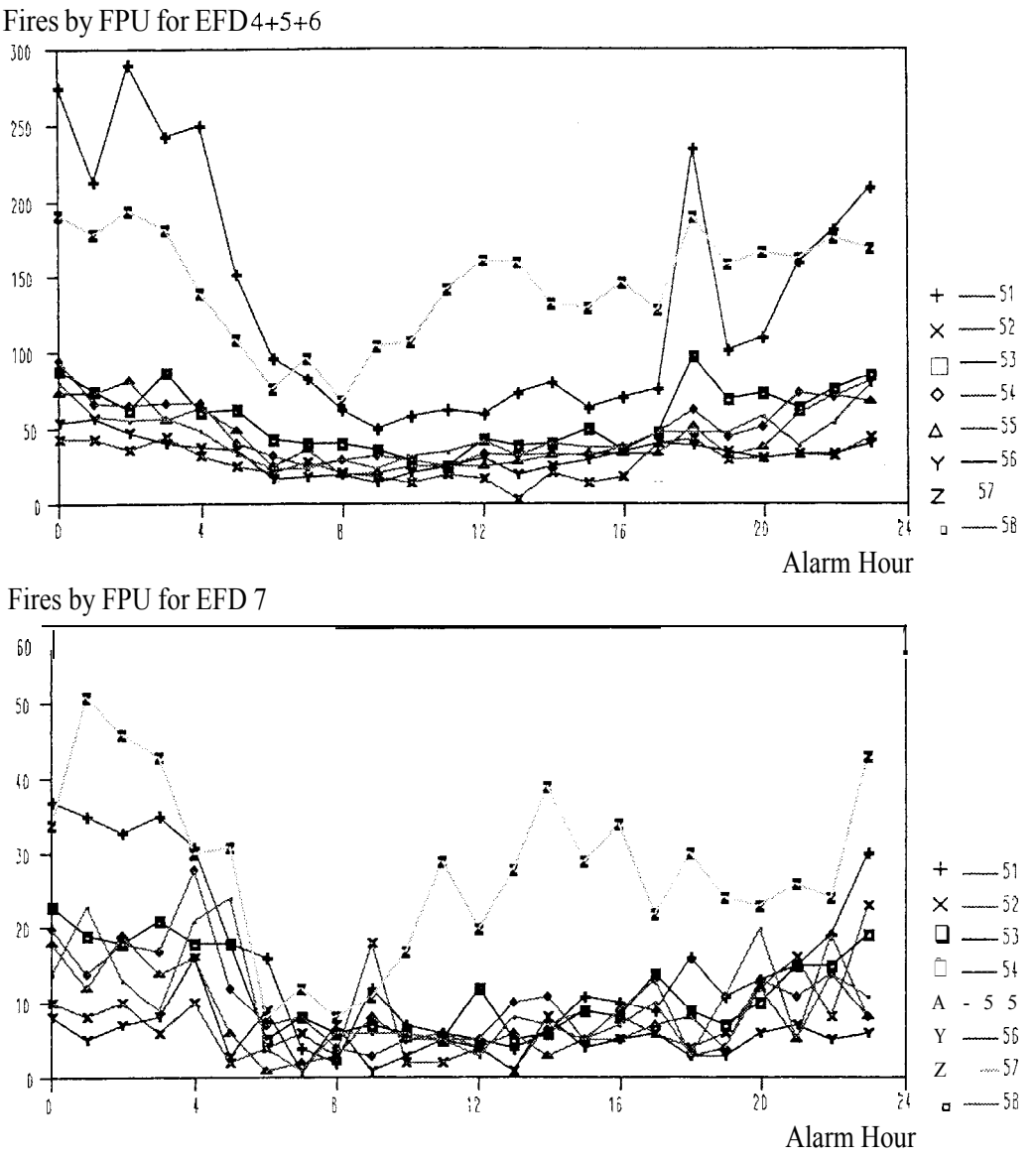


FIGURE B25 VARIATION OF NUMBER OF FIRES BY FIXED PROPERTY USE AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR (CONTINUED)

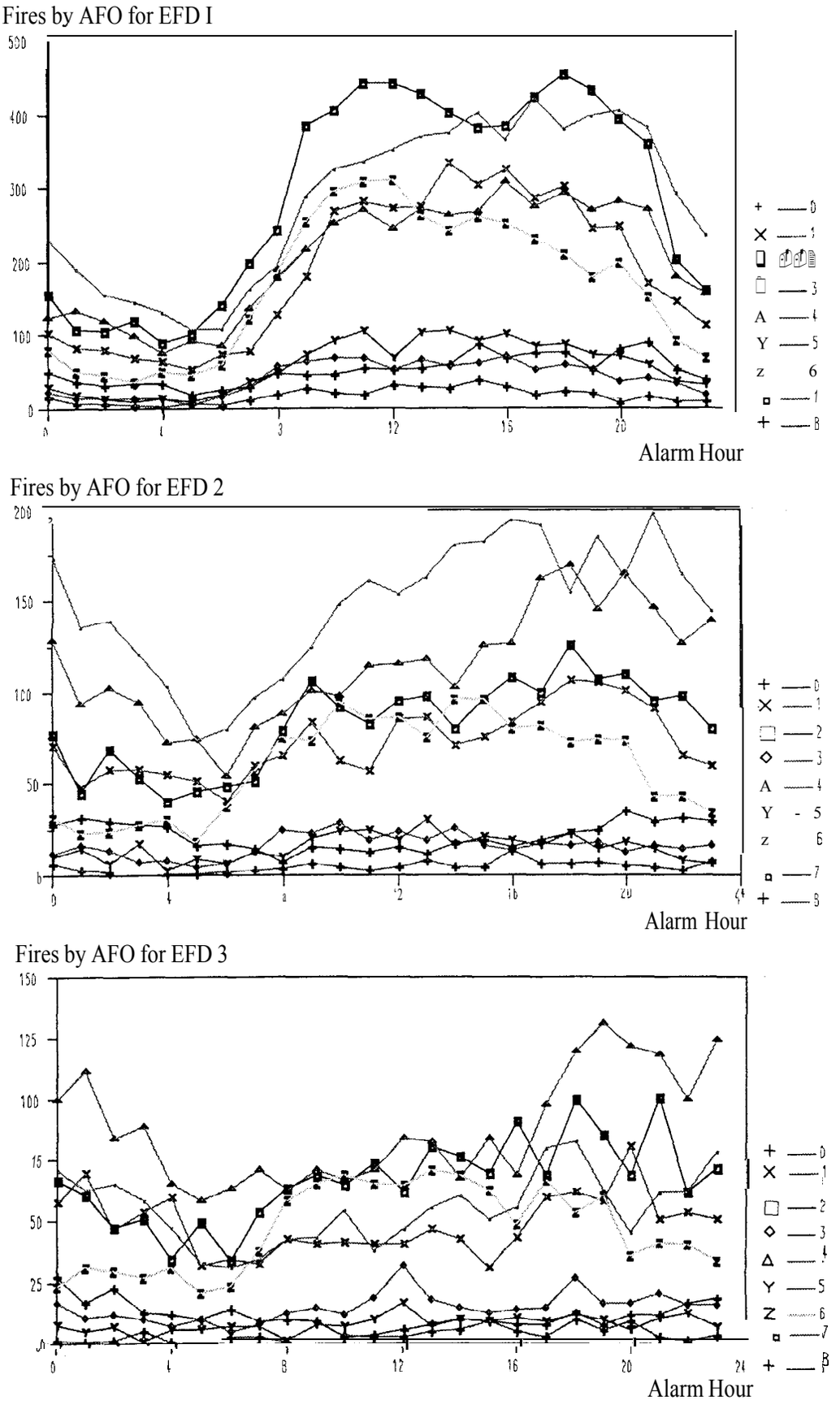
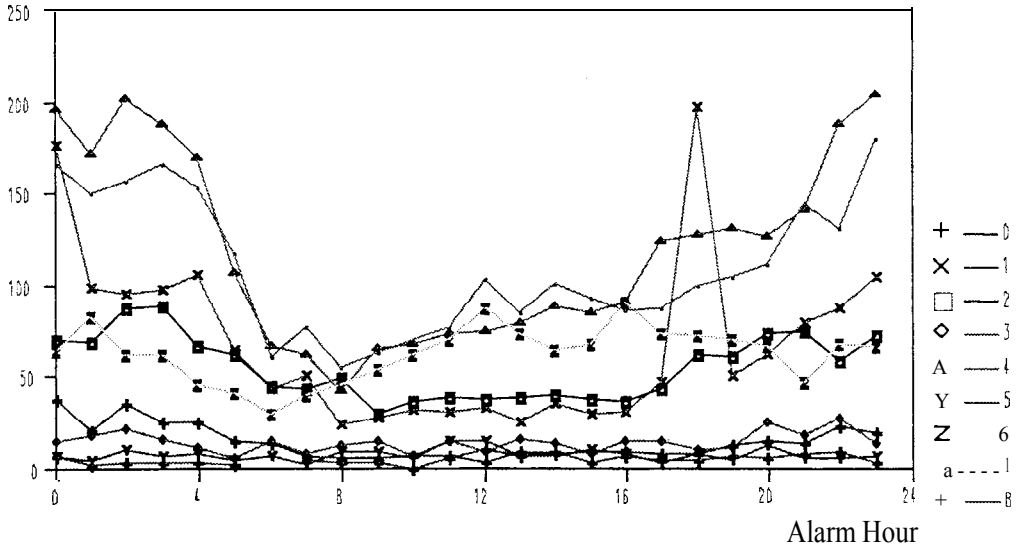


FIGURE B26 VARIATION OF NUMBER OF FIRES BY AREA **OF** FIRE ORIGIN **AND** EXTENT **OF FLAME DAMAGE WITH ALARM HOUR**

Fires by AFO for EFD4+5+6



Fires by AFO for EFD 7

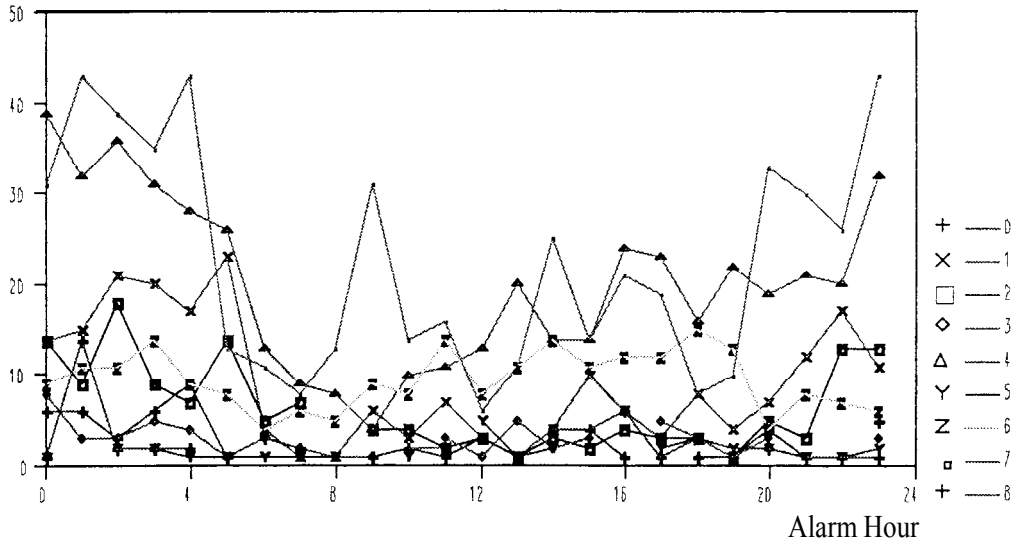
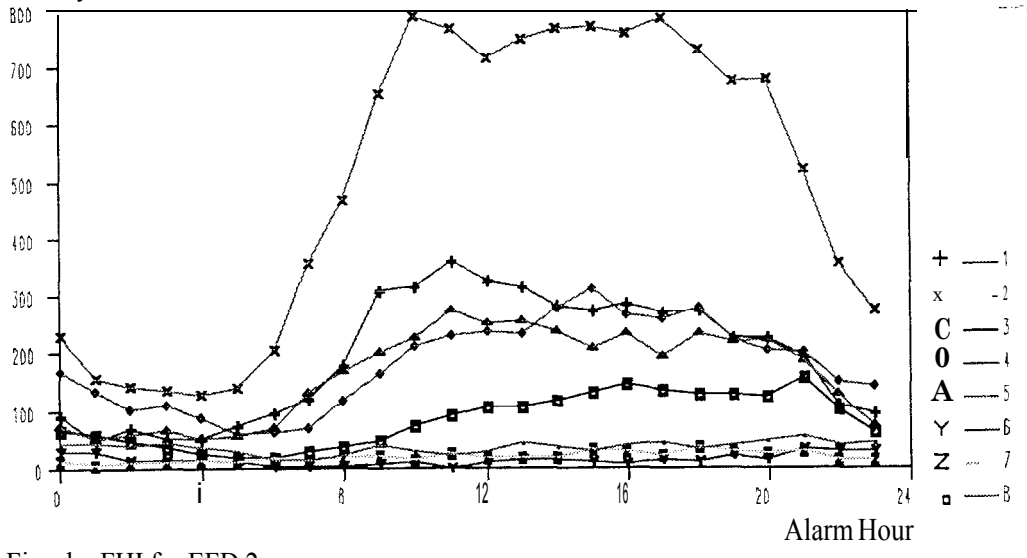
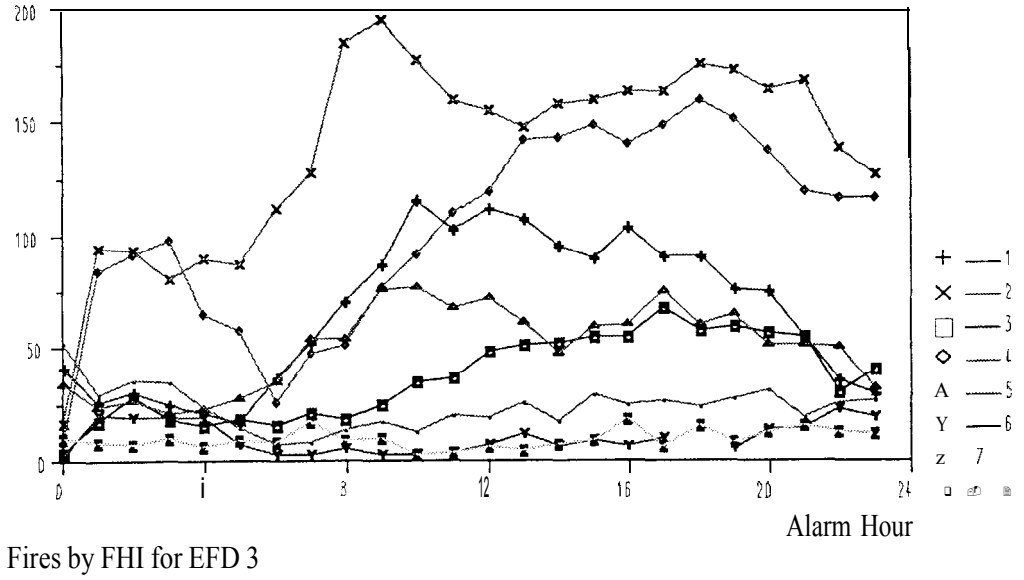


FIGURE B26 **VARIATION** OF NUMBER OF FIRES BY AREA OF FIRE ORIGIN AND **EXTENT OF FLAME DAMAGE** WITH ALARM HOUR (CONTINUED)

Fires by FHI for EFD 1



Fires by FHI for EFD 2



Fires by FHI for EFD 3

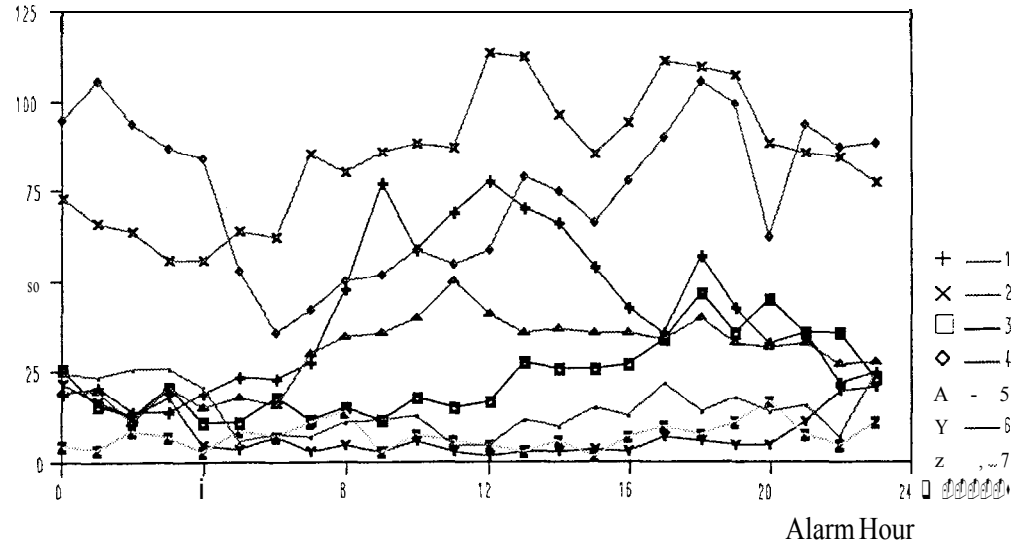
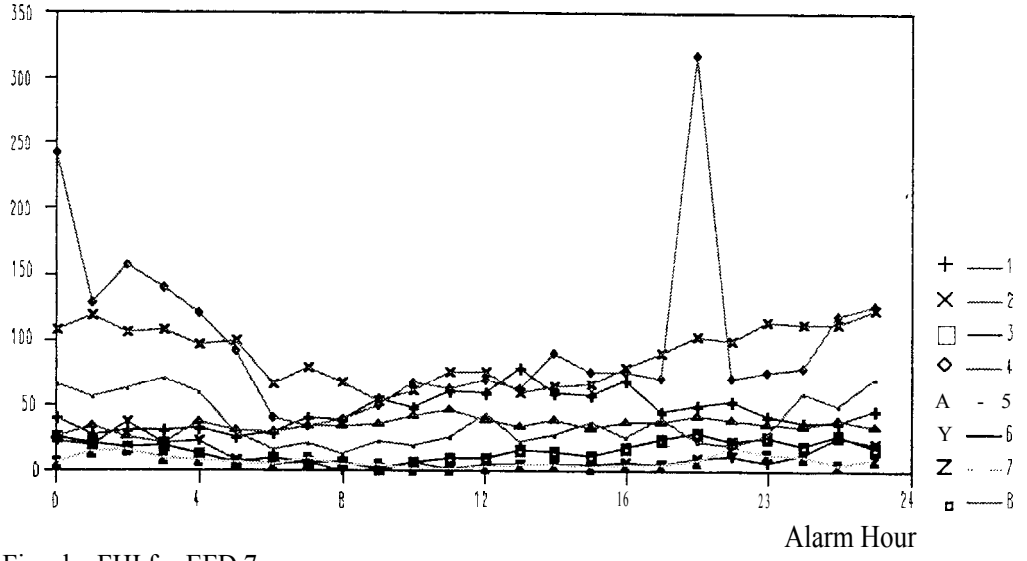


FIGURE B27 VARIATION OF NUMBER OF **FIRES** BY FORM OF HEAT OF IGNITION AND **EXTENT OF FLAME DAMAGE WITH ALARM HOUR**

Fires by FHI for EFD 4+5+6



Fires by FHI for EFD 7

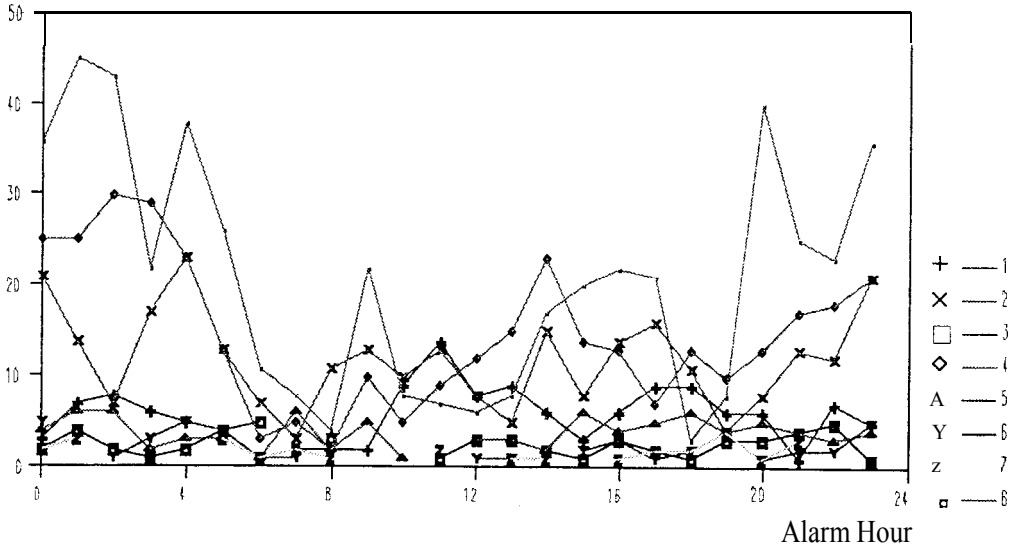
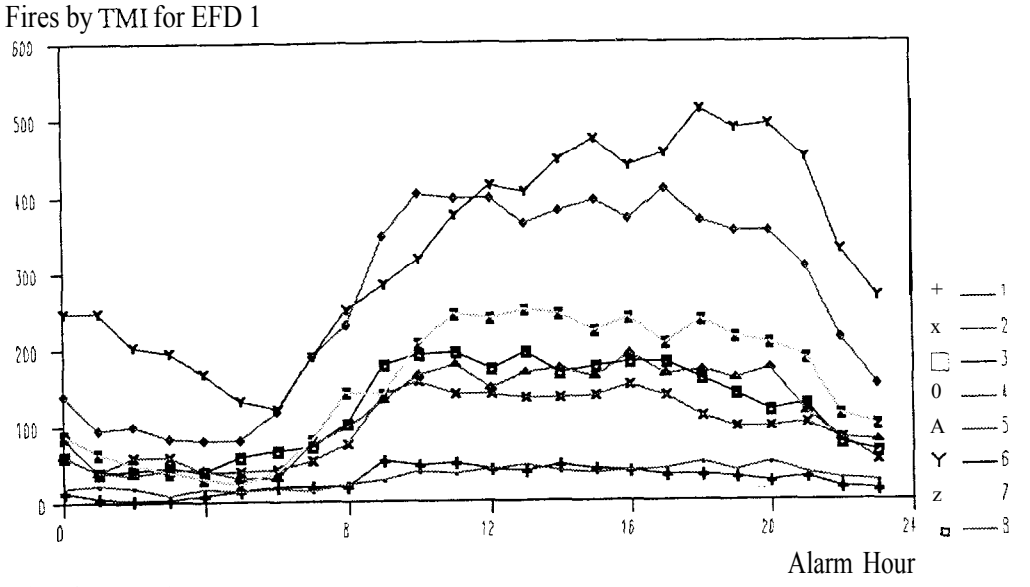
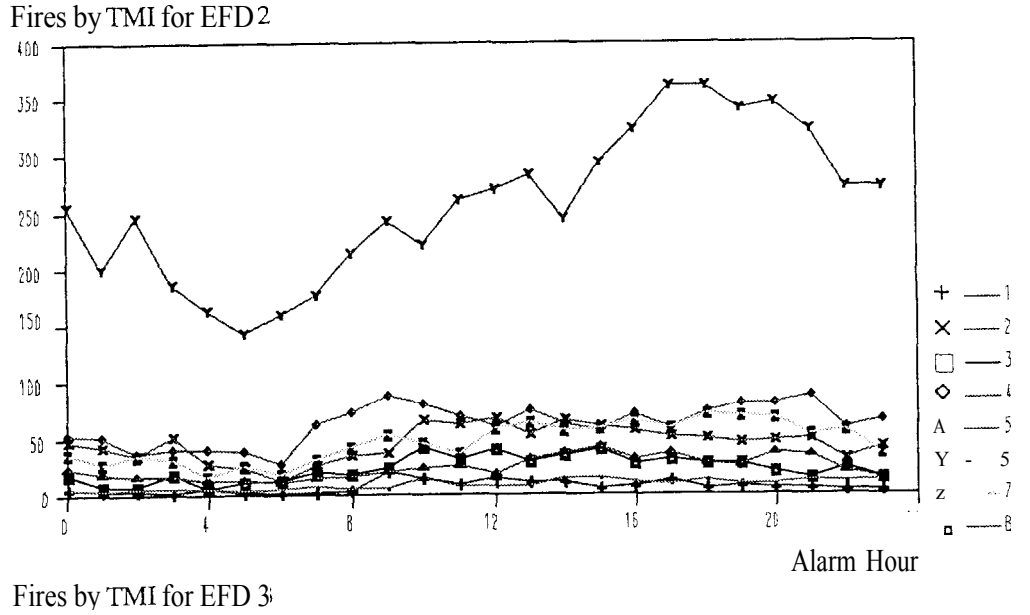


FIGURE B27 VARIATION OF NUMBER OF **FIRES** BY FORM OF HEAT OF IGNITION AND EXTENT OF **FLAME DAMAGE WITH ALARM** HOUR (CONTINUED)





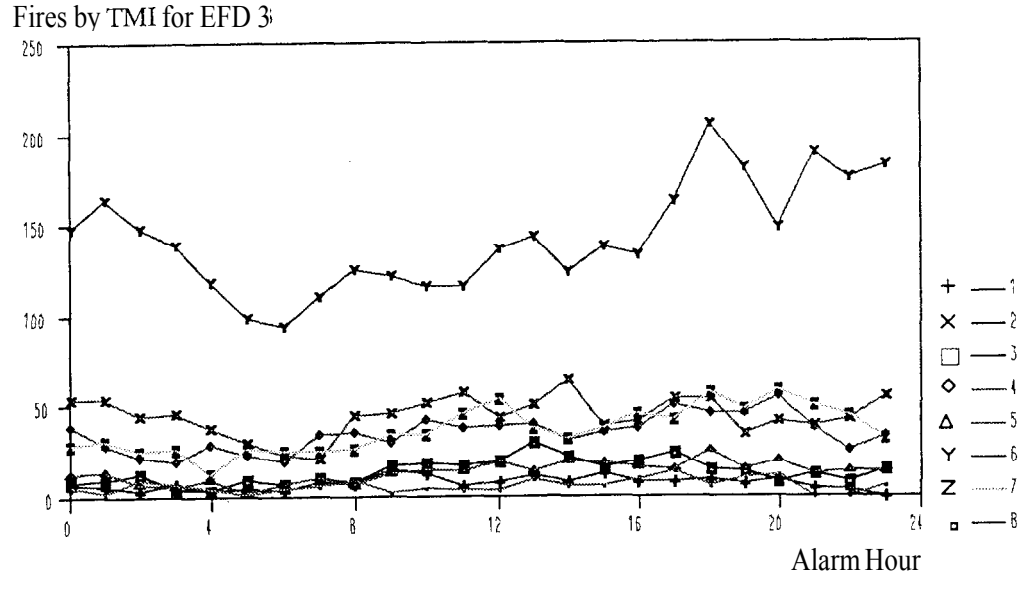


FIGURE B28 VARIATION OF NUMBER OF FIRES BY TYPE OF MATERJAL IGNITED AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR

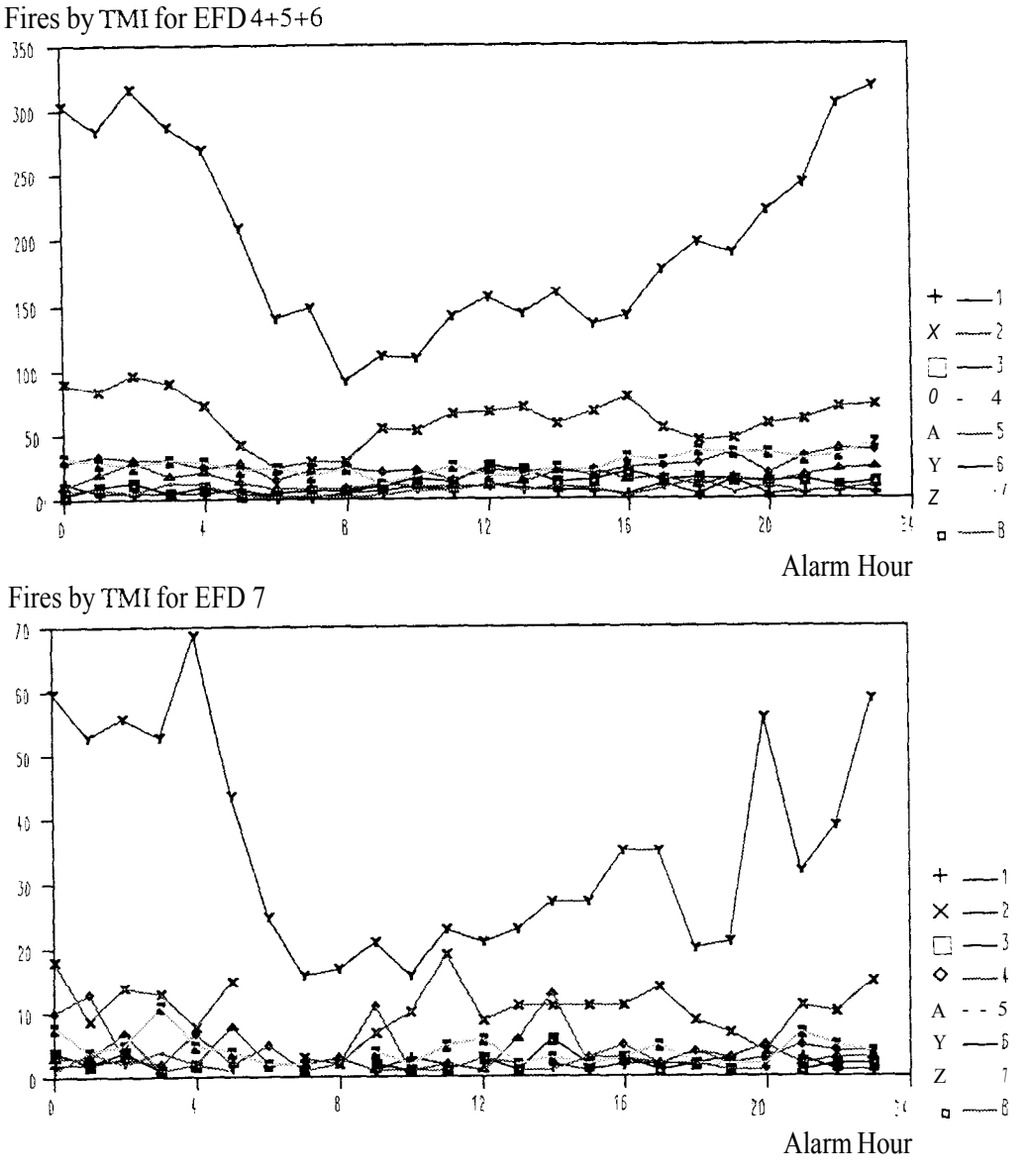


FIGURE B28 VARIATION **OF NUMBER** OF FIRES BY TYPE OF MATERIAL **IGNITED AND EXTENT** OF FLAME DAMAGE WITH ALARM HOUR (CONTINUED)

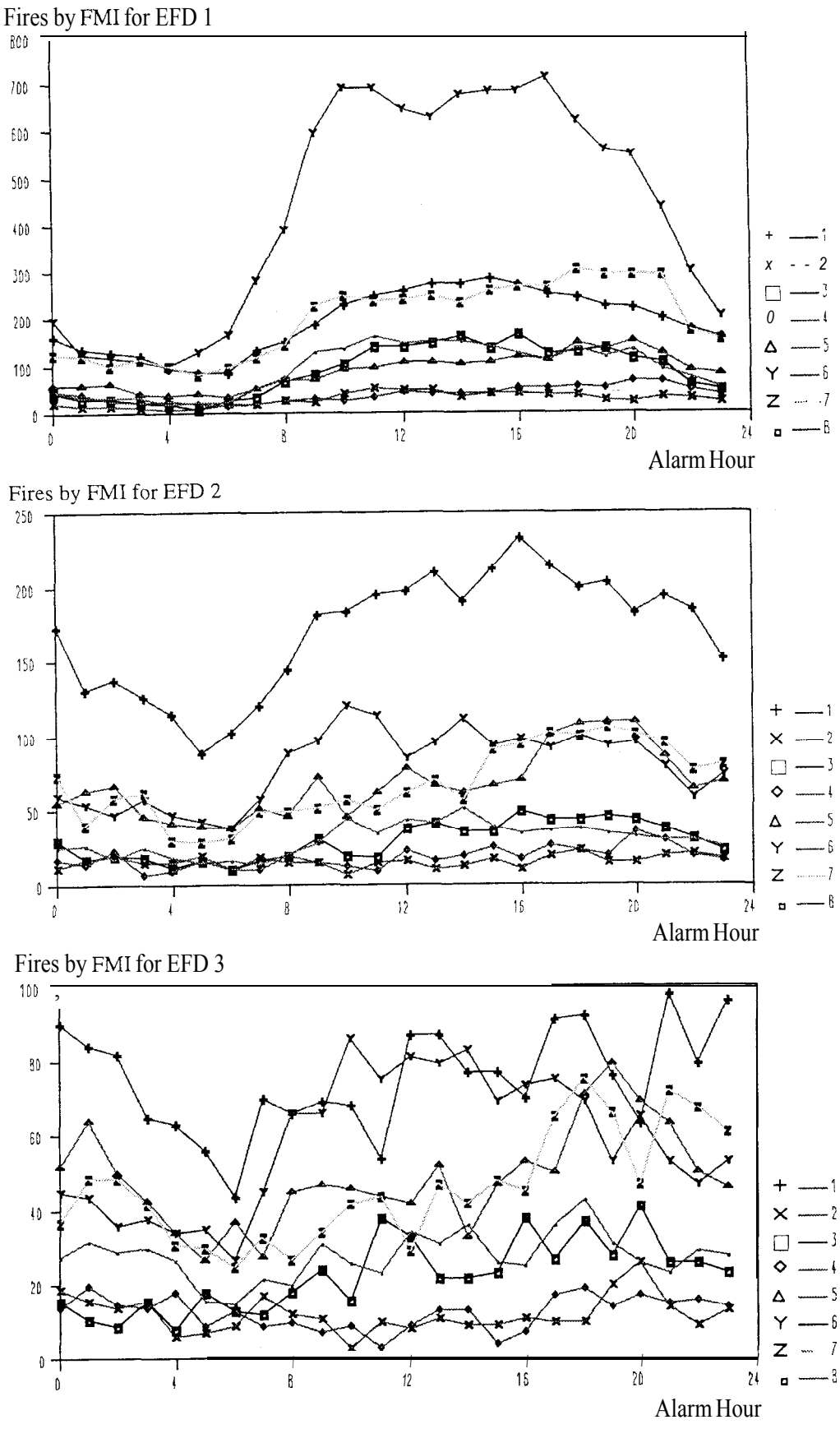


FIGURE B29 VARIATION OF NUMBER OF FIRES BY FORM OF MATERIAL IGNITED AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR

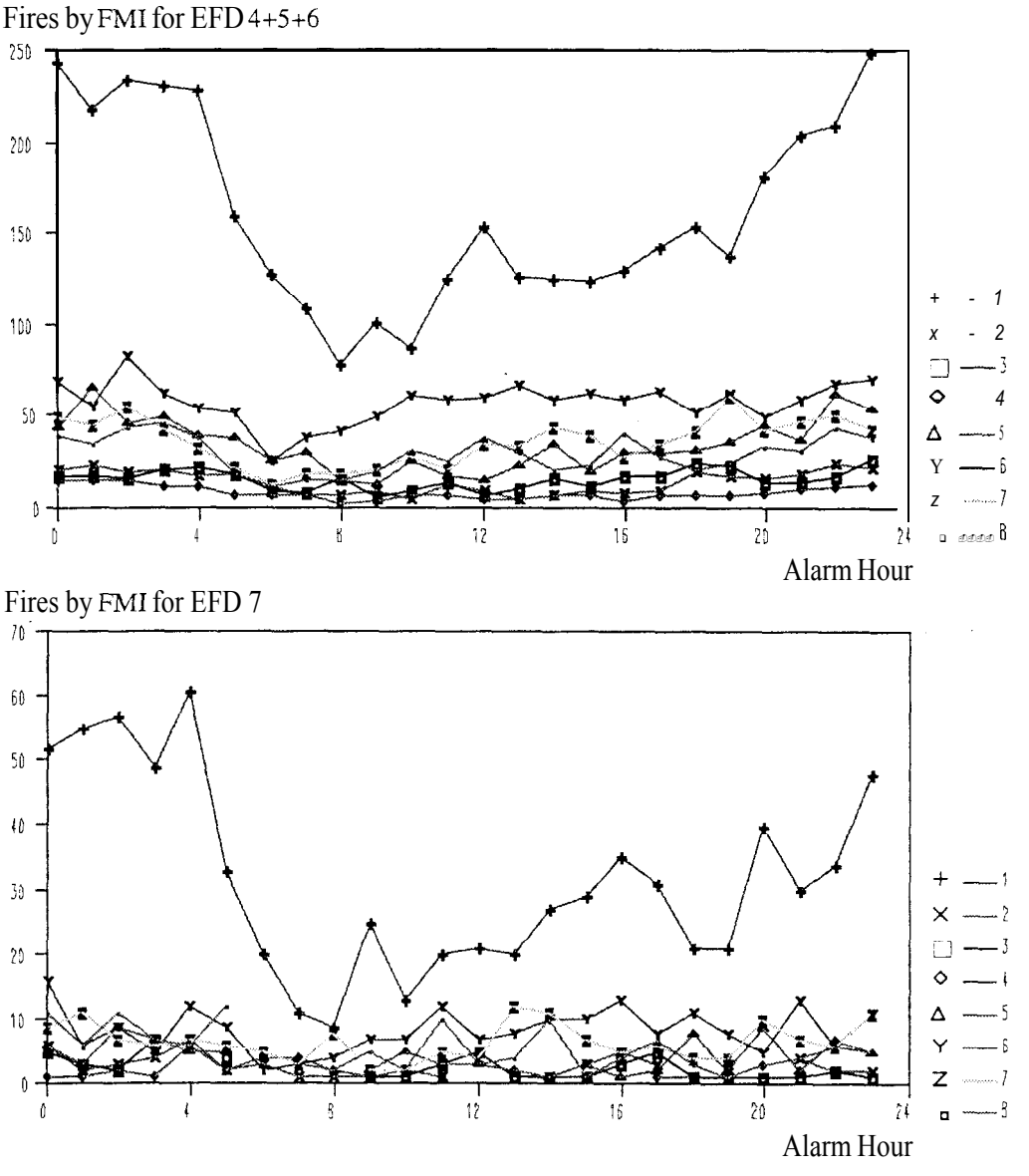


FIGURE B29 VARIATION OF NUMBER OF **FIRES** BY FORM OF MATERIAL IGNITED AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR (CONTINUED)

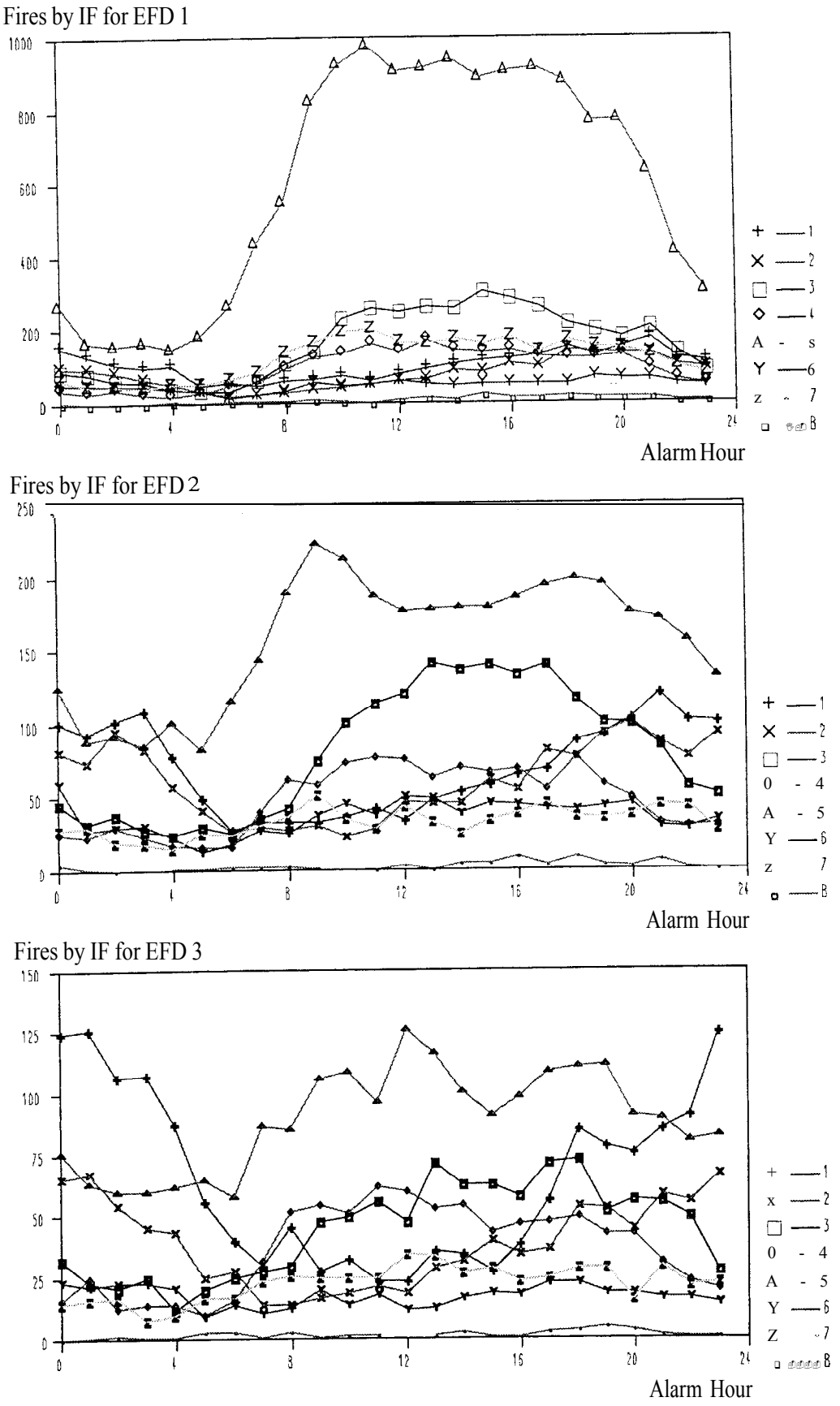


FIGURE B30 **VARIATION** OF **NUMBER** OF FIRES BY IGNITION FACTOR AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR

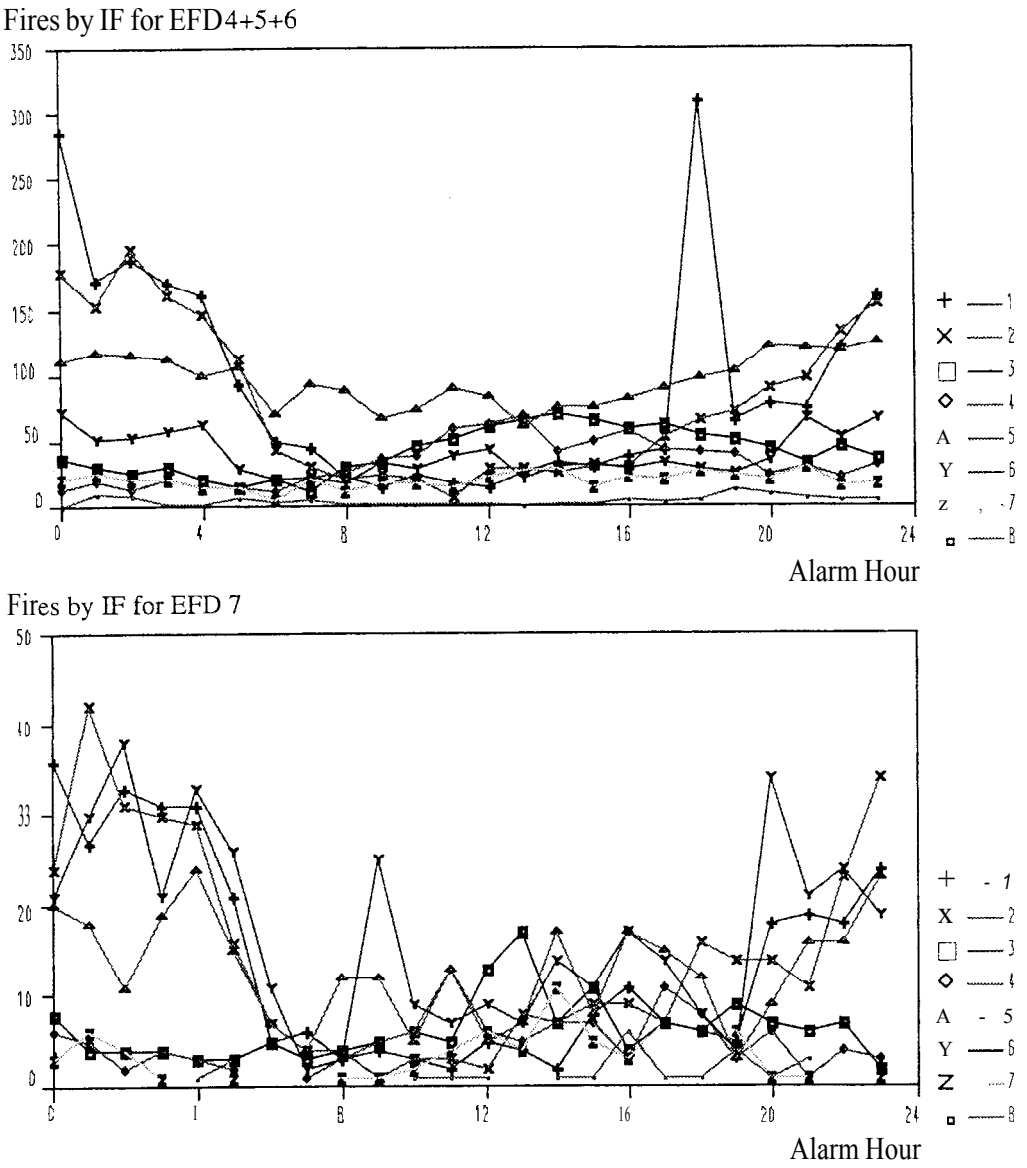


FIGURE B30 VARIATION OF NUMBER OF FIRES BY IGNITION FACTOR AND EXTENT OF **FLAME DAMAGE** WITH ALARM HOUR (CONTINUED)

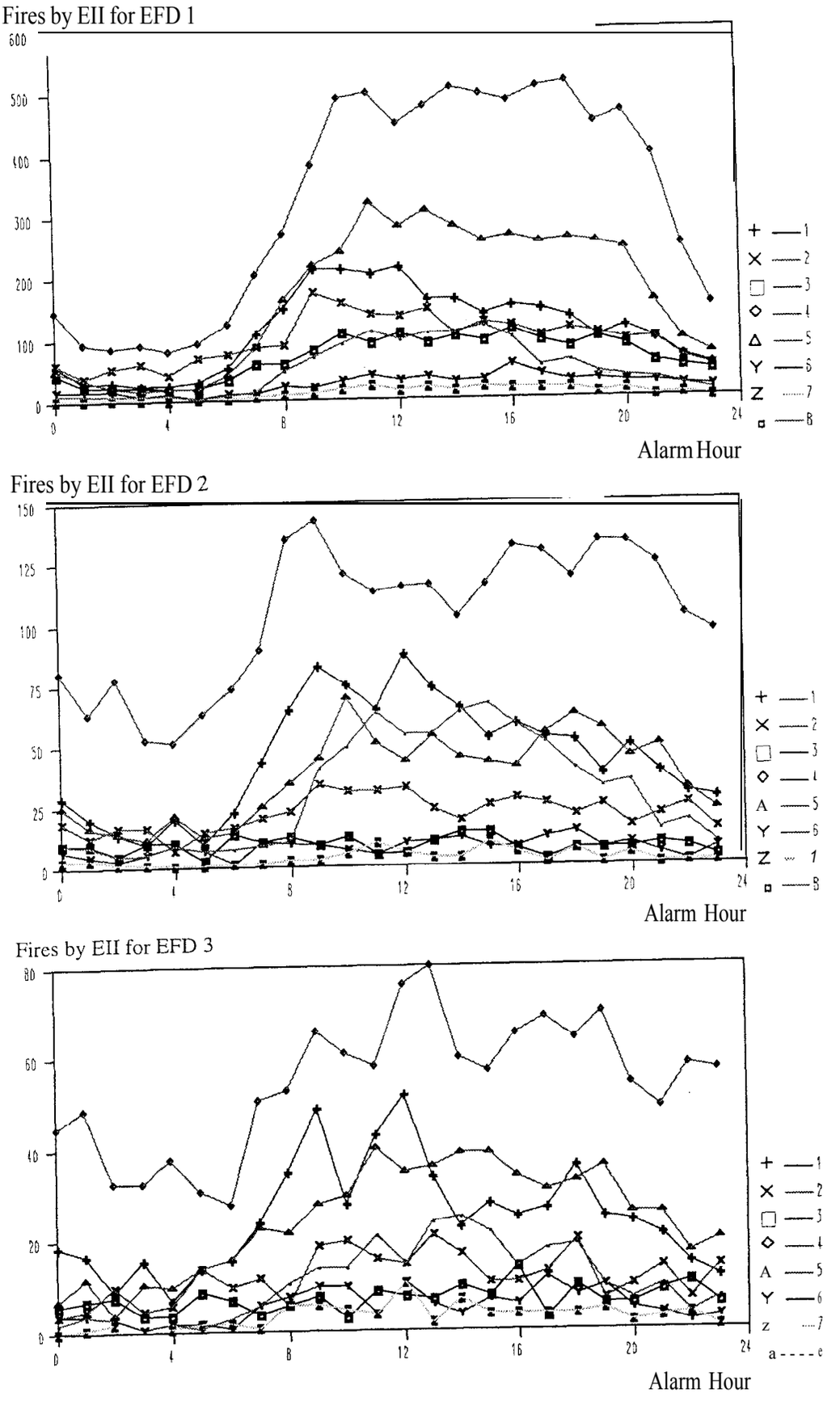
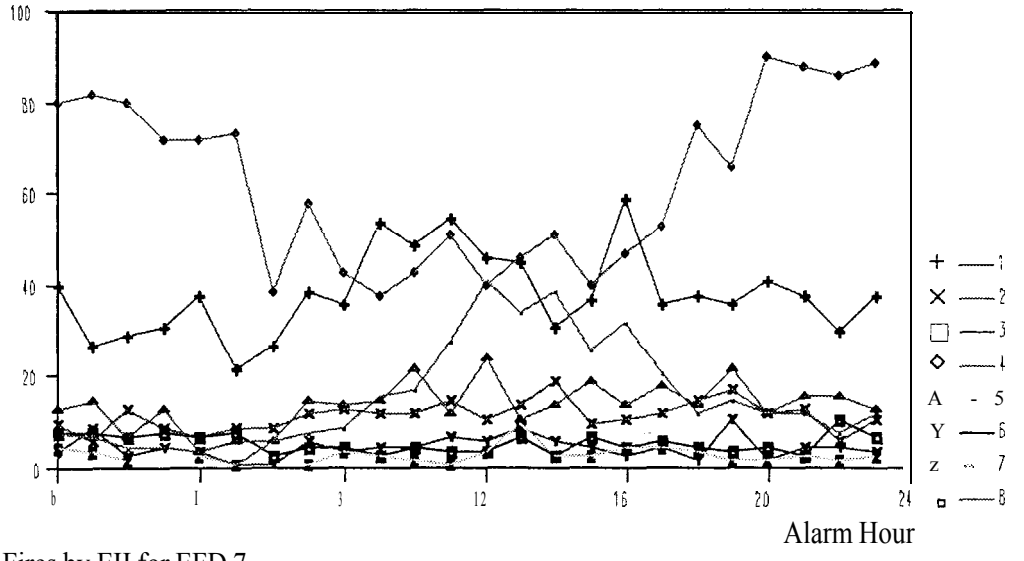


FIGURE B3 1 **VARIATION** OF NUMBER OF **FIRES** BY EQUIPMENT INVOLVED IN IGNITION AND EXTENT OF FLAME DAMAGE **WITH** ALARM **HOUR**

Fires by EII for EFD4+5+6



Fires by EII for EFD 7

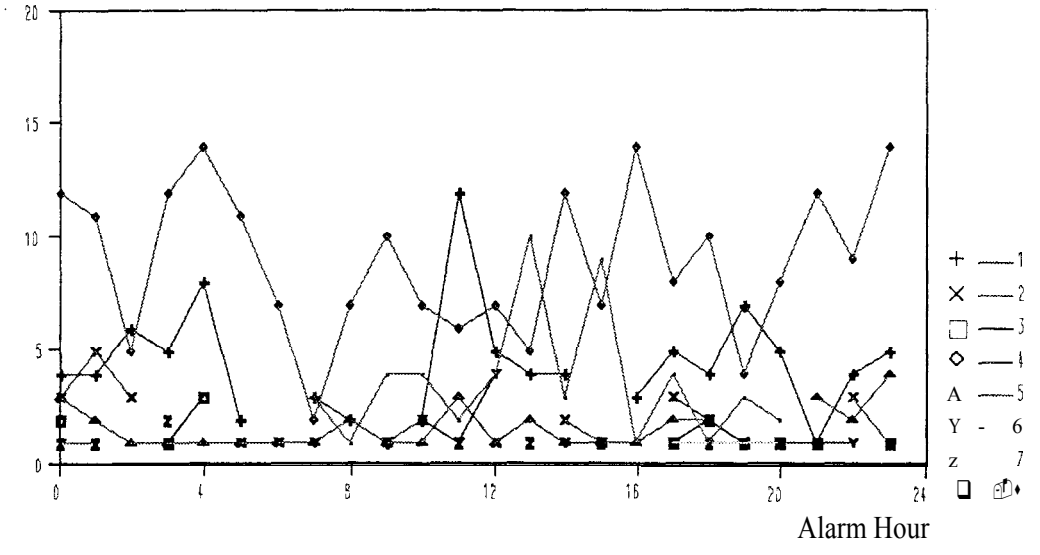
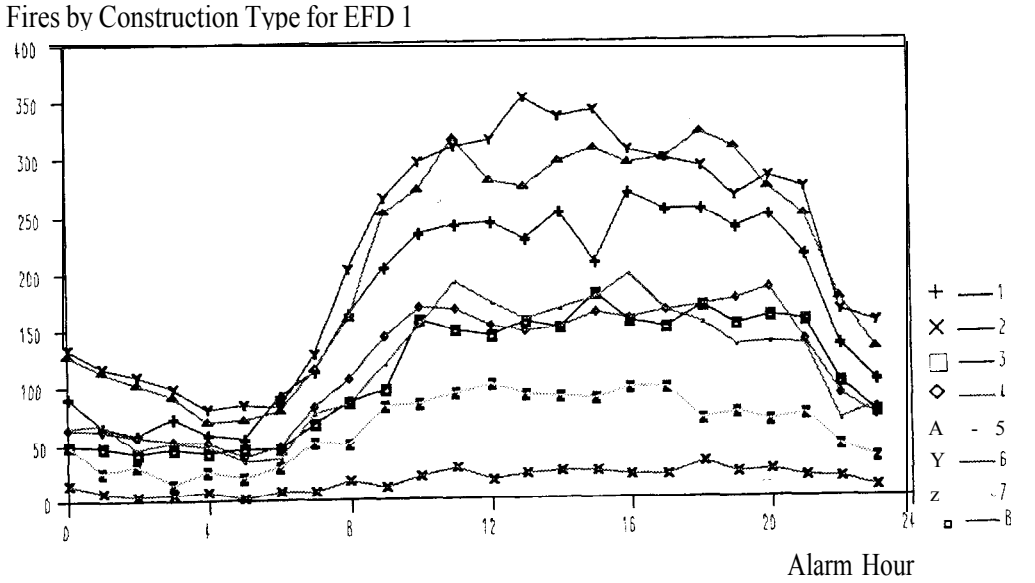
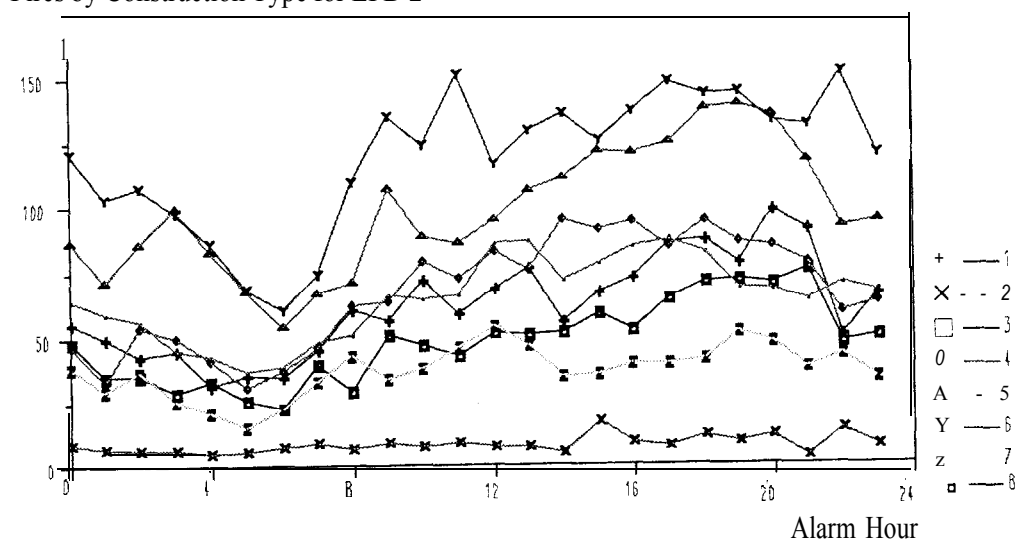


FIGURE B3 1 VARIATION OF NUMBER OF **FIRES** BY EQUIPMENT INVOLVED IN **IGNITION** AND EXTENT OF **FLAME** DAMAGE WITH ALARM HOUR (CONTINUED)





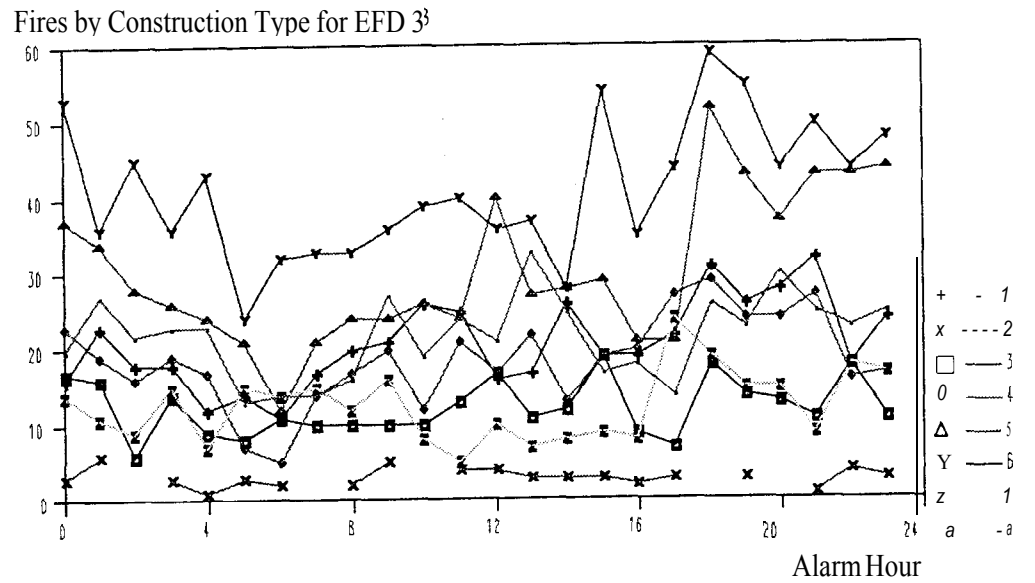
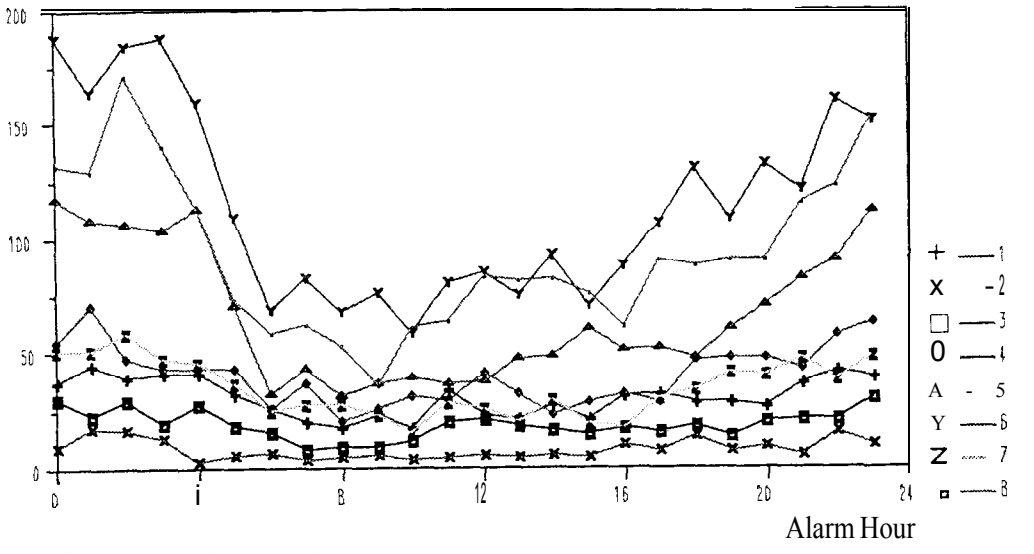


FIGURE B32 VARIATION OF NUMBER OF FIRES BY CONSTRUCTION TYPE AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR

Fires by construction Type for EFD 4+5+6



Fires by Construction Type for EFD 7

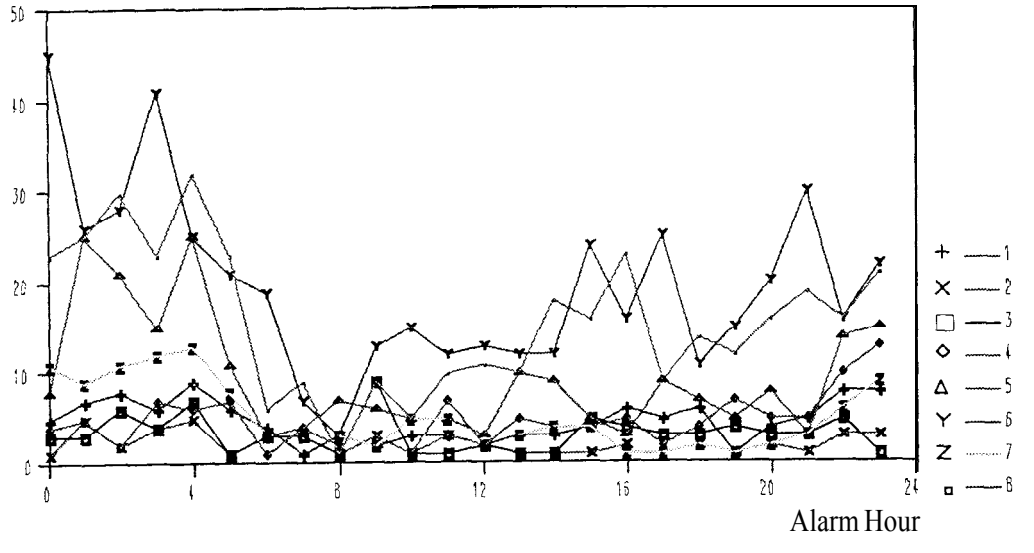


FIGURE B32 VARIATION OF NUMBER OF FIRES BY CONSTRUCTION TYPE AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR (CONTINUED)

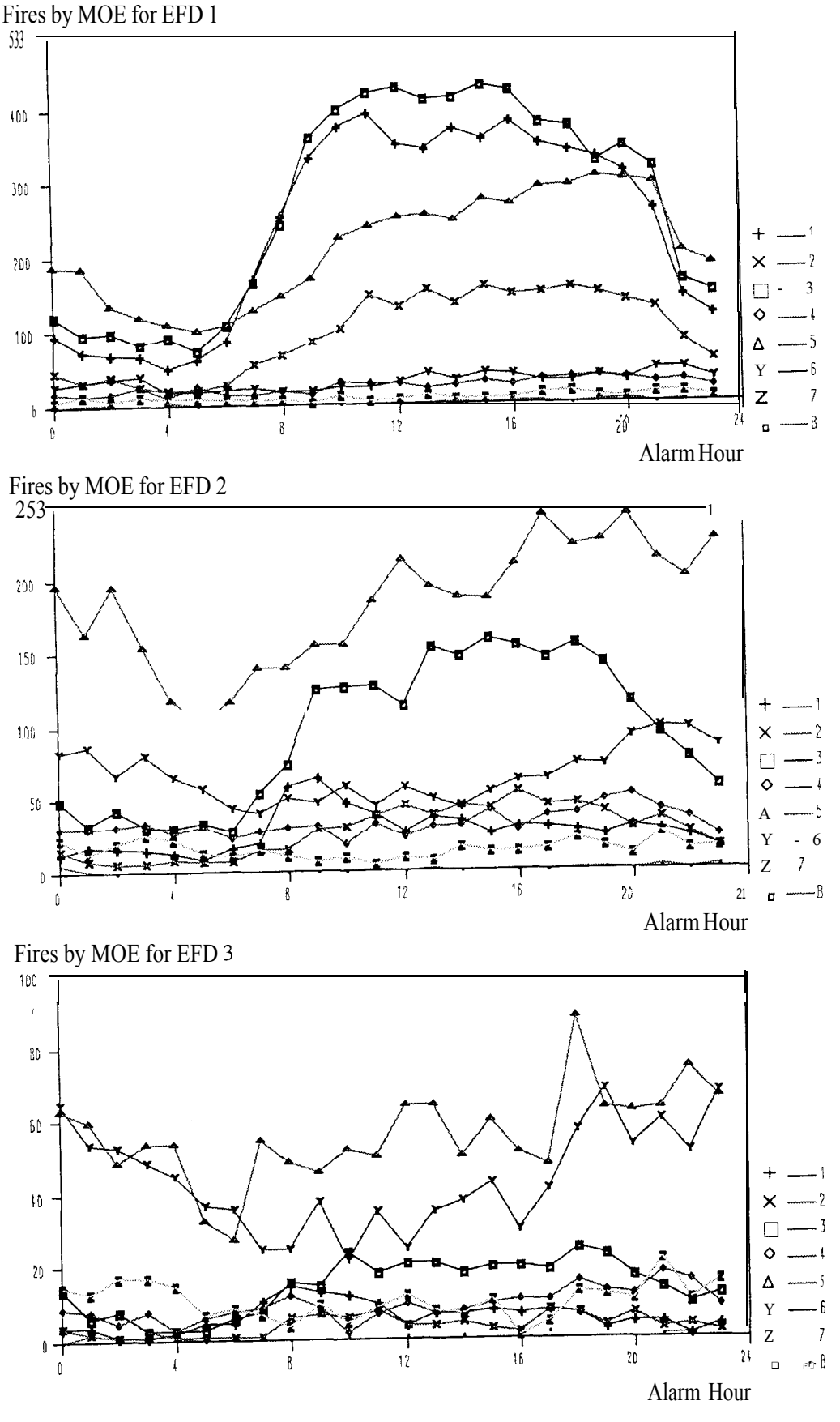
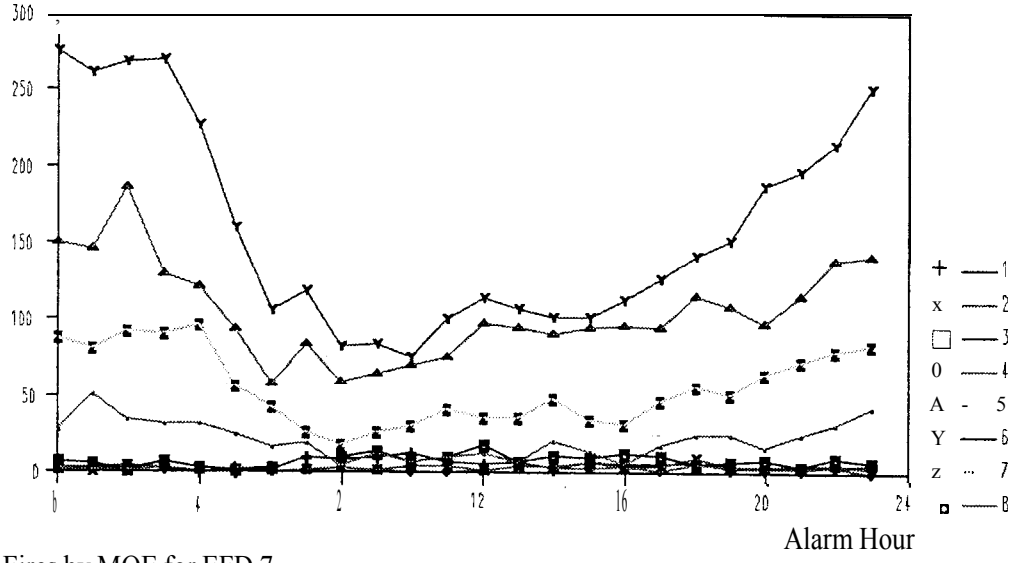


FIGURE B33 VARIATION OF NUMBER OF FIRES BY METHOD OF EXTINGUISHMENT AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR

Fires by MOE for EFD 4+5+6



Fires by MOE for EFD 7

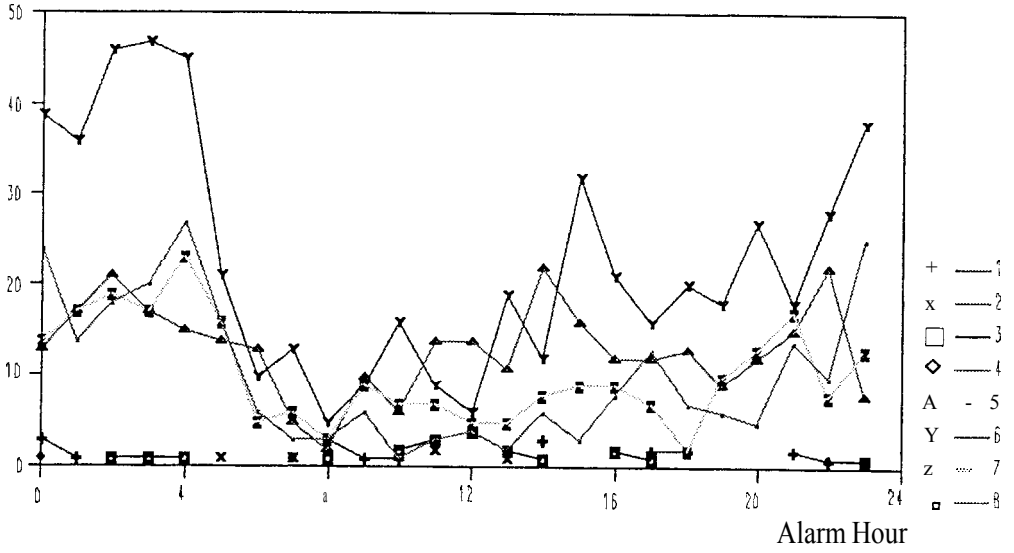


FIGURE B33 VARIATION OF NUMBER OF FIRES BY METHOD OF EXTINGUISHMENT AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR (CONTINUED)

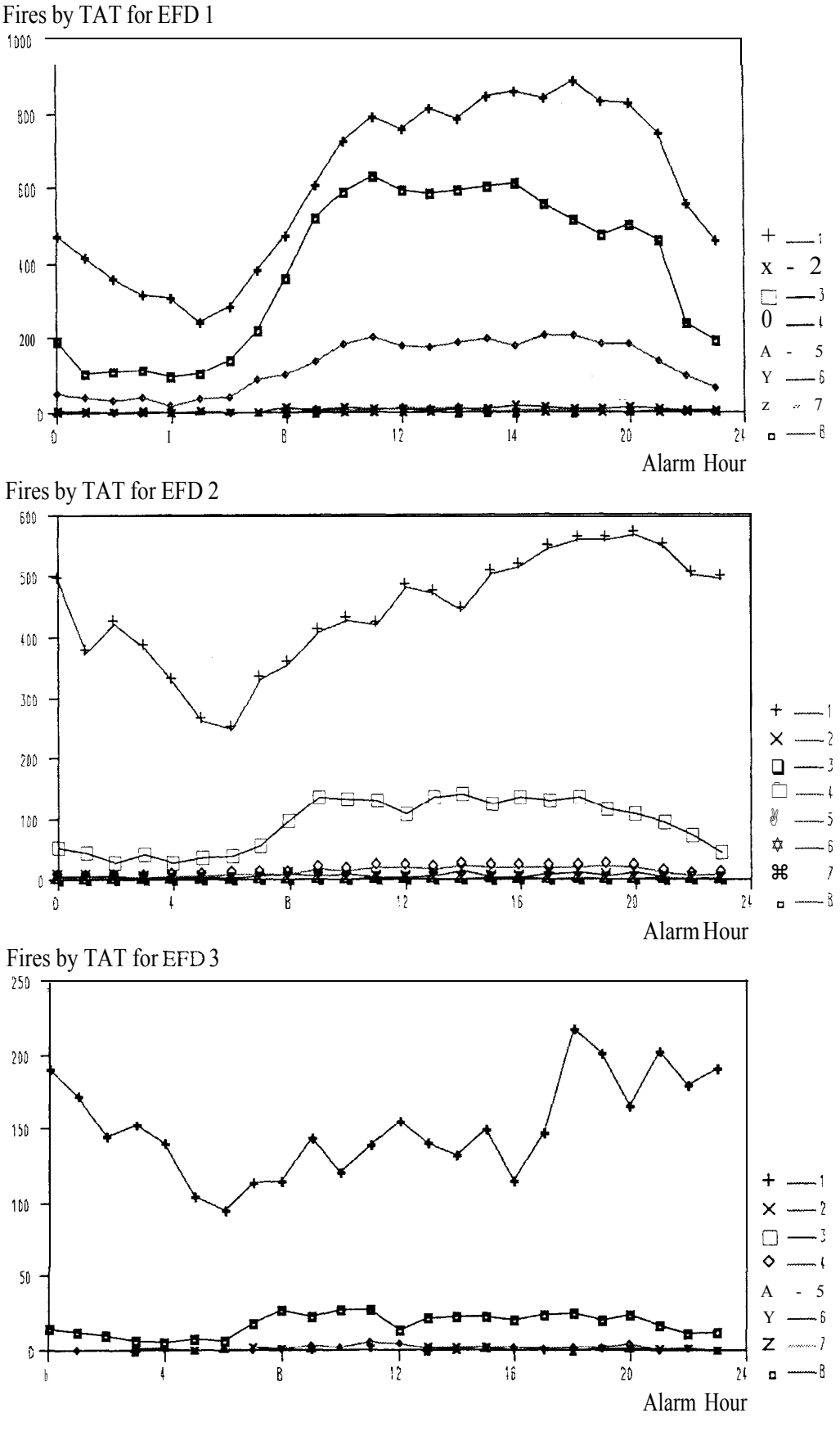


FIGURE B34 **VARIATION** OF NUMBER OF FIRES BY **TYPE** OF ACTION TAKEN AND EXTENT OF **FLAME** DAMAGE WITH ALARM HOUR

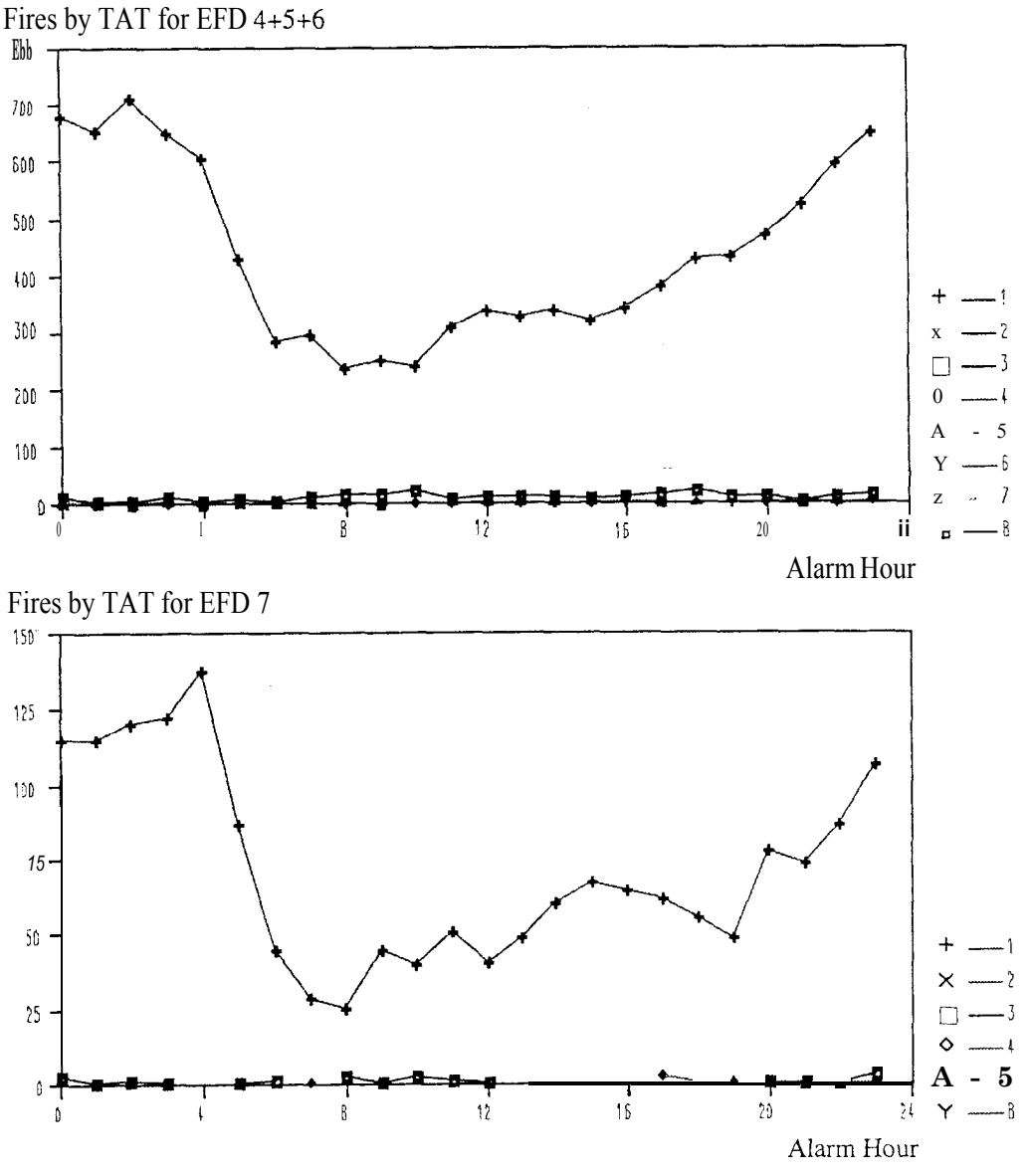


FIGURE B34 VARIATION OF NUMBER OF FIRES BY TYPE OF ACTION **TAKEN** AND EXTENT OF FLAME DAMAGE WITH ALARM HOUR (CONTINUED)

Scenario 1 **Midnight to 4 am**

Extent of flame damage: confined to object of origin

During the period from **midnight to** 4 **am** the fires classified as having *extent of flame damage* **confined to the object of origin** fall from 30% to 25% of all of the fires during each hourly period and the average is 27%.

Of these fires on average 54% are classified as *shopping complex,* with 27% in no *complex,* The remainder had *unknown complex.* Similarly, on average 42% are classified as *fixed property use food and beverage sales,* with 17% in *motor vehicle or boat* sales, *services* and 13% in *general item stores.* When classified by *area of fire origin* on average 28% are classified as *structural areas, 19% function areas (largely residential and office)*, 19% *storage areas* and 1370 *assembly, sales areas.*

When classified by *form of heat of ignition* on average 29% are classified as *heat from electrical equipment arcing, overload, 2370 heat from open flame, spark,* 9% *heat from smoking material* and *8% heat spreading from another fire (exposure).* Similarly, when classified by *type of material ignited* 40% are classified as *wood, paper*, *18% plastic, 11% flammable, combustible liquid* and 11% *material compounded with oil.* A related classification is *form of material ignited* and classified in this way 24% are classified as *structural component, finish, 24%* as *power transfer equipment, fuel* and 20% *general form.*

When classified by *ignition factor* 31% are classified as *mechanical failure, malfunction, 20% incendiary,* 14% *suspicious* and 12% *misuse of heat of ignition.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 36% involve *electrical distribution equipment, 19% cooking equipment, 13% heating systems* and 1170 *appliances, equipment.*

Classified by *type of construction* 23% are classified as *unprotected ordinary, 2270* as *protected ordinary,* 15% as *fire resistive, 12 %* as *unprotected non-combustible or limited combustible* and 12% as *unprotected wood frame.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 36% of fires, 23% *portable extinguisher* and 18% self *extinguished.* The *type of action taken* by the fire fighters for 68% of fires is classified as *extinguishment, 23% investigation only* and *8% remove hazard.*

Scenario 2 **Midnight to 4 am**

Extent of flame damage: confined to area of origin

During this period **(from midnight to** 4 **am)** the fires classified as having *extent of flame damage* **confined to the area of origin** ranges between 18% to 19% of all of the fires during each hourly period.

Of these fires on average 58% are classified as *shopping complex,* with 34% in *no complex.* The remainder had *unknown complex.* Similarly, on average 36% are classified as *fixed property use food and beverage* sales, with 17% in *motor vehicle or boat sales, services* and 12% in *general item stores.* When classified by *area of fire origin* on average 3270 are classified as *structural areas, 23% storage areas,* 1370 *assembly, sales areas* and 13% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 28% are classified as *heat from electrical equipment arcing, overload, 2870 heat from open flame, spark,* 1170 *heat spreading from another fire (exposure), 9% heat from fuel fired, fuel powered object* and *8% heat from hot object.* Similarly, when classified by *type of material ignited* 57% are classified as *wood, paper, 12% plastic,* 12% *flammable, combustible liquid* and 9% *material compounded with oil.* A related classification is *form of material ignited* and classified in this way 36% are classified as *structural component, finish,* 15% *supplies, stock,* 15% *general form* and 14% as *power transfer equipment, fuel.*

When classified by *ignition factor* 25% are classified as *incendiary*, *24% mechanical failure, malfunction* and 20% *suspicious.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 4870 involve *electrical distribution equipment,* 12% *heating systems, 12% cooking equipment* and 1170 *appliances, equipment.*

Classified by *type of construction 25%* are classified as *unprotected ordinary, 20%* as *protected ordinary*, 13% as *unprotected wood frame,* 1170 as *fire resistive* and 11 % as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 4770 of fires, 21% *pre-connected hose lines with water from hydrant, draft, standpipe* and 1070 *portable extinguisher.* The *type of action taken* by the fire fighters for 8970 of fires is classified as *extinguishment* and 9% *investigation only.*

Scenario 3 **Midnight to 4 am**

Extent of flame damage: confined to room of origin

During this period **(from midnight to 4 am)** the fires classified as having extent of flame damage **confined to the room of origin** ranges between 14% to 16% of all of the fires during each hourly period.

Of these fires on average 46% are classified as *unknown complex* with 35% *shopping complex.* The remainder had *no complex.* Similarly, on average 34% are classified as *food and beverage* sales and 22% in *motor vehicle or boat sales, services*. When classified by *area of fire origin* on average 2870 are classified as *storage areas, 19% structural areas,* 1770 *assembly, sales areas* and 1670 *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 36% are classified as *heat from open flame, spark, 2570 heat from electrical equipment arcing, overload* and 10% *heat spreading from another fire (exposure).* Similarly, when classified by *type of material ignited* 52% are classified as *wood, paper,* 1770 *flammable, combustible liquid* and 1070 *fabric, textile, fur.* A related classification is *form oj material ignited* and classified in this way 2770 are classified as *structural component, finish,* 1870 as *supplies, stock,* 1570 *general form* and 1470 *power transfer equipment, fuel.*

When classified by *ignition factor* 3670 are classified as *incendiary, 2070 mechanical failure, malfunction* and 1870 *suspicious. A* related classification is *equipment involved in ignition* (if any) and when classified in this way 4870 involve *electrical distribution equipment,* 1870 *heating systems* and 1270 *appliances, equipment.*

Classified by *type of construction 2670* are classified as *unprotected ordinary,* 19% as *protected ordinary,* 1470 as *unprotected wood frame, 1270* as *fire resistive* and 12 70 as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for *3870* of fires, *3770 pre-connected hose lines with water from hydrant, draft, standpipe* and 11% *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 93% of fires is classified as *extinguishment* and *7% investigation only.*

Scenario 4 **Midnight to 4 am**

Extent of flame damage: confined ta the fire rated compartment, storey or structure of origin

During this period **(from midnight to 4 am)** the fires classified as having extent of flame damage **confined to the fire rated compartment, storey or structure of origin** rises from 31% to 34% of all of the fires during each hourly period.

Of these fires on average 45% are classified as *shopping complex,* with 35% in *no complex.* The remainder had *unknown complex.* Similarly, on average 3 1% are classified as *fixed property use food and beverage sales,* with 23% in *motor vehicle or boat sales, services* and 1070 in *household goods sales, repairs.* When classified by *area of fire origin* on average 28% are classified as *storage areas: 24% structural areas,* 17% *assembly, sales areas* and 12% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 36% are classified as *heat from open flame, spark, 2470 heat from electrical equipment arcing, overload* and 1470 *heat spreading from another fire (exposure).* Similarly, when classified by *type of material ignited 6070* are classified as *wood, paper* and 1870 *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 4770 are classified as *structural component, finish,* 1470 as *power transfer equipment, fuel* and 1070 as *supplies, stock* and 1070 *general form.*

When classified by *ignition factor 3270 incendiary, 2870 suspicious* and 18% are classified as *mechanical failure, malfunction.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 51% involve *electrical distribution equipment* and *2* 1% *heating systems.*

Classified by *type of construction 29%* are classified as *unprotected ordinary, 23%* as *unprotected wood frame* and *18%* as *protected ordinary,*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 4870 of fires, *2770 pre-connected hose lines with water in apparatus tanks* and 1670 *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 9870 of fires is classified as *extinguishment* and 1% *investigation only.*

Scenario 5 **Midnight to 4 am**

Extent of flame damage: beyond the structure of origin

During this period (from **midnight to 4 am)** the fires classified as having extent of flame damage **beyond the structure of origin** rises from 6% to 7% of all of the fires during each hourly period.

Of these fires on average 48% are classified as *shopping complex,* with 29% in unknown complex, The remainder had no complex. Similarly, on average 27% are classified as *motor vehicle or boat* sales, *services,* with 22% classified as *fixed property use food and beverage sales,* services, *13%* in *household goods sales, repairs, 11% specialty shops* and 10% recreation, hobby or home repair supply, sales, personal services. When classified by *area of fire origin* on average 29% are classified as *structural areas, 27%* as *storage areas, 14% assembly, sales areas* and 10% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 38% are classified as *heat spreading from another fire (exposure), 2970 heat from open flame, spark* and 16% *heat from electrical equipment arcing, overload.* Similarly, when classified by *type of material ignited* 59% are classified as *wood, paper* and 14% *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 57% are classified as *structural component, finish, 9%* as *power transfer equipment, fuel* and *970 general form* and *970 special form.*

When classified by *ignition factor 26% incendiary, 26% suspicious, 22% design, construction deficiency* and 14% are classified as *mechanical failure, malfunction.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 45% involve *electrical distribution equipment* and 24% *heating systems* and 13% *cooking equipment.*

Classified by *type of construction* 33% are classified as *unprotected ordinary, 24%* as *unprotected wood frame,* 16% as *protected ordinary* and 10% protected wood frame.

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for *43%* of fires, *20% master stream device;* 18% *pre-connected hose lines with water in apparatus tanks* and 17% *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 98% of fires is classified as *extinguishment* and 1% *investigation only.*

Scenario 6 **4 am to 8am**

Extent of flame damage: confined to object of origin

During the period from 4 **am** to **8 am** the fires classified as having extent of flame damage **confined to the object of origin** rises from 25% to 44% of all of the fires during each hourly period and the average is 34%.

Of these fires on average 56% are classified as *shopping complex,* with 27% in no *complex.* The remainder had *unknown complex.* Similarly, on average 42% are classified as *fixed property use food and beverage sales,* with 16% in *motor vehicle or boat sales, services* and 1370 in *general item stores.* When classified by *area of fire origin* on average 23% are classified as *structural areas, 23% function areas (largely residential and office),* 17% *storage areas* and 12% *assembly, sales areas.*

When classified by *form of heat of ignition* on average 38% are classified as *heat from electrical equipment arcing, overload,* 1770 *heat from fuel fired, fuel powered object,* 1570 *heat from hot object* and 14% *heat from open flame, spark.* Similarly, when classified by *type of material ignited* 32% are classified as *wood, paper, 23% plastic* and 12% *volatile solid, chemical.* A related classification is *form of material ignited* and classified in this way 3370 are classified as *power transfer equipment, fuel, 20% structural component, finish* and *20% general form.*

When classified by *ignition factor* 47% are classified as *mechanical failure, malfunction, 13% incendiary* and 12% *operational deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 36% involve *electrical distribution equipment,* 21% *cooking equipment,* 15% *heating systems* and 11% *appliances, equipment.*

Classified by *type of construction* 21% are classified as *unprotected ordinary, 19%* as *protected ordinary,* 18% as *fire resistive* and 12 *%* as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 2970 of fires, *21% portable extinguisher* and 2270 self *extinguished.* The *type of action taken* by the fire fighters. for 62% of fires (range 6% to 7%) is classified as *extinguishment, 28% investigation only* and 9% remove hazard.

Scenario-7 **4 am to 8am**

Extent of flame damage: confined to area of origin

During this period (4 **am to** 8 **am)** the fires classified as having extent of flame damage **confined to the area of origin** rises from 18% to 21% of all of the fires during each hourly period.

Of these fires on average 57% are classified as *shopping complex,* with 36% in *no complex.* The remainder had *unknown complex.* Similarly, on average 34% are classified as *fixed property use food and beverage sales,* with 21% in *motor vehicle or boat sales, services* and 12% in *general item stores.* When classified by *area of fire origin* on average 27% are classified as *structural areas,* 21% *storage areas,* 16% *assembly, sales areas* and 14% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 38% are classified as *heat from electrical equipment arcing, overload, 18% heat from open flame, spark, 13% heat from hot object,* 12% *heat from fuel fired, fuel powered object* and 11% *heat spreading from anotherfire (exposure).* Similarly, when classified by *type of material ignited* 56% are classified as *wood, paper* and 15% *plastic.* A related classification is *form of material ignited* and classified in this way 37% are classified as *structural component, finish, 16%* as *power transfer equipment, fuel,* 15% *supplies, stock* and 12% *general form.*

, When classified by *ignition factor* 37% are classified as *incendiary, 16%* as *design, construction deficiency, 15% mechanical failure, malfunction* and 12% *operational deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way *46%* involve *electrical distribution equipment,* 15% *heating systems,* 12% *appliances, equipment* and 10% *cooking equipment.*

Classified by *type of construction* 23% are classified as *unprotected ordinary, 21%* as *protected ordinary,* 13% as *unprotected wood frame,* 12% as *fire resistive* and 12 % as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 44% of fires, 19% *pre-connected hose lines with water from hydrant, draft, standpipe,* 13% *portable extinguisher* and 10% *automatic extinguishing system.* The *type of action taken* by the fire fighters for 85% of fires is classified as *extinguishment* and 12% *investigation only.*

Scenario 8 **4 am to 8am**

Extent of flame damage: confined to room of origin

During this period (4 **am** to 8 **am)** the fires classified as having extent of flame damage **confined to the room of origin** ranges between 14% to 15% of all of the fires during each hourly period.

Of these fires on average 42% are classified as *unknown complex* with 39% *shopping complex.* The remainder had *no complex.* Similarly, on average 32% are classified as *food and beverage sales* and 1970 in *motor vehicle or boat sales, services*. When classified by *area of fire origin* on average 27% are classified as *storage areas,* 1870 *function areas (largely residential and office),* 1670 *assembly, sales areas* and 15% *structural areas.*

When classified by *form of heat of ignition* on average 34% *heat from electrical equipment arcing, overload, 2770 heat from open flame, spark, 1270 heat from fuel fired, fuel powered object* and 1270 *heat from hot object.* Similarly, when classified by *type of material ignited 50%* are classified as *wood, paper,* 14% *flammable, combustible liquid, 13% plastic* and 11% *fabric, textile, fur.* A related classification is *form of material ignited* and classified in this way 28% are classified as *structural component, finish,* 17% *power transfer equipment, fuel, 1570* as *supplies, stock* and 1470 *general form.*

When classified by *ignition factor* 3 1% are classified as *mechanical failure, malfunction, 24% incendiary,* 12% *suspicious* and 10% *misuse of heat of ignition.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 41% involve *electrical distribution equipment,* 17% *appliances, equipment,* 16% *heating systems* and 12% *cooking equipment.*

Classified by *type of construction* 28% are classified as *unprotected ordinary,* 17% as *protected ordinary,* 14% as *unprotected wood frame,* 14 *70* as *unprotected non-combustible or limited combustible* and 1270 as *fire resistive.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for *3970* of fires, *3470 pre-connected hose lines with water from hydrant, draft, standpipe* and 970 *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 90% of fires is classified as *extinguishment* and 870 *investigation only.*

Scenario 9,

Extent of flame damage: confined to the fire rated compartment, storey or structure of origin

During this period (4 **am** to 8 **am)** the fires classified as having extent of flame damage **confined to the fire rated compartment, storey or structure of origin** falls from 34% to 19% of all of the fires during each hourly period.

Of these fires on average 48% are classified as *shopping complex,* with 36% in *no complex.* The remainder had *unknown complex.* Similarly, on average 30% are classified as *fixed property use food and beverage sales,* with 23% in *motor vehicle or boat sales, services* and 1170 in *household goods sales, repairs.* When classified by *area of fire origin* on average 25% are classified as *storage areas, 25% structural areas,* 16% *assembly, sales areas* and *14%* as *unprotected non-combustible or limited combustible* and 1470 *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 31% are classified as *heat from electrical equipment arcing, overload, 2470 heat from open flame, spark,* 1270 *heat from fuel fired, fuel powered object* and 1270 *heat spreading from hot object.* Similarly, when classified by *type of material ignited* 61% are classified as *wood, paper* and 13% *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 50% are classified as *structural component, finish,* 1470 as *power transfer equipment, fuel* and 11% as *supplies, stock.*

When classified by *ignition factor* 28% are classified as *mechanical failure, malfunction, 2470 incendiary* and *2270 suspicious.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 49% involve *electrical distribution equipment* and *26% heating systems.*

Classified by *type of construction* 28% are classified as *unprotected ordinary,* 21% as *unprotected woodframe* and 17% as *protected ordinary.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 4670 of fires, *2770 pre-connected hose lines with water in apparatus tanks* and 16% *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 98% of fires is classified as *extinguishment* and *2% investigation only.*

Scenario 10 **4 am to 8am**

Extent of flame damage: beyond the structure of origin

During this period (4 **am to** 8 **am)** the fires classified as having extent of flame damage **beyond the structure of origin** falls from 8% to 2% of all of the fires during each hourly period.

Of these fires on average 53% are classified as *shopping complex,* with 25% in *no complex.* The remainder had unknown complex. Similarly, on average 22% are classified as *motor vehicle* or *bout* sales, *services,* with 18% classified as *fixed property use food and beverage sales,* services, 15% in *specialty shops* and 14% in *household goods sales, repairs.* When classified by *urea of fire origin* on average 27% are classified as *storage areas, 24%* as *structural areas, 13% assembly, sales areas* and 13% *function areas (largely residential and office).*

When classified by *form of heat* ***of*** *ignition* on average 36% are classified as *heat spreading from another fire (exposure),* 1970 *heat from electrical equipment arcing, overload* and *18% heat from open flame, spark.* Similarly, when classified by *type of material ignited* 65% are classified as *wood, paper* and 10% *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 50% are classified as *structural component, finish,* 10% as *power transfer equipment, fuel* and 7% *general form.*

When classified by *ignition factor 24% design, construction deficiency, 23 70 incendiary, 2070 suspicious* and 1970 are classified as *mechanical failure, malfunction*. A related classification is *equipment involved in ignition* (if any) and when classified in this way 56% involve *electrical distribution equipment* and 18 *% heating systems*.

Classified by *type of construction* 30% are classified as *unprotected ordinary, 26%* as *unprotected woodframe* and *14%* as *protected ordinary.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 36% of fires, 22% *pre-connected hose lines with water in apparatus tanks, 20% hand-laid hose lines with water from standpipe, hydrant, draft* and 1970 *master stream device.* The *type of action taken* by the fire fighters for 97% of fires is classified as *extinguishment* and 3% *investigation only.*

Scenario 11 **Sam to 12 noon**

Extent of flame damage: confined to object of origin

During the period from **8 am to 12 noon** the fires classified as having extent of flame damage **confined to the object of origin** rises from 50% to 59% of all of the fires during each hourly period and the average is 56%.

Of these fires on average 58% are classified as *shopping complex,* with 25% in *no complex.* The remainder had *unknown complex.* Similarly, on average 24% are classified as *fixed property use food and beverage sales,* 15% professional supplies, services, , *1570 motor vehicle or boat sales, services,* 1570 *general item stores.* When classified by *area of fire origin* on average 13% are classified as *function areas (largely residential and office),* 18% as transportation, vehicle areas, 17% as service facilities, 15% *storage areas* and 13% *assembly, sales areas.*

When classified by *form of heat of ignition* on average 45% are classified as *heat from electrical equipment arcing, overload, 2070 heat from fuel fired, fuel powered object,* 1570 *heat from hot object* and *1290 heat from open flame, spark.* Similarly, when classified by *type of material ignited* 2570 are classified as *plastic, 23%* as *wood, paper*, *14%* as *fabric, textile, fur, 12% volatile solid, chemical* and 1190 *natural product {rubber, cork, leather, etc).* A related classification is form *of material ignited* and classified in this way 42% are classified as *power transfer equipment, fuel* and 16% *general form.*

When classified by *ignition factor* 56% are classified as *mechanical failure, malfunction,* 12% misuse of heat of ignition and 12% *operational deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 3470 involve *electrical distribution equipment, 2070 appliances, equipment,* 1770 *heating systems* and 1270 *cooking equipment.*

Classified by *type of construction* 22% are classified as *unprotected ordinary, 2070* as *protected ordinary,* 1770 as *fire resistive,* 12 *%* as *unprotected non-combustible or limited combustible* and *1170* as *unprotected wood frame.*

The *method of extinguishment* is classified as *portable extinguisher* for 3470 of fires (range % to %), *33% self extinguished,* 19% *pre-connected hose lines with water in apparatus tanks* and 1070 make-shift aids. The *type of action taken* by the fire fighters for 48% of fires is classified as *extinguishment, 39% investigation only* and 12% remove hazard.

Scenario 12 **8am to 12 noon**

Extent of flame damage: confined to area of origin

During this period **(from** 8 **am to 12 noon)** the fires classified as having extent of flame damage confined to the area of origin falls 21% to 18% of all of the fires during each hourly period.

Of these fires on average 59% are classified as *shopping complex,* with 34% in *no complex.* The remainder had *unknown complex.* Similarly, on average 22% are classified as *fixed property use food and beverage sales,* with 23% in *motor vehicle or boat sales, services* and 1470 in *general item stores.* When classified by *area of fire origin* on average 25% are classified as *structural areas,* 19% *storage areas*, *15% structural areas* and 17% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 3870 are classified as *heat from electrical equipment arcing, overload, 1970 heat from fuel fired, fuel powered object,* 1770 *heat from open flame, spark* and *1470 heat from hot object.* Similarly, when classified by *type of material ignited 4970* are classified as *wood, paper,* 1670 *plastic,* 1070 *flammable, combustible liquid* and 1070 *fabric, textile, fur.* A related classification is *form of material ignited* and classified in this way 37% are classified as *structural component, finish, 22%* as *power transfer equipment, fuel, 1270 supplies, stock* and 11% *general form.*

When classified by *ignition factor* 41% are classified as *mechanical failure, malfunction,* 16% as misuse of heat of ignition and 14% *misuse of material ignited.* A related classification is *equipment involved in ignition* (if any) and when classified in this way *38%* involve *electrical distribution equipment,* 21% *heating systems,* 14% *appliances, equipment* and 12% service, maintenance equipment.

Classified by *type of construction* 26% are classified as *unprotected ordinary, 18%* as *protected ordinary, 14%* as *unprotected non-combustible or limited combustible,* 1270 as *fire resistive* and *1270* as *unprotected woodframe.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for *3670* of fires, *2570 portable extinguisher,* 12 *% self extinguished* and 1270 *pre-connected hose lines with water from hydrant, draft, standpipe.* The *type of action taken* by the fire fighters for 7370 of fires is classified as *extinguishment* and *2270 investigation only* and *370 remove hazard, standby.*

Scenario 13 **8am to 12 noon**

Extent of confined to room of origin

During this period (8 **am to 12 noon)** the fires classified as having extent of flame damage **confined to the room of origin** ranges between 10% to 14% of all of the fires during each hourly period.

Of these fires on average 42% are classified as *unknown complex* with 39% *shopping complex.* The remainder had *no complex.* Similarly, on average 24% are classified as *motor vehicle or boat sales, services, 20 %* as *food and beverage sales,* 11% as professional supplies, services and 11% *general item stores.* When classified by *area of fire origin* on average 21% are classified as *function areas (largely residential and office), 21% storage areas, 20%* means of egress, 14% service facilities and 13% *assembly, sales areas.*

When classified by *form of heat of ignition* on average 3070 *heat from electrical equipment arcing, overload, 2370 heat from fuel fired, fuel powered object, 1970 heat from open flame, spark* and 14% *heat from hot object.* Similarly, when classified by *type of material ignited* 4270 are classified as *wood, paper, 1870 flammable, combustible liquid,* 1370 *plastic* and *1270 fabric, textile, fur.* A related classification is *form of material ignited* and classified in this way 2670 are classified as *power transfer equipment, fuel, 2370* as *structural component, finish, 16%* as *supplies, stock,* 16% as adornment, recreational material and 13% as *general form.*

When classified by *ignition factor 34%* are classified as *mechanical failure, malfunction,* 1970 *misuse of material ignited,* 1570 misuse of heat of ignition and 11% *incendiary.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 3470 involve *electrical distribution equipment, 22% heating systems* and 1770 *appliances, equipment.*

Classified by *type of construction 25%* are classified as *unprotected ordinary,* 17% as *protected ordinary,* 1670 as *fire resistive,* 14% as *unprotected wood frame* and 12 % as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 3870 of fires, *2370 pre-connected hose lines with water from hydrant, draft, standpipe,* 14% *portable extinguisher* and 10% *self extinguished.* The *type of action taken* by the fire fighters for 8070 of fires is classified as *extinguishment, 1770 investigation only* and 2% *remove hazard, standby.*

Scenario 14 **8am to 12 noon**

Extent of flame damage: confined to the fire-rated compartment, storey or structure of origin

During this period **(from 8 am to 12 noon)** the fires classified as having extent of flame damage **confined to the fire-rated compartment, storey or structure of origin** ranges between 10% to 13% of all of the fires during each hourly period.

Of these fires on average 4 1% are classified as *shopping complex,* with 4 1% in no *complex.* The remainder had *unknown complex.* Similarly, infixed *property use* on average 33% are classified as *motor vehicle or boat sales, services,* with 18% *food and beverage sales* and *11%* in *household goods sales, repairs.* When classified by *area of fire origin* on average 23% are classified as *structural areas, 21% storage areas, 2070 service, equipment areas* and 1470 *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 27% are classified as *heat from electrical equipment arcing, overload, 2270 heat from open flame, spark,* 2170 *heat from fuel fired, fuel powered object* and 16% *heat spreading from hot object.* Similarly, when classified by *type of material ignited 47% are* classified as *wood, paper* and 21% *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 41% are classified as *structural component, finish, 2270* as *power transfer equipment, fuel, 970* as *general form* and *970 special form.*

When classified by *ignition factor 32%* are classified as *mechanical failure, malfunction,* 16% misuse of heat of ignition, 16% *misuse of material ignited* and 12% *design, construction deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 32% involve *heating systems,* 29% involve *electrical distribution equipment,* 11% *appliances, equipment* and 11% *natural condition.*

Classified by *type of construction 2870* are classified as *unprotected ordinary,* 2170 as *unprotected wood frame,* 14% as *unprotected ordinary* and 11% as *protected ordinary.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for *3970* of fires, 3170 *pre-connected hose lines with water in apparatus tanks* and 1370 *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 9870 of fires is classified as *extinguishment 6% investigation only* and 1% *remove hazard, standby.*

Scenario 15 **Sam to 12 noon**

Extent of flame damage: beyond the structure of origin

During this period **(from** 8 **am to 12 noon)** the fires classified as having extent of flame damage **beyond the structure of origin** is steady at 2% of all of the fires during each hourly period.

Of these fires on average 37% are classified as *shopping complex,* with 34% in *no complex.* The remainder had unknown complex. Similarly, on average 29% are classified *fixed property use motor vehicle or boat sales, services,* with 12% *food and beverage sales,* services, 11% in *textile, wearing apparel sales,* 11% in *household goods sales, repairs* and 11% *general item stores.* When classified by *area of fire origin* on average 40% are classified as *structural areas,* 19% as *storage areas* and 19% *service equipment areas.*

When classified by *form of heat of ignition* on average 32% are classified as *heat from electrical equipment arcing, overload, 2470 heat spreading from another fire (exposure),* 1770 *heat from fuel fired, fuel powered object* and 1570 *heat from open flame, spark.* Similarly, when classified by *type of material ignited 5* 1% are classified as *wood, paper* and *22% flammable, combustible liquid.* A related classification is *for-m of material ignited* and classified in this way 42% are classified as *structural component, finish,* 1970 as *power transfer equipment, fuel,* 13% as *general form* and *11% special form.*

When classified by *ignition factor 26% are* classified as *mechanical failure, malfunction*, *2470* as *design, construction deficiency,* 1670 as *misuse of material ignited* and 13% misuse of heat of ignition. A related classification is *equipment involved in ignition* (if any) and when classified in this way 45% involve *electrical distribution equipment,* 18% *heating systems,* 16% service, maintenance equipment and 10% *appliances, equipment.*

Classified by *type of construction 28%* are classified as *unprotected ordinary*, 18% *protected ordinary,* 15% as *unprotected wood frame* and 11% as protected wood frame.

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for *3270* of fires, *2470 pre-connected hose lines with water in apparatus tanks,* 21% *hand-laid hose lines with water from standpipe, hydrant, draft* and 1170 *master stream device.* The *type of action taken* by the fire fighters for 94% of fires is classified as *extinguishment, 6% investigation only* and 1% *remove hazard, standby.*

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Scenario 6 12 noon to 4 pm

Extent of flame damage: confined to object of origin

During the period from 12 **noon to 4 pm** the fires classified as having extent of flame damage **confined to the object of origin** ranges between 56 % to 57% of all of the fires during each hourly period and the average is 57%.

Of these fires on average 58% are classified as *shopping complex,* with 24% in no *complex.* The remainder had *unknown complex.* Similarly, on average 24% are classified as *fixed property use food and beverage sales,* 17% *general item stores,* 15% professional supplies, services, 14% *motor vehicle or boat sales, services, .* When classified by *area of fire origin* on average 22% are classified as *function areas (largely residential and office)*, 20% as transportation, vehicle areas, 16% *assembly, sales areas* and 14% *storage areas.*

When classified by *form of heat of ignition* on average 43% are classified as *heat from electrical equipment arcing, overload, 1770 heat from fuel fired, fuel powered object, 15% heat from open flame, spark* and 12% *heat from hot object.* Similarly, when classified by *type of material ignited* 27% are classified as *wood, paper,* 24% *plastic,* 15% as *fabric, textile, fur* and 11% *volatile solid, chemical.* A related classification is *fonn of material ignited* and classified in this way 39% are classified as *power transfer equipment, fuel ,* 17% *structural component, finish* and 15% *general form.*

When classified by *ignition factor* 52% are classified as *mechanical failure, malfunction,* 15% misuse of heat of ignition and 10% *operational deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 37% involve *electrical distribution equipment,* 21% *appliances, equipment, 1370 heating systems* and *1070 cooking equipment.*

Classified by *type of construction* 23% are classified as *unprotected ordinary, 20%* as *protected ordinary, 16%* as *fire resistive,* 12% as *unprotected wood frame,* 11% heavy timber and 11% as protected non-combustible or limited combustible.

The *method of extinguishment* is classified as *portable extinguisher* for 33% of fires (range *%* to *%*), *28% self extinguished,* 21% *pre-connected hose lines with water in apparatus tanks* and 12% make-shift aids. The *type of action taken* by the fire fighters for 50% of fires is classified as *extinguishment, 37% investigation only* and 12% *remove hazard, standby.*

Scenario 17 **12 noon to 4 pm**

Extent of flame damage: confined to area of origin

During the period from 12 **noon to 4 pm** the fires classified as having extent of flame damage **confined to the area of origin** ranges between 18% to 19% of all of the fires during each hourly period.

Of these fires on average 59% are classified as *shopping complex,* with 34% in *no complex.* The remainder had *unknown complex.* Similarly, on average 21% are classified as *fixed property use food and beverage sales,* with 21% in *motor vehicle or boat sales, services,* 1770 in *general item stores* and 1070 professional supplies, services. When classified by *area of fire origin* on average 28% are classified as *structural areas,* 19% *storage areas,* 15% *function areas (largely residential and office),* 1570 *service, equipment areas* and 1370 *assembly, sales areas.*

When classified by *form of heat of ignition* on average 28% are classified as *heat from electrical equipment arcing, overload, 2570 heat from open flame, spark,* 18% *heat from fuel fired, fuel powered object, 11% heat from hot object* and 10% heat from smoking material. Similarly, when classified by *type of material ignited* 4970 are classified as *wood, paper,* 14% *plastic,* 1170 *flammable, combustible liquid* and 1170 *fabric, textile, fur.* A related classification is *form of material ignited* and classified in this way 36% are classified as *structural component, finish,* 17% as *power transfer equipment, fuel,* 13% *general form* and 12% *supplies, stock.*

When classified by *ignition factor* 3 1% are classified as *mechanical failure, malfunction,* 24% as misuse of heat of ignition and 12% *misuse of material ignited.* A related classification is *equipment involved in ignition* (if any) and when classified in this way *37%* involve *electrical distribution equipment, 20% heating systems,* 18% service, maintenance equipment and 14% *appliances, equipment.*

Classified by *type of construction* 22% are classified as *unprotected ordinary,* 19% as *protected ordinary,* 1570 as *unprotected non-combustible or limited combustible,* 1470 as *unprotected woodframe* and 12% *fire resistive.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for *3870* of fires, *2870 portable extinguisher, 1070 pre-connected hose lines with waterfrom hydrant, draft, standpipe* and 870 make-shift aids. The *type of action taken* by the fire fighters for 7570 of fires is classified as *extinguishment* and *2070 investigation only* and *370 remove hazard, standby.*

Scenario 18 **12 noon to 4 pm**

Extent of flame damage: confined to room of origin

During the period from 12 **noon to 4 pm** the fires classified as having extent of flame damage **confined to the room of origin** falls from 11% to 10% of all of the fires during each hourly period.

Of these fires on average *46%* are classified as unknown *complex* with 36% *shopping complex.* The remainder had no *complex.* Similarly, on average 27% are classified as *motor vehicle or boat sales, services, 20%* as *food and beverage sales,* 13% as professional supplies, services and 10% general *item stores.* When classified by *area of fire origin* on average 22% are classified as *storage areas, 20% function areas (largely residential and office),* 19% *service, equipment areas* and 15% service facilities.

When classified by *form of heat of ignition* on average *32% heat from electrical equipment arcing, overload, 22% heat from open flame, spark, 2 1% heat from fuel fired, fuel powered object* and 1270 *heat from hot object.* Similarly, when classified by *type of material ignited* 42% are classified as *wood, paper, 16% flammable, combustible liquid,* 13% *fabric, textile, fur* and 12% *plastic.* A related classification is *form of material ignited* and classified in this way 26% are classified as *structural component, finish, 24% power transfer equipment, fuel,* 13% as *general form* and 10% as *special form.*

When classified by *ignition factor* 33% are classified as *mechanical failure, malfunction,* 18% misuse of heat of ignition and *16% misuse of material ignited.* A related classification is *equipment involved in ignition* (if any) and when classified in this way *34%* involve *electrical distribution equipment,* 19% *appliances, equipment,* 17% *heating systems* and 11% service, maintenance equipment.

Classified by *type of construction* 2470 are classified as *unprotected ordinary, 20%* as *protected ordinary,* 15% as *unprotected wood frame,* 13% as *fire resistive* and 11 % as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 4170 of fires, 2470 *pre-connected hose lines with water from hydrant, draft, standpipe* and 1470 *portable extinguisher.* The *type of action taken* by the fire fighters for 84% of fires is classified as *extinguishment,* 12% *investigation only* and 270 *remove hazard, standby.*

Scenario 19 **12 noon to 4 pm**

Extent of flame damage; confined to the fire-rated compartment, storey or structure of origin

During the period from 12 **noon to 4 pm** the fires classified as having extent of flame damage **confined to the fire-rated compartment, storey or structure of origin** ranges between 11% to 12% of all of the fires during each hourly period.

Of these fires on average 40% are classified as *shopping complex,* with 4 1% in *no complex.* The remainder had *unknown complex.* Similarly, in *fixed property use* on average 37% are classified as *motor vehicle or boat sales, services,* with 17% *food and beverage* sales and 1170 in *textile, wearing apparel sales.* When classified by *area of fire origin* on average 27% are classified as *structural areas, 23% storage areas, 20% service, equipment areas* and 11% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 25% are classified as *heat from open flame, spark, 2270* as *heat from fuel fired, fuel powered object, 2270* as *heat from electrical equipment arcing, overload, 16% heat spreading from hot object* and 11% as heat from another fire (exposure). Similarly, when classified *by type of material ignited* 47% are classified as *wood, paper* and *21 % flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 4370 are classified as *structural component, finish, 2070* as *power transfer equipment, fuel* and 12% as *general form*.

When classified by *ignition factor* 2470 are classified as *mechanical failure, malfunction,* 2170 misuse of heat of ignition, 1870 *misuse of material ignited* and 1070 *design, construction deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 27% involve *electrical distribution equipment,* 24% involve *heating systems,* 21% service, maintenance equipment and 10% *appliances, equipment.*

Classified by *type of construction* 26% are classified as *unprotected ordinary, 2670* as *unprotected wood frame,* 16% as *protected ordinary* and 10% as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 3870 of fires, 3470 *pre-connected hose lines with water in apparatus tanks* and 1470 *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 95% of fires is classified as *extinguishment 470 investigation only* and 1% *remove hazard, standby.*

Scenario 20 **12 noon to 4 pm**

Extent of flame damage: beyond the structure of origin

During the period from 12 **noon to 4 pm** the fires classified as having extent of flame damage **beyond the structure of origin** ranges between 2% to 3% of all of the fires during each hourly period.

Of these fires on average 38% are classified as *shopping complex,* with 36% in *no complex.* The remainder had unknown complex. Similarly, on average 41% are classified *fixed property use motor vehicle or boat sales, services,* with 12% in *household goods sales, repairs* and 11% *specialty shops.* When classified by *area of fire origin* on average 28% are classified as *storage areas, 24%* as *structural areas* and 20% service equipment areas.

When classified by *form of heat of ignition* on average 31% are classified as *heat from open flame, spark, , 2470* as *heat spreading from another fire (exposure), 17%* as *heat from electrical equipment arcing, overload* and 14% *heat from fuel fired, fuel powered object.* Similarly, when classified by *type of material ignited* 49% are classified as *wood, paper,* 21% *flammable, combustible liquid* and 10% *natural product (rubber, cork, leather, etc).* A related classification is *form oj material ignited* and classified in this way 4870 are classified as *structural component, finish, 17%* as *power transfer equipment, fuel* and *17%* as *general form*.

When classified by *ignition factor* 22% are classified as misuse of heat of ignition, 18% as *design, construction deficiency,* 16% as *appliances, equipment,* 11% *cooking equipment,* 11% *electrical distribution equipment* and 11% *operational deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 35% involve *electrical distribution equipment, 30%* service, maintenance equipment and 15% *heating systems.*

Classified by *type of construction* 31% are classified as *unprotected ordinary, 28%* as *unprotected wood frame* and 14% *protected ordinary.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 3670 of fires, *3570 pre-connected hose lines with water in apparatus tanks* and 1570 *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 99% of fires is classified as *extinguishment* and 170 *investigation only.*

Scenario 21 **4 pm to 8 pm**

Extent of flame damage: confined to object of origin

During the period from 4 **pm to 8 pm** the fires classified as having extent of flame damage **confined to the object of origin** falls from 56% to 5 1% of all of the fires during each hourly period and the average is 52%.

Of these fires on average 58% are classified as *shopping complex,* with 23% in *no complex.* The remainder had *unknown complex.* Similarly, on average 26% are classified as *fixed property use food and beverage sales, 1770 general item stores,* 14% professional supplies, services and 14% *motor vehicle or boat sales, services.* When classified by area *of fire origin* on average 23% are classified as *function areas (largely residential and office), 21%* as *structural areas,* 16% *assembly, sales areas* and 15% *storage areas.*

When classified by *form of heat of ignition* on average 43% are classified as *heat from electrical equipment arcing, overload,* 16% *heat from fuel fired, fuel powered object,* 15% *heat from open flame, spark* and 13% *heat from hot object.* Similarly, when classified by *type of material ignited* 29% are classified as *wood, paper, 2370 plastic, 1470* as *fabric, textile, fur, 11% natural product (rubber, cork, leather, etc)* and *10% volatile solid, chemical.* A related classification is form *of material ignited* and classified in this way 3970 are classified as *power transfer equipment, fuel,* 1770 *general form* and 1570 *structural component, finish.*

When classified by *ignition factor* 50% are classified as *mechanical failure, malfunction* and 1470 *suspicious.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 41% involve *electrical distribution equipment, 2* 170 *appliances, equipment* and 1170 *heating systems.*

Classified by *type of construction* 2170 are classified as *unprotected ordinary,* **20%** as *protected ordinary,* 17% as *fire resistive,* 12% as *unprotected non-combustible or limited combustible,* 11% as protected non-combustible or limited combustible and 11% *unprotected wood frame.*

The *method of extinguishment* is classified as *portable extinguisher* for 30% of fires (range *% to %*), *2870 self extinguished, 23% pre-connected hose lines with water in apparatus tanks* and 12% make-shift aids. The *type of action taken* by the fire fighters for 53% of fires is classified as *extinguishment, 33% investigation only* and 12% *remove hazard, standby.*

Scenario 22 **4 pm to 8 pm**

Extent of flame damage: confined to area of origin

During this period (from 4 **pm to** 8 **pm)** the fires classified as having extent of flame damage **confined to the area of origin** ranges between 18% to 20% of all of the fires during each hourly period.

Of these fires on average 62% are classified as *shopping complex,* with 30% in *no complex.* The remainder had *unknown complex.* Similarly, on average 23% are classified as *fixed property use food* and *beverage sales,* with 20% in *motor vehicle or boat sales, services* and 19% in *general item stores.* When classified by *area of fire origin* on average 27% are classified as *structural areas, 22% storage areas,* 16% *function areas (largely residential and office),* 1470 *assembly, sales areas* and 11% *service, equipment areas.*

When classified by *form of heat of ignition* on average 29% are classified as *heat from electrical equipment arcing, overload, 26% heat from open flame, spark,* 16% *heat from fuel fired, fuel powered object,* 11% *heat from hot object* and 10% heat from smoking material. Similarly, when classified by *type of material ignited* 56% are classified as *wood, paper,* 12% *plastic* and 11% *fabric, textile, fur.* A related classification is *form of material ignited* and classified in this way 34% are classified as *structural component, finish,* 1670 *general form,* 1670 *special form,* 15% as *power transfer equipment, fuel* and 12% *supplies, stock.*

When classified by *ignition factor* 31% are classified as *mechanical failure, malfunction,* 20% as misuse of heat of ignition, 13% *incendiary,* 12% *suspicious* and 10% *misuse of material ignited.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 40% involve *electrical distribution equipment,* 17% *appliances, equipment,* 16% as *heating systems* and 14% service, maintenance equipment.

Classified by *type of construction* 22% are classified as *unprotected ordinary, 20%* as *protected ordinary,* 1470 as *unprotected non-combustible or limited combustible, 13* 70 *fire resistive,* 13% as *unprotected wood frame* and 10% protected non-combustible or limited combustible.

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 39% of fires, 26% *portable extinguisher* and 12% *pre-connected hose lines with water from hydrant, draft, standpipe.* The *type of action taken* by the fire fighters for 77% of fires is classified as *extinguishment* and 28% *investigation only* and *3% remove hazard, standby.*

Scenario 22 **4 pm to 8 pm**

Extent of flame damage: confined to room of origin

During this period (from 4 **pm to** 8 **pm)** the fires classified as having extent of flame damage **confined to the room of origin** rises 10% to 13% of all of the fires during each hourly period.

Of these fires on average 44% are classified as *unknown complex* with 39% *shopping complex.* The remainder had no *complex.* Similarly, on average 24% are classified as *food and beverage sales, 2470* as *motor vehicle or boat sales, services,* 13% *general item stores* and 10% as professional supplies, services. When classified by *area of fire origin* on average 25% are classified as *storage areas,* 21% *function areas (largely residential and office,,* 17% *structural areas, 14% service, equipment areas* and 13% assembly sales areas.

When classified by *form of heat of ignition* on average *3* 1% *heat from electrical equipment arcing, overload, 27% heat from open flame, spark,* 13% *heat from fuel fired, fuel powered object,* 10% heat from smoking material and 10% *heat from hot object.* Similarly, when classified by *type of material ignited 46%* are classified as *wood, paper, 1370 flammable, combustible Liquid,* 13% *fabric, textile, fur* and 1270 *plastic.* A related classification is *form of material ignited* and classified in this way 22% are classified as *structural component, finish,* 1870 *power transfer equipment, fuel,* 1770 as *supplies, stock* and 1770 as *general form.*

When classified by *ignition factor 29%* are classified as *mechanical failure, malfunction, 17% heating systems,* 17% misuse of heat of ignition, 13% *misuse of material ignited* and 12% *suspicious.* A related classification is *equipment involved in ignition* (if any) and when classified in this way *38%* involve *electrical distribution equipment, 19% appliances, equipment* and *16% heating systems.*

Classified by *type of construction 26%* are classified as *unprotected ordinary,* 18% as *protected ordinary, 14%* as *fire resistive,* 14 *%* as *unprotected non-combustible or limited combustible* and 11% as *unprotected woodframe.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 3870 of fires, *2970 pre-connected hose lines with water from hydrant, draft, standpipe* and 13% *portable extinguisher.* The *type of action taken* by the fire fighters for 86% of fires is classified as *extinguishment,* 12% *investigation only* and *170 remove hazard, standby.*

Scenario 24 **4 pm to 8 pm**

Extent of flame damage: confined to the fire-rated compartment, storey or structure of origin

During this period (from 4 **pm to** 8 **pm)** the fires classified as having extent of flame damage **confined to the fire-rated compartment, storey or structure of origin** rises from 12% to 15% of all of the fires during each hourly period.

Of these fires on average 39% are classified as *shopping complex,* with 37% in no *complex.* The remainder had *unknown complex.* Similarly, in *fixed property use* on average 30% are classified as *motor vehicle or boat* sales, *services,* with 21% *food and beverage* sales and 11% in *household goods sales, repairs.* When classified by *area of fire origin* on average 26% are classified as *storage areas,* 21% *structural areas,* 1770 *service, equipment areas, 16% assembly, sales areas* and 11% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 30% are classified as *heat from open flame, spark, 2570* as *heat from electrical equipment arcing, overload,* 1570 *heat from fuel fired, fuel powered object,* 1170 *heat from hot object.* Similarly, when classified by *type of material ignited* 5 1% are classified as *wood, paper,* 17% *flammable, combustible liquid* and 10% heat from natural source. A related classification is *form of material ignited* and classified in this way 41% are classified as *structural component, finish, 17%* as *power transfer equipment, fuel'* and 12% as *general form.*

When classified by *ignition factor* 23% are classified as *mechanical failure, malfunction, 22% incendiary,* 1.5% misuse of heat of ignition, 13% *suspicious* and 12% *misuse of material ignited.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 36% involve *electrical distribution equipment,* 25% involve *heating systems,* 12% involve a *natural condition* and 10% *mechanical failure, malfunction.*

Classified by *type of construction* 29% are classified as *unprotected ordinary,* 22% as *unprotected wood frame,* 14% as *protected ordinary* and 1070 as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 4170 of fires, *3270 pre-connected hose lines with water in apparatus tanks* and 1470 *hand-laid hose lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 9570 of fires is classified as *extinguishment 470 investigation only* and 1% *remove hazard, standby.*

Scenario 25 4 **pm to 8 pm**

Extent of flame damage: beyond the structure of origin .

During this period (from 4 **pm to** 8 **pm)** the fires classified as having extent of flame damage **beyond the structure of origin** is steady at 2% of all of the fires during each hourly period.

Of these fires on average 42% are classified as *shopping complex,* with 3 1% in *no complex.* The remainder had unknown complex. Similarly, on average 35% are classified *fixed property use motor vehicle or boat sales, services,* 15% *food and beverage sales,* with 12% in *household goods* sales, *repairs* and 10% *general item stores.* When classified by *area of fire origin* on average 33% are classified as *storage areas, 22%* as *structural areas* and 21% service equipment areas.

When classified by *for-m of heat of ignition* on average 23% are classified as *heat spreading from another fire (exposure),* 21% as*heat from open flame, spark, , 20%* as *heat from electrical equipment arcing, overload,* 1470 *heat from fuel fired, fuel powered object* and *9% heat from hot object.* Similarly, when classified by *type of material ignited 52%* are classified as *wood, paper* and 19% *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 4970 are classified as *structural component, finish,* 19% as *power transfer equipment, fuel* and *970* as *general form.*

When classified by *ignition factor 20%* are classified as *suspicious* (range % to *%*), *1870* as *mechanical failure, malfunction,* 1770 as *design, construction deficiency,* 12% as *incendiary,* 11% as air conditioning, refrigeration equipment. A related classification is *equipment involved in ignition* (if any) and when classified in this way 43% involve *electrical distribution equipment, 23%* as *heating systems* and 11% service, maintenance equipment.

Classified by *type of construction* 32% are classified as *unprotected ordinary, 27%* as *unprotected wood frame,* 1270 *protected ordinary* and 9% *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 40% of fires, *2470 pre-connected hose lines with water in apparatus tanks,* 1870 *master stream device* and 1570 *hand-laid hose 'lines with water from standpipe, hydrant, draft.* The *type of action taken* by the fire fighters for 97% of fires is classified as *extinguishment* and 2% *remove hazard, standby.*

Scenario 26 **8 pm to 12 midnight**

Extent of flame damage: confined to object of origin

During the period from **8 pm to 12 midnight** the fires classified as having extent of flame damage **confined to the object of origin** falls from 50% to 32% of all of the fires during each hourly period and the average is 42%.

Of these fires on average 57% are classified as *shopping complex,* with 24% in no *complex.* The remainder had *unknown complex.* Similarly, on average 34% are classified as *fixed property use food and beverage sales, 16% general item stores,* 15% *motor vehicle or boat* sales, *services* and 12% professional supplies, services. When classified by *area of fire origin* on average 26% are classified as *structural areas,* 21% as *function areas (largely residential and office),* 17% *storage areas,* 13% as means of egress and 10% as service facilities.

When classified by *form of heat of ignition* on average 39% are classified as *heat from electrical equipment arcing, overload,* 16% *heat from open flame, spark,* 13% *heat from fuel fired, fuel powered object,* 13% *heat from hot object* and 10% heat from smoking material. Similarly, when classified by *type of material ignited* 34% are classified as *wood, paper, 22% plastic,* 13% as *fabric, textile, fur* and 10% *natural product (rubber, cork, leather, etc).* A related classification is *for-m of material ignited* and classified in this way 3 1% are classified as *power transfer equipment, fuel, 20% general form,* 17% *structural component, finish* and 10% as *supplies, stock.*

When classified by *ignition factor* 43% are classified as *mechanical failure, malfunction,* 13 % as misuse of heat of ignition, 12% as *incendiary, 10% suspicious* and 10% *operational deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 42% involve *electrical distribution equipment, 19% appliances, equipment,* 12% *heating systems* and 11% *cooking equipment.*

Classified by *type of construction* 22% are classified as *unprotected ordinary, 20%* as *protected ordinary,* 17% as *fire resistive,* 12% as protected non-combustible or limited combustible, 12% as *unprotected non-combustible or limited combustible* and 10% *unprotected wood frame.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 29% of fires (range % to %), with *27% portable extinguisher, 23% self extinguished* and 12% make-shift aids. The *type of action taken* by the fire fighters for 58% of fires is classified as *extinguishment, 30% investigation only* and 11% *remove hazard, standby.*

Scenario 27 **8 pm to 12 midnight**

Extent of flame damage: confined to area of origin

During this period (from **8 pm to 12 midnight)** the fires classified as having extent of flame damage **confined to the area of origin** ranges between 19% to 20% of all of the fires during each hourly period.

Of these fires on average 61% are classified as *shopping complex,* with 33% in *no complex.* The remainder had *unknown complex.* Similarly, on average 30% are classified as *fixed property use food and beverage sales,* with 18% in *motor vehicle or boat sales, services* and 16% in *general item stores.* When classified by *area of fire origin* on average 28% are classified as *structural areas, 24% storage areas, 1670 function areas (largely residential and office)* and 14% *assembly, sales areas.*

When classified by *form of heat of ignition* on average 32% are classified as *heat from electrical equipment arcing, overload, 2670 heat from open flame, spark,* 10% *heat from fuel fired, fuel powered object,* 1070 heat from smoking material and 1070 *heat from hot object.* Similarly, when classified by *type of material ignited 5670* are classified as *wood, paper, 14% plastic* and 1070 *fabric, textile, fur.* A related classification is *form of material ignited* and classified in this way 33% are classified as *structural component, finish, 17% general form* and 1470 as *power transfer equipment, fuel.*

When classified by *ignition factor* 29% are classified as *mechanical failure, malfunction, 2070 incendiary,* 17% *suspicious* and 17% as misuse of heat of ignition. A related classification is *equipment involved in ignition* (if any) and when classified in this way 48% involve *electrical distribution equipment, 15%* as heating *systems* and 15% *appliances, equipment.*

Classified by *type of construction 24%* are classified as *unprotected ordinary,* 19% as *protected ordinary, 13% fire resistive, 1270* as *unprotected non-combustible or limited combustible, 1270* as *unprotected wood frame* and 1170 protected non-combustible or limited combustible.

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 44% of fires, 1870 *pre-connected hose lines with water from hydrant, draft, standpipe* and 1770 *portable extinguisher.* The *type of action taken* by the fire fighters for 84% of fires is classified as *extinguishment,* 13% *investigation only* and *270 remove hazard, standby.*

Scenario 28 **8 pm-to 12 midnight**

Extent of flame damage: confined to room of origin-

During this period (from **8 pm to 12 midnight)** the fires classified as having extent of flame damage **confined to the room of origin** rises from 12% to 15% of all of the fires during each hourly period.

Of these fires on average 43% are classified as *unknown complex* with 40% *shopping complex.* The remainder had *no complex.* Similarly, on average 28% are classified as *food and beverage sales, 24%* as *motor vehicle or boat sales, services* and 1270 *general item stores.* When classified by *area of fire origin* on average 29% are classified as *storage areas, 19% function areas (largely residential and office)*, *16% structural areas,* 15% assembly sales areas and 10% *service, equipment areas.*

When classified by *form of heat of ignition* on average *28% heat from electrical equipment arcing, overload, 27% heat from open flame, spark,* 12% heat from smoking material, 10% *heat from fuel fired, fuel powered object* and 10% *heat from hot object.* Similarly, when classified by *type of material ignited 5* 1% are classified as *wood, paper,* 1470 *fabric, textile, fur,* 13% *flammable, combustible liquid,* and 11% *plastic.* A related classification is *form of material ignited* and classified in this way 24% are classified as *structural component, finish,* 18% as *general form,* 17% as *supplies, stock* and 1670 as *power transfer equipment, fuel.*

When classified by *ignition factor 2670* are classified as *incendiary, 2470* as *mechanical failure, malfunction,* 1670 as *suspicious* and 1370 as misuse of heat of ignition. A related classification is *equipment involved in ignition* (if any) and when classified in this way 4370 involve *electrical distribution equipment,* 1770 *appliances, equipment* and 1470 *heating systems.*

Classified by *type of construction* 24% are classified as *unprotected ordinary,* 22% as *protected ordinary, 1470* as *unprotected wood frame,* 1370 as *fire resistive* and 11 *70* as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water in apparatus tanks* for 3870 of fires, 3370 *pre-connected hose lines with water from hydrant, draft, standpipe, 8% portable extinguisher* and 8% automatic *extinguishing system.* The *type of action taken* by the fire fighters for 9070 of fires is classified as *extinguishment, 870 investigation only* and 170 *remove hazard, standby .*

Scenario 29 **8 pm to 12 midnight**

Extent of flame damage: confined to the fire rated compartment, storey or structure of origin

During this period (from **8 pm to 12 midnight)** the fires classified as having extent of flame damage **confined to the fire rated compartment, storey or structure of origin** rises from 15% to 28% of all of the fires during each hourly period.

Of these fires on average 45% are classified as *shopping complex,* with 36% in *no complex.* The remainder had *unknown complex.* Similarly, in *fixed property use* on average 26% are classified as *motor vehicle or boat sales, services,* with 25% *food and beverage sales,* 11% in *household goods sales, repairs* and 10% *specialty shops.* When classified by *area of fire origin* on average 25% are classified as *storage areas, 24% structural areas,* 14% *assembly, sales areas,* 12% *function areas (largely residential and office)* and 11% *service, equipment areas.*

When classified by *form of heat of ignition* on average 30% are classified as *heat from electrical equipment arcing, overload, 2570* as *heat from open flame, spark,* 13% as *heat spreading from another fire (exposure)* and 10% as *heat from fuel fired, fuel powered object.* Similarly, when classified by *type of material ignited* 60% are classified as *wood, paper* and 15% *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 46% are classified as *structural component, finish,* 1470 as *power transfer equipment, fuel,* 11% as *supplies, stock* and 10% as *general form*.

When classified by *ignition factor 25%* are classified as *mechanical failure, malfunction, 23%* as *suspicious, 21% incendiary* and 11% *design, construction deficiency.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 5 1% involve *electrical distribution equipment,* 21% involve *heating systems* and 8% involve a *natural condition.*

Classified by *type of construction* 27% are classified as *unprotected ordinary, 23%* as *unprotected wood frame, 17%* as *protected ordinary* and 10% as *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 4670 of fires, *27% pre-connected hose lines with water in apparatus tanks,* 16% *hand-laid hose lines with water from standpipe, hydrant, draft* and *6% master stream device.* The *type of action taken* by the fire fighters for 9770 of fires is classified as *extinguishment 2% investigation only* and 170 *remove hazard, standby.*

Scenario 30 **8 pm to 12 midnight**

Extent of flame damage: beyond the structure of origin

During this period (from **8 pm to 12 midnight)** the fires classified as having extent of flame damage **beyond the structure of origin** rises from 3% to 5% of all of the fires during each hourly period.

Of these fires on average 53% are classified *as shopping complex,* with 26% in *unknown complex.* The remainder were *no complex.* Similarly, on average 37% are classified *fixed property use motor vehicle or boat sales, services,* 16% *food* and beverage *sales,* with 1270 in *textile, wearing apparel sales,* 12% in *household goods* sales, *repairs* and 11% *general item stores.* When classified by *area of fire origin* on average 37% are classified as *structural areas, 26%* as *storage areas,* 13% *assembly, sales areas* and 9% *function areas (largely residential and office).*

When classified by *form of heat of ignition* on average 40% are classified as *heat spreading from another fire (exposure), 2270* as *heat from open flame, spark* and 17% as *heat from electrical equipment arcing, overload.* Similarly, when classified by *type of material ignited 64%* are classified as *wood, paper* and 1470 *flammable, combustible liquid.* A related classification is *form of material ignited* and classified in this way 5470 are classified as *structural component, finish,* 13% as *power transfer equipment, fuel* and 12% as *general form.*

When classified by *ignition factor* 2770 are classified as *design, construction deficiency, 22% incendiary, 22% suspicious* and 17% as *mechanical failure, malfunction.* A related classification is *equipment involved in ignition* (if any) and when classified in this way 5270 involve *electrical distribution equipment, 1870* as *heating systems* and 11% *appliances, equipment.*

Classified by *type of construction* 3070 are classified as *unprotected ordinary, 2470* as *unprotected wood frame,* 13% *protected ordinary* and 1170 *unprotected non-combustible or limited combustible.*

The *method of extinguishment* is classified as *pre-connected hose lines with water from hydrant, draft, standpipe* for 4070 of fires, 2170 *pre-connected hose lines with water in apparatus tanks,* 19% *hand-laid hose lines with water from standpipe, hydrant, draft* and 1870 *master stream device.* The *type of action taken* by the fire fighters for 9770 of fires is classified as *extinguishment, 2% investigation only* and 1% *remove hazard, standby.*